ECOSYSTEM CARBON MEASUREMENT:
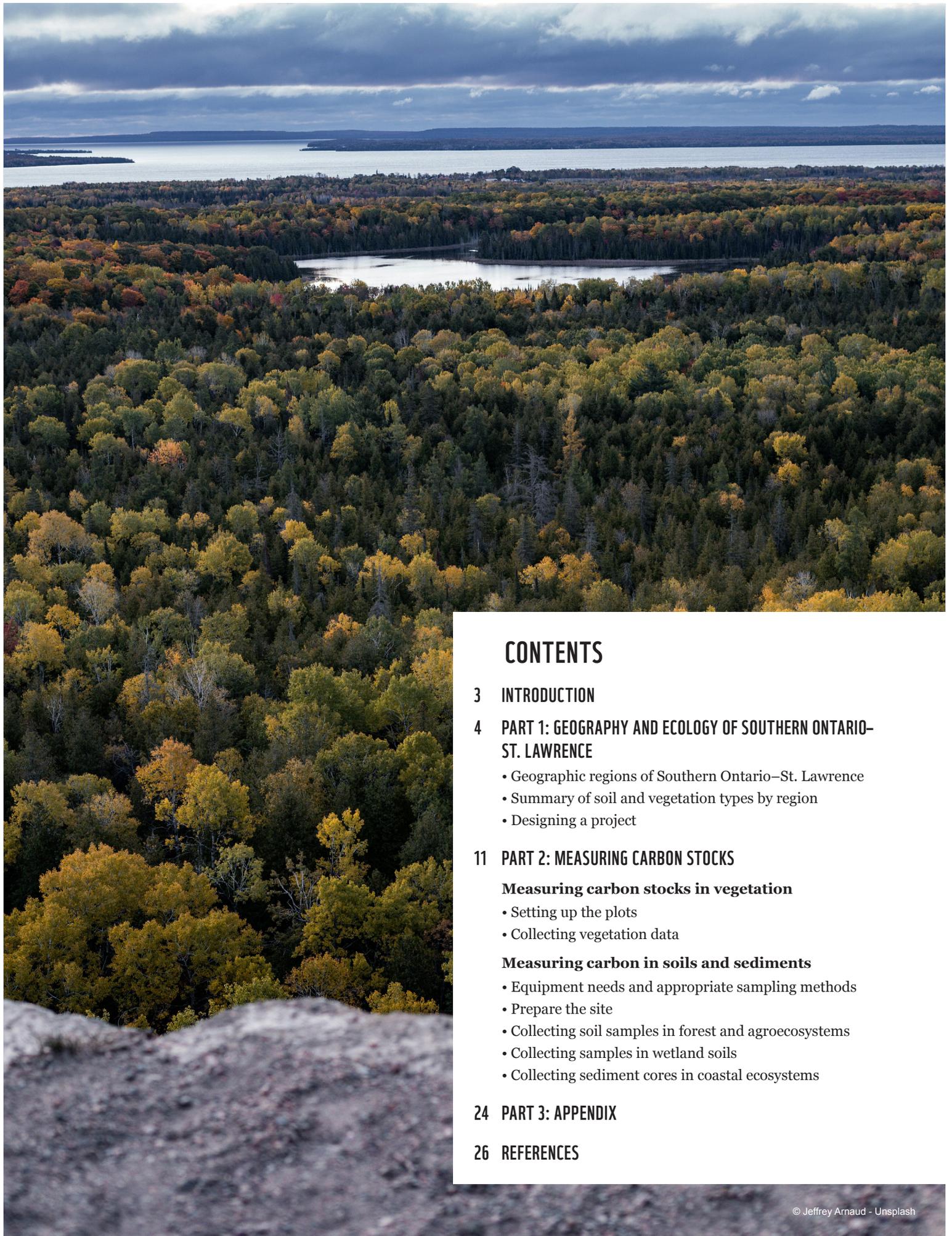## REGIONAL PROTOCOL FOR SOUTHERN ONTARIO – ST. LAWRENCE, CANADA

CONTENTS

INTRODUCTION

Field sampling is essential for estimating carbon stock, which is the amount of carbon stored in an ecosystem at a specific point in time. The carbon stock of an ecosystem is made up of two main carbon pools:

1) Vegetation or "biomass," including:

- trees
- shrubs
- herbaceous plants

2) Soils, including:

- peat soils (consisting of partially decomposed plant materials)
- non-peat soils (consisting of a mix of decomposed plant matter and other mineral sediments)

Ecosystems can vary in soil types, vegetation and geographic characteristics. Measuring their carbon pools therefore requires different methods and tools depending on the ecosystem being studied. Having background knowledge about your study area can help guide your project, anticipate conditions you might encounter and determine the specific equipment needed to accurately estimate carbon stocks.

This field guide is intended for use in the ecosystems found in Southern Ontario and the St. Lawrence Lowlands in Southern Quebec (i.e., Southern Ontario–St. Lawrence). It is divided into two parts:

Part 1 introduces the diverse landscapes in Southern Ontario–St. Lawrence, highlighting common vegetation communities and soil types in each region. This information will assist in developing a strategy for a carbon measurement project.

Part 2 contains abbreviated in-field carbon measurement instructions (full guides for each ecosystem type are available through WWF-Canada's Carbon Measurement Learning Library) as well as specific instructions for measuring in ecosystems throughout the Southern Ontario–St. Lawrence region.

GEOGRAPHY AND ECOLOGY OF SOUTHERN ONTARIO—ST.LAWRENCE

REGIONAL OVERVIEW

The Southern Ontario–St. Lawrence region is described in this guide as the land below the Canadian Shield to the southern Canada–United States border, roughly extending east from Lake Huron to the mouth of the St. Lawrence River. The region is divided into four distinct geographic regions (Fig. 1):

Legend

- Lake Erie Lowland
- Manitoulin–Lake Simcoe
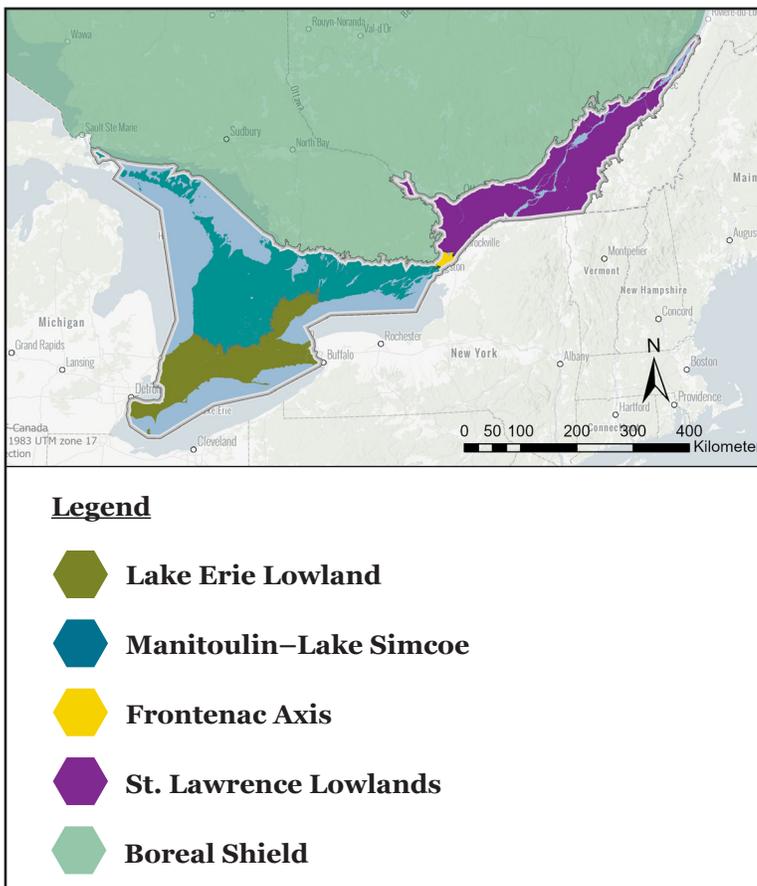- Frontenac Axis
- St. Lawrence Lowlands
- Boreal Shield

Figure 1: Map of regions in Southern Ontario–St. Lawrence, capturing areas with distinct soil and vegetation ecosystems (data from Agriculture and Agri-Food Canada, 2024).

LAKE ERIE LOWLAND

This region is characteristically temperate, with cool winters and hot summers, hosting the biggest diversity of plants in all of Canada. Here can be found remnants of Carolinian forests with genera such as oaks, hickories, hackberries and sycamore, as well as genera more common throughout Canada, such as maples, ash and pine. This region is also the most urbanized, industrialized and ecologically imperiled in Canada, as centuries of forest degradation and wetland drainage for agricultural land use has transformed the landscape. Soils here overlay remnants of ancient lakes, are typically rich in mineral components and contain the lowest levels of soil carbon compared to the other areas in this region (Table 1). This region also includes lake plain prairies, oak savannahs, sand dunes and large coastal marshes.

MANITOULIN—LAKE SIMCOE

This region is directly south of the Canadian Shield and contains a wide mix of forest types whose distribution is heavily influenced by hydrology and topography. The land is mostly flat, with gently rolling topography, and is underlain by thick mineral-rich sediments that support water drainage into the large waterbodies throughout the regions (i.e., Lake Simcoe, Georgian Bay and Lake Ontario), with the exception of the Niagara escarpment, whose rugged and elevated landscape protrudes in the northern and central parts of the area. The carbonate-rich soils in the Manitoulin–Lake Simcoe region are low in acidity, in stark contrast to the acidic soils found throughout the Canadian Shield north of this region. There are alvars that stretch from the Bruce Peninsula north to Manitoulin Island and from the east side of Lake Simcoe following the Canadian Shield south to the Frontenac Axis.

FRONTENAC AXIS

The Frontenac Axis is an arch of rock between Algonquin Provincial Park and the Adirondacks in the United States. It is a small area characterized by its rugged topography, where numerous lakes and high hills create a highly variable landscape. Frontenac Axis is the smallest of the four regions described here, but despite its geographic constraints boasts a wide mix of forest and wetland ecosystem types.

ST. LAWRENCE LOWLANDS

The St. Lawrence Lowlands are generally flat or gently rolling with deep, rich soils. Vegetation in this region is characterized by mixed-wood forests dominated by maple, birch, eastern hemlock, eastern white pine and American beech. Drier sites are dominated by red pine, white cedar and red oak. Wetter sites include red maple, black ash, white spruce, tamarack and eastern white cedar. Other ecosystem types here include bogs and fens, inland dunes and sand barrens, alvars, and marshes along the St. Lawrence River.

SOIL AND VEGETATION IN SOUTHERN ONTARIO–ST. LAWRENCE

Understanding these regions is crucial for carbon measuring and monitoring projects because each supports different types of vegetation and soil. Ecosystems can also vary considerably within each region, largely due to differences in water flow, nutrients and local climatic conditions. Figure 2 summarizes the effects of these three factors on the soil and vegetation properties across Southern Ontario–St. Lawrence.
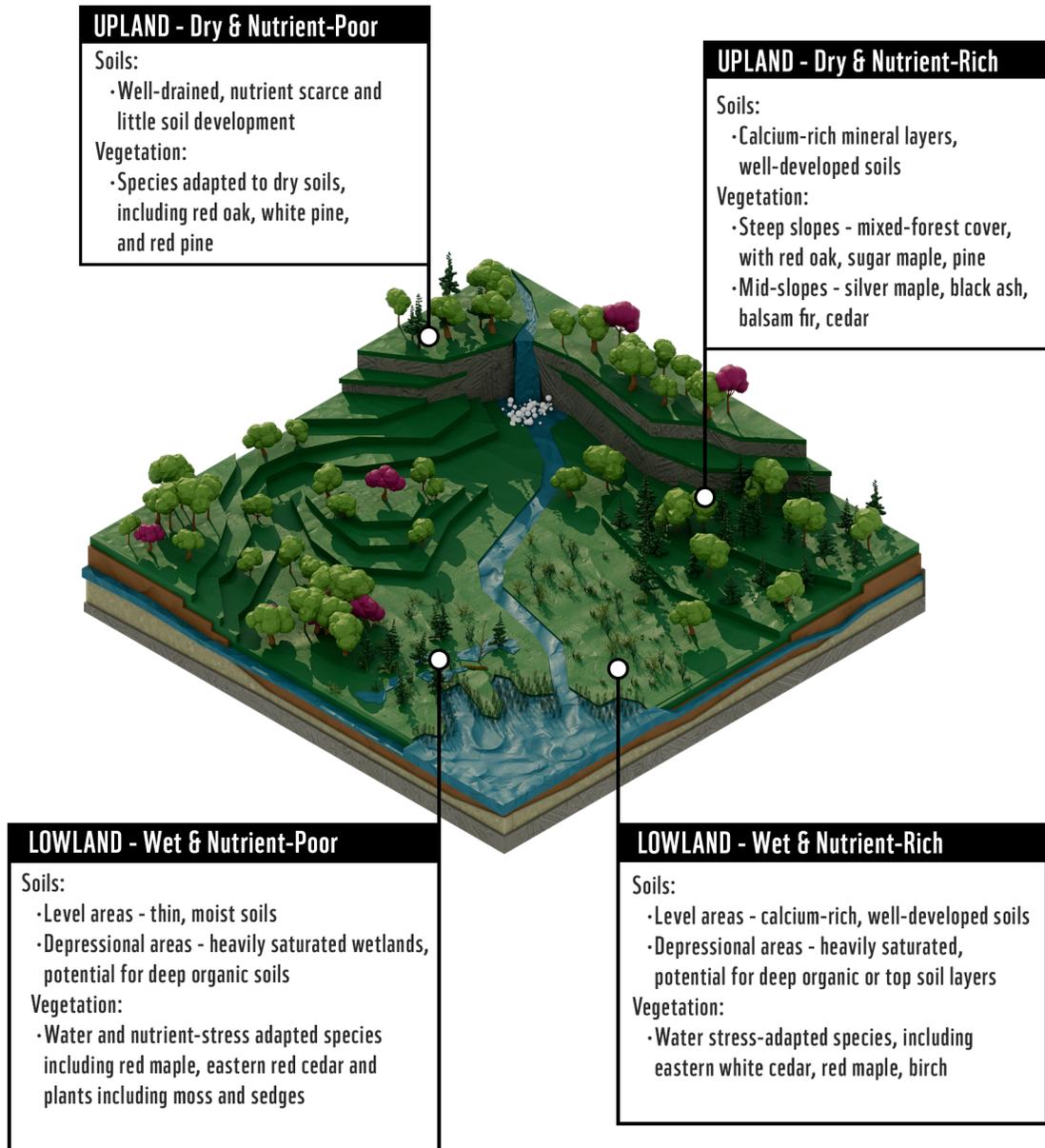
UPLAND - Dry & Nutrient-Poor

Soils:
  • Well-drained, nutrient scarce and little soil development

Vegetation:
  • Species adapted to dry soils, including red oak, white pine, and red pine

UPLAND - Dry & Nutrient-Rich

Soils:
  • Calcium-rich mineral layers, well-developed soils

Vegetation:
  • Steep slopes - mixed-forest cover, with red oak, sugar maple, pine
  • Mid-slopes - silver maple, black ash, balsam fir, cedar

LOWLAND - Wet & Nutrient-Poor

Soils:
  • Level areas - thin, moist soils
  • Depressional areas - heavily saturated wetlands, potential for deep organic soils

Vegetation:
  • Water and nutrient-stress adapted species including red maple, eastern red cedar and plants including moss and sedges

LOWLAND - Wet & Nutrient-Rich

Soils:
  • Level areas - calcium-rich, well-developed soils
  • Depressional areas - heavily saturated, potential for deep organic or top soil layers

Vegetation:
  • Water stress-adapted species, including eastern white cedar, red maple, birch

Figure 2: *Common soil properties and associated vegetation communities of the Southern Ontario–St. Lawrence region across gradients of nutrients and water content.*

GEOGRAPHY AND ECOLOGY OF SOUTHERN ONTARIO–ST. LAWRENCE

Table 1: *Summary of carbon stocks (data from Sothe et al., 2022) for each Southern Ontario–St. Lawrence region, separated into soil carbon, forest biomass carbon (including above-ground biomass, below-ground biomass and downed-woody biomass) and total carbon (soil and forest biomass). Maps for each component can be found in the Appendix (Figs. 6 and 7).*

| Region	Total area of region (ha)	Area of terrestrial soil cover (ha)	Average soil carbon stock (kg/m²)	Total soil carbon stock *1 metre [m] depth;* (kilotonnes)	Area of forest cover (ha)	Average forest biomass carbon stock (kg/m²)	Total forest biomass carbon (kilotonnes)	Total carbon *soil carbon + forest biomass carbon* (kilotonnes)
LAKE ERIE LOWLAND	4,115,162	2,336,165	21.3	497,603.1	266,259	1.3	3,461.4	501,065
MANITOULIN–LAKE SIMCOE	8,193,355	4,336,716	21.9	949,740.80	1,293,310	1.5	19,399.7	969,141
FRONTENAC AXIS	98,877	79,162	28.6	22,640.33	40,975	1.3	532.7	23,173
ST. LAWRENCE LOWLANDS	4,549,937	4,097,340	36.1	1,479,140	1,358,253	1.5	20,373.8	1,499,513

ECOSYSTEM SPOTLIGHT

Greenock Swamp

This largest forested wetland in Southern Ontario hosts critical habitat for diverse water-adapted species, regulates water flow and acts as a major carbon sink.

It's made up of a mix of low-lying swamp ecosystems that have accumulated several metres of woody peat over thousands of years.

Greenock Swamp faces considerable threats from hydrological changes, invasive species and climate change, which can disrupt the health of the ecosystem.
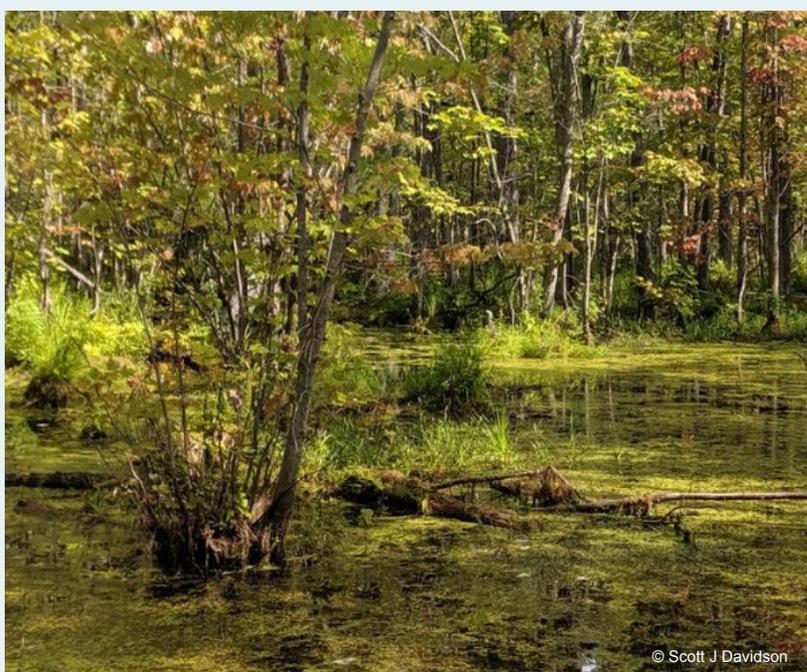
© Scott J Davidson

SUMMARY OF SOIL AND VEGETATION TYPES BY REGION

Knowing the types of soil and vegetation of a study area is crucial for choosing the appropriate method to collect samples and design an effective project. The information below and Figure 3 provide detailed information about the soil and vegetation commonly found in each region. Use this information to answer some key questions that will guide your carbon measuring and monitoring work:

1. What kinds of soils and vegetation can I expect to find in my study area?

2. Based on the expected soils and vegetation, what equipment is most suitable for this specific ecosystem?

3. Which carbon pools am I focusing on?

4. How can I design a project that covers all these components effectively?

LAKE ERIE LOWLAND

- **Soils:** High mineral content, thin organic layers. Compact and brittle soils, especially in gleysol areas. Shallower, drier, less nutrient-rich soils at higher elevations.
- **Vegetation:** Most plant-diverse region in Canada. Dominant trees: sugar maple, American beech, oaks, hickories, white birch. Forested swamps: silver maple, red ash.
- **Sampling considerations:** Use soil cores if conditions allow. Compacted soils during late summer may require heavy hammer weights. Wetlands: suitable for box-style or sludge corers. Use local guides for species identification due to high diversity.

MANITOULIN–LAKE SIMCOE

- **Soils:** Varies by terrain; compact in forests, loose and wet in valleys.
- **Vegetation:** Mix of deciduous, coniferous and mixed forests. Common trees: sugar maple, American beech, hemlock, red oak, basswood. Pioneer species: eastern white pine, birch, trembling aspen. Wet sites: silver maple, balsam fir, black ash, white cedar. Dry sites: red oak, white pine, red pine.
- **Sampling considerations:** Equipment needs vary by site type and water table depth. Stratify sites or increase sampling to capture habitat variation. Learn local vegetation types ahead of time.

FRONTENAC AXIS

- **Soils:** Water-influenced or mineral-rich; upland soils are shallow and lowland soils are saturated.
- **Vegetation:** Moist sites: yellow birch, white elm, red maple. Depressions/streams: slippery elm, black ash, white cedar. Dry sites: red oak, white and red pine.
- **Sampling considerations:** Use open-barrel corers; surface water is often below the ground layer. Sample across elevation gradients to capture species diversity.

ST. LAWRENCE LOWLANDS

- **Soils:** Flat to gently rolling terrain with deep, rich soils. Forest soils are harder; wetland soils are soft and saturated. Soil hardness is influenced by water table depth.
- **Vegetation:** Mixed wood forests: maple, yellow birch, hemlock, white pine, beech. Dry sites: red pine, white cedar, red oak. Wet sites: red maple, black ash, white spruce, tamarack, eastern white cedar.
- **Sampling considerations:** Match equipment to soil type and water table position. Stratify sampling to reflect habitat variation. Field identification of species is time-consuming, so advance preparation is recommended.
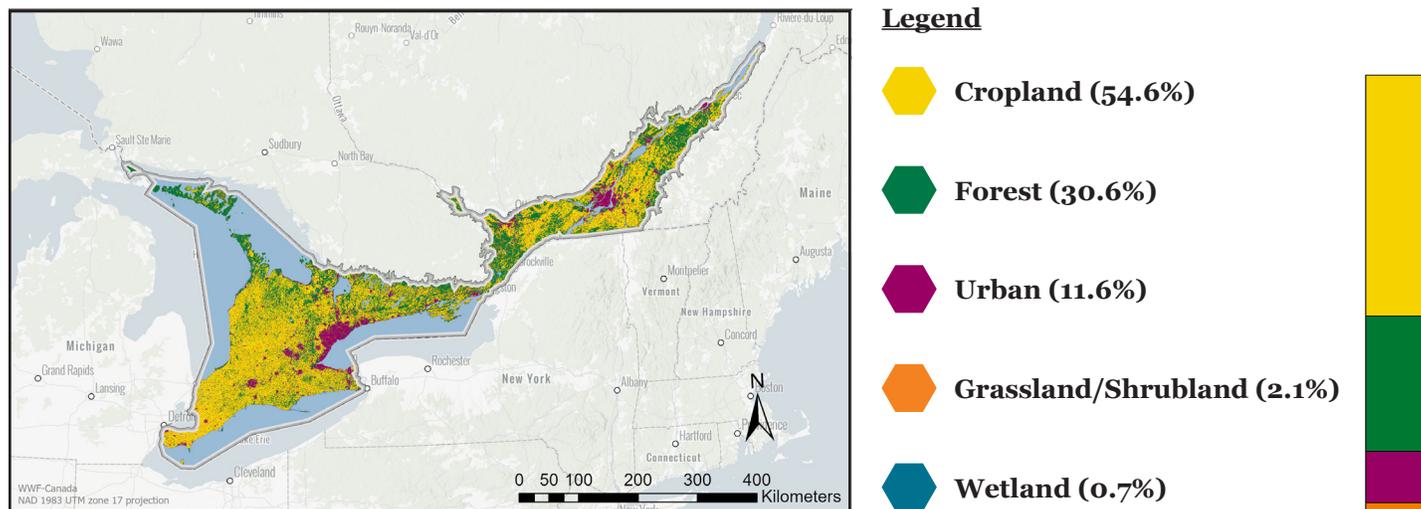
LAND COVER

Figure 3: *(Left) Map of ecosystem and land cover class for the Southern Ontario–St. Lawrence region. (Right) Bar graph showing relative proportion of each class at a 30-by-30m resolution (data from Natural Resources Canada, 2020).*
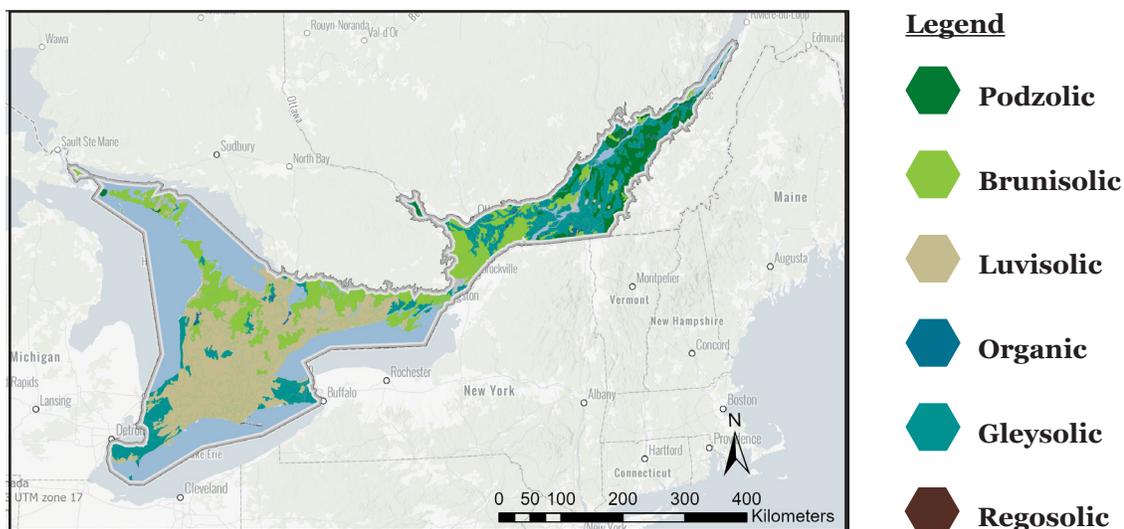
SOIL GREAT GROUPS

Figure 4: *Soil types divided into ecosystem groups and soil order (data from Canadian System of Soil Classification) and the distribution of these soils in Southern Ontario–St. Lawrence (data from Canadian National Soil Database, 2021).*

Table 2: *Soil carbon stock (to 1m depth, including average and total carbon) for each soil order and ecosystem soil type in each of the Southern-Ontario–St. Lawrence regions (from Fig. 4) (data from Sothe et al., 2022).*

Soil type	Soil type coverage (ha)	Average soil carbon stock (1m depth; kg/m²)	Total carbon stock (kilotonnes)
FOREST SOIL	7,801,514	25.4	1,981,585
Podzolic (sandy/loamy soils; compact and brittle)	1,155,563	37.4	432,181
Brunisolic (less developed forest soils; faint horizons)	2,745,109	28.3	776,866
Luvisolic (loamy forest soils; compact and consolidated)	3,900,842	19.8	772,367
WETLAND SOIL	2,909,795	31	902,036
Organic (deep, carbon-rich soil; heavily saturated with water)	142,503	61.8	88,067
Gleysolic (prolonged water saturation; lack mineral-organic surface soils; very low organic carbon)	2,767,292	29.4	813,584
UNDEVELOPED **Regosol** (no distinguishable soil layers; mineral-rich and highly varied)	11,231	58.4	6,558.90

ECOSYSTEM SPOTLIGHT

Carolinian forests and Crawford Lake

Mild climate, long growing seasons and fertile soils support diverse flora species found throughout southeastern Ontario.

In this forest lies a unique open-water habitat called Crawford Lake, whose lake sediments have been recording the changes to the Carolinian forests for thousands of years.

These sediments contain a chronological record of environmental impacts of industrial pollutants, including evidence of rising greenhouse gas levels in the atmosphere.

It's a standing a remnant of a vast forest and a critical scientific study site.

© ROM (Royal Ontario Museum)

DESIGNING A PROJECT

Designing your project depends on your goals. For more information on designing a project, please refer to the guide "Carbon Measurement: Sampling Design," in WWF-Canada's Carbon Measurement Learning Library, which includes information on:

A) **Sample allocation (how many samples are needed)**, which depends on how big the area of interest is and the degree of accuracy you wish to achieve in your estimates.

B) **Sample distribution (where to take your samples)**, which can be achieved using a statistically rigorous sampling approach (i.e., random, systematic or stratified-random), or by convenience, depending on your project goals. Be sure to consider the ecosystems and soil types where you are sampling (Fig. 4), as they may affect the anticipated carbon stock (Table 2).

Convenience sampling

Systematic sampling

Stratified-random sampling
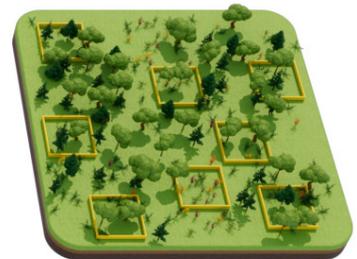
Random sampling

In addition to the sampling design resources, Table 3 (see Appendix) summarizes relevant carbon measurement protocols for the Southern Ontario–St. Lawrence region for communities interested in participating in larger-scale projects, and points to the federal and international standards associated with forest carbon monitoring projects.

2 MEASURING CARBON STOCKS

To estimate the carbon stock in ecosystems, you'll need to survey and collect samples from different carbon pools, including soils, biomass, or both. If you aim to measure multiple carbon pools in the same area, you can use an "integrated plot design." This means setting up overlapping plots.

Here's how it works:

A) **Create separate plots** for large vegetation, medium vegetation, small vegetation and soil carbon with the same centre mark, such that the plots are overlapping (Fig. 5).

B) **Collect data** for each carbon pool within their respective plots. Consider the order in which the carbon pools are sampled; to avoid damaging samples, the order is usually small vegetation → medium vegetation → large vegetation → soils. This ensures no samples are damaged from another sampling method.

C) **Extrapolate values to the study area and add them up to obtain** the total ecosystem carbon stock of a study area.
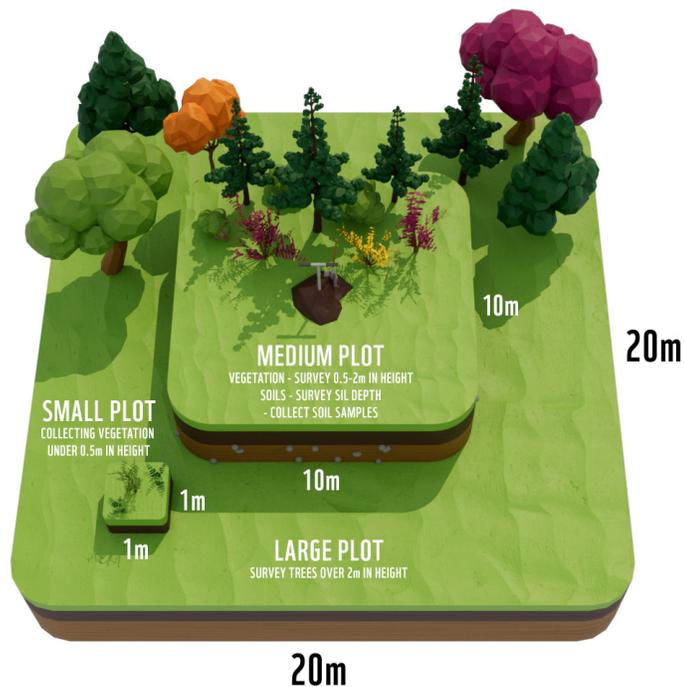
Figure 5: *Integrated plot design where soils are sampled alongside the three vegetation types, within their respective large, medium and small plots.*

MEASURING CARBON STOCKS IN VEGETATION

Carbon measurement of vegetation involves categorizing plants based on their heights in three groups:

A)   **Large vegetation** (trees): plants over 2m in height.

B)   **Medium vegetation** (shrubs and short-statured trees): plants that range from 0.5 to 2m in height.

C)   **Small vegetation** (ground vegetation): plants that are under 0.5m in height.

SETTING UP THE PLOTS

For each plot:
- **Record** the **date, location, plot ID, latitude, longitude** and **elevation** of the plot centre.

- For large and medium plots:
  - Mark out the border of your plots using a compass, laser rangefinder and measuring tapes, marking the trees on the border with flagging tape.
  - Using a laser rangefinder, **measure** and **record slope** in both the north-south and east-west directions.

- For small plots:
  - Mark out your plots using a compass and 1m-by-1m quadrat.

If additional sampling is being conducted within the same plot (e.g., measurements of soil carbon or other biomass), be sure to avoid disturbing these sample locations.

SOUTH ➡ NORTH

WEST ➡ EAST

COLLECTING VEGETATION DATA

LARGE VEGETATION PLOTS (trees)

- In a systematic way (such as flagging each tree before surveys), choose a tree to measure and identify the species. **Record** the **tree ID** and **species name**.

- Measure the tree diameter at breast height (DBH). **Record** the **DBH (cm)** in a notebook or datasheet.

- Measure the tree height using a laser rangefinder. **Record** the **tree height (m)**.

- Repeat this for all trees in your plot.

- Input data into the accompanying datasheets found on WWF-Canada's Carbon Measurement Learning Library to calculate the carbon mass of each tree.
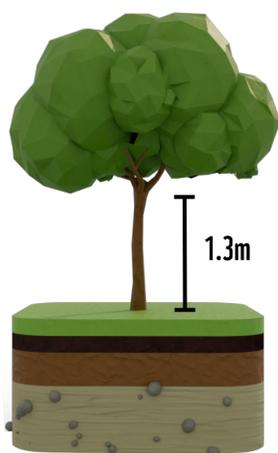
TREE HEIGHT REQUIRES THREE MEASUREMENTS

1.3m
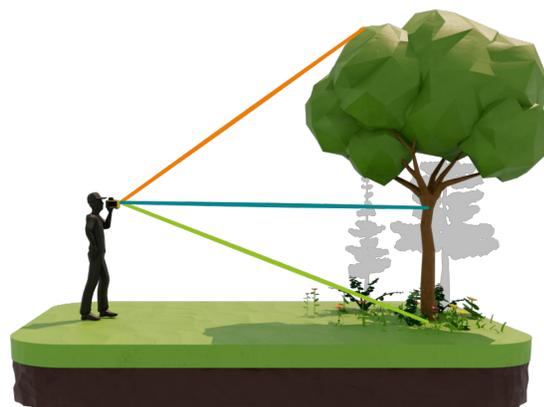
1 YOUR DISTANCE FROM THE TREE (IN METRES)

2 ANGLE TO THE TREE TOP

3 ANGLE TO THE TREE BASE

MEDIUM VEGETATION PLOTS
(trees and vegetation)

0.5-2m

- Using a systematic method (such as flagging all plants 0.5–2m in height before surveys), identify each plant.

- **Record** the **unique species ID** and **species name**. Another option is to take a photo of the plant components for later identification in the lab.

- If the species is a **short-statured tree**, measure the tree diameter (cm) of the stem at 0.3m in height (diameter at stem height, or DSH) and record this value in a notebook.

- If the species is a **shrub** or **herbaceous plant**, measure the plant's volume (m³) instead of its diameter:
  - Measure the height (m) of the plant.
  - Measure the width (m) of the plant (east-west direction).
  - Measure the length (m) of the plant (north-south direction).

- **Record** these values in a notebook.

- **Upload** the data to the accompanying datasheets found on WWF-Canada's Carbon Measurement Learning Library, which will automatically calculate the carbon stock value for each plant.
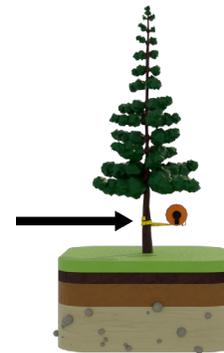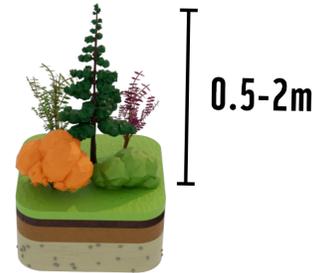
SMALL VEGETATION PLOTS

- Take a photo of the entire plot from directly above the quadrat. **Record** the **photo ID** and **plot ID**.
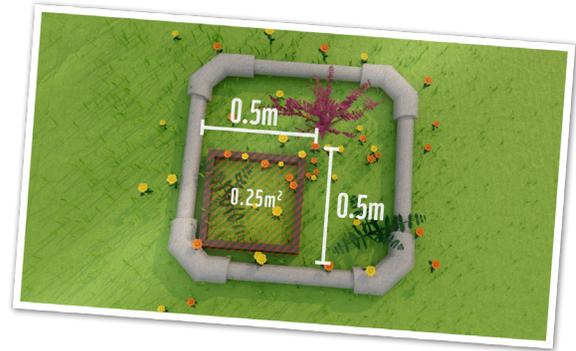
- Section off one quarter of the plot by using a 0.25m² quadrat or a circle with a radius of 0.28m (0.25m²).

LESS THAN 0.5m

- Within this 0.25m² area, clip all vegetation under 0.5m at 3cm above the ground. Place each unique species clipping into its own resealable bag labelled with a unique plot ID, species name and date.
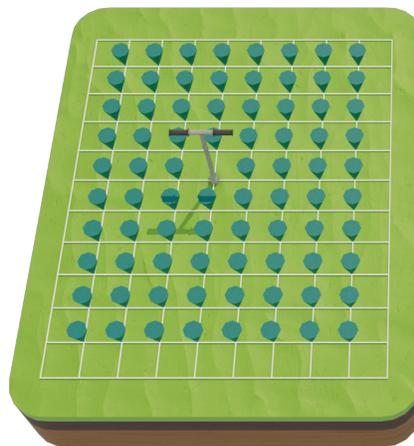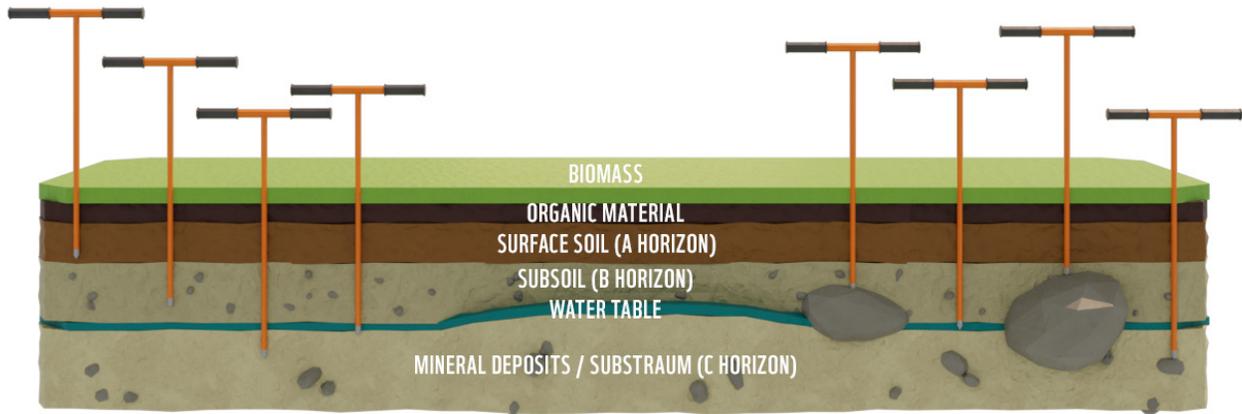

3 cm

MEASURING CARBON IN SOILS AND SEDIMENTS

EQUIPMENT NEEDS AND APPROPRIATE SAMPLING METHODS

The equipment and methods for collecting soil samples depends on the water content and condition of the soil. Across Southern Ontario–St. Lawrence, soil conditions vary from well-drained, dry soils, with shallow layers of organic matter and topsoil in upland areas, to poorly-drained, wet soils with more organic materials in lowland areas that may be saturated.

Use a soil probing tool to measure the depth of the soil at regular intervals (every 10-100m) in a grid pattern across the study sites. The number of sample points depends on the size of the site, but there should be enough soil depth measurements to cover the variation across the study site.

BIOMASS

ORGANIC MATERIAL

SURFACE SOIL (A HORIZON)

SUBSOIL (B HORIZON)

WATER TABLE

MINERAL DEPOSITS / SUBSTRAUM (C HORIZON)

Example survey grid, where at each dot a measurement of peat depth is taken and recorded. This information is used to understand the variation in peat depths across the site, which will help to ensure sampling is effective.

MEASURING CARBON STOCKS

Based on your investigations, plots can be mapped out within each site to capture the variability in soil depths across the study site. The larger the site and the more variation in soil depth, the more plots you'll need. Here is a basic plot design for setting up study plots:

Step 1: Establish plots within the site to capture the variation in soil depth.

Step 2: Survey every 1m-by-1m within a 10m-by-10m plot to ensure the coring/sampling locations are representative of the plot area.

PREPARE THE SITE

- **Record** the **Core ID**. For example, PE-01-B represents "location-site-sample number."

- **Record** the **latitude**, **longitude** and **elevation** of the coring site.

- **Document the vegetation** of the coring site using a 14-photo series protocol by taking photos from the coring site that capture views pointing:
  - straight up (canopy)
  - straight down (vegetation)
  - for all cardinal directions: one parallel with the ground; one 45 degrees up; and one 45 degrees down

- Find a flat area close to the coring spot, lay down a tarp and prepare the required equipment.
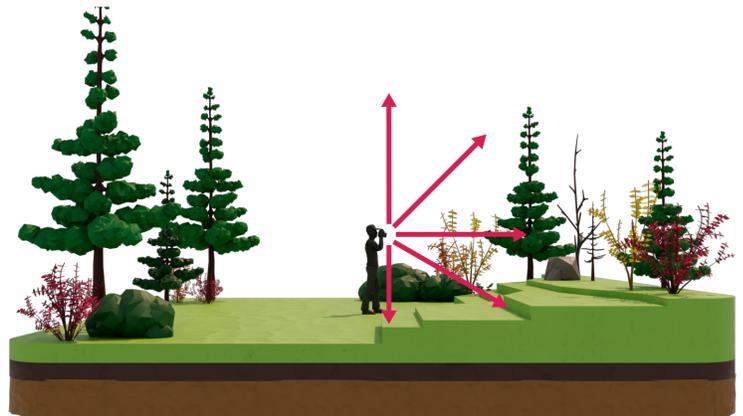
14 PHOTOS

3 PHOTOS FOR EACH CARDINAL DIRECTION

1 DOCUMENTING VEGETATION

1 DOCUMENTING CANOPY COVER

COLLECTING SOIL SAMPLES

## COLLECTING SOIL SAMPLES IN FOREST AND AGROECOSYSTEMS

Forests and agricultural ecosystems in Southern Ontario–St. Lawrence have diverse soil properties, supporting both natural and anthropogenic areas. Former wetland and forests have been converted to croplands; however, the legacy of these habitats persists in areas unaffected by external forces.

Here are two recommended methods for collecting soil samples in this region:

1. **Soil coring:** Use this method in areas where the soil is softer, holds together well, and has noticeable layers of organic matter or topsoil.
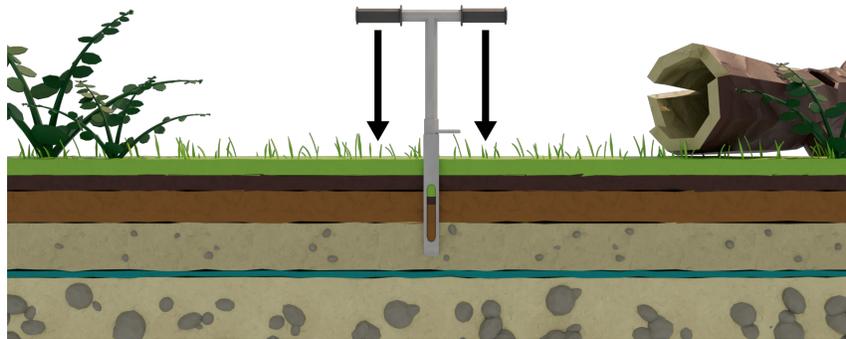
2. **Soil pit digging:** Use this method if the soil is too hard and/or too loosely packed (i.e., breaks apart easily) for soil coring.
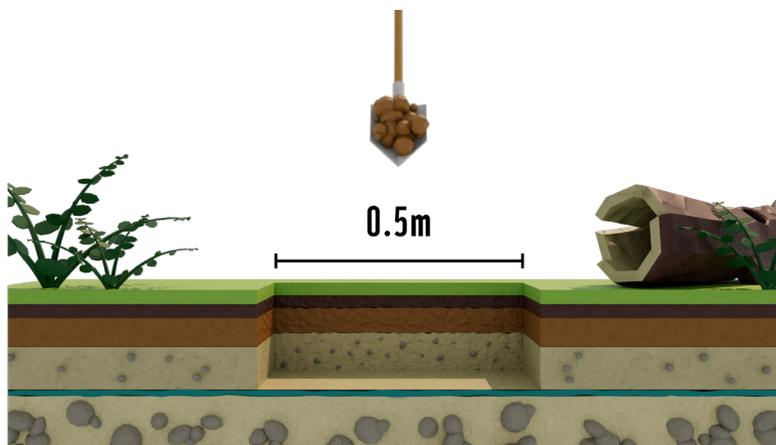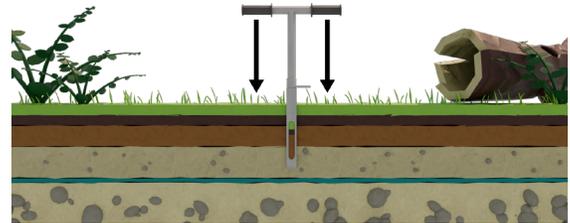

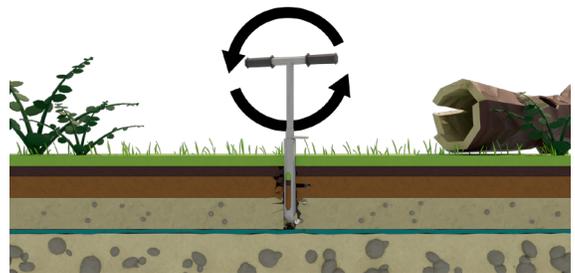**NOTE**: In some situations, it may be practical to use both methods.

METHOD 1 – SOIL CORING

1. Gently push the corer into the soil, keeping it as straight as possible.
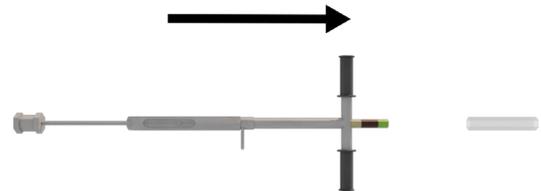
2. With the corer fully inserted, twist and jiggle the corer to release the bottom part of the core sample from the base sediment.

3. Remove the corer with the sample inside. Keep pressure on the bottom of the corer to prevent the sample from falling out.

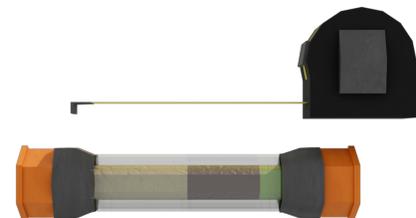4. Turn the corer horizontally and place a plastic core sleeve around it.

5. Use a core extraction tool to push the core out of the corer into the sleeve. Place the appropriate end caps on the top and bottom of the core tube and secure it with tape.

6. Measure and **record** the **core length** and the **depth of the hole**.
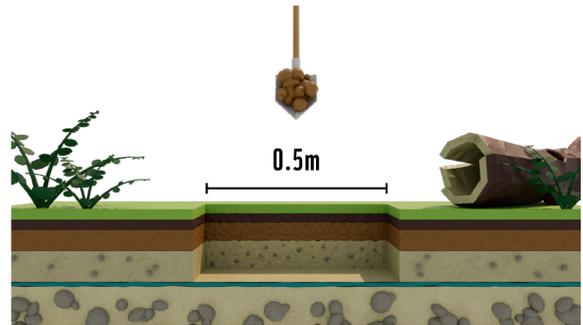
7. Label the sample and place it in a cooler.

METHOD 2 – DIGGING SOIL PITS

1. At the selected site, dig a hole 0.5m wide and to the desired sampling depth.

2. For each soil layer, **record** the **depth interval**, **colour** and **texture**.

Example:

10cm | dark brown | loam

15cm | red brown | clay loam

25cm | light brown | silt

3. Label resealable bags with a unique Core ID and sample depth interval for each layer.

4. With a soil sampling ring/bulk density disk, obtain a sample from the middle of each of the soil layers and transfer each of the samples to its respective labelled bag.

5. **Note:** Additional samples from each layer can be collected and transferred to a separate bag.
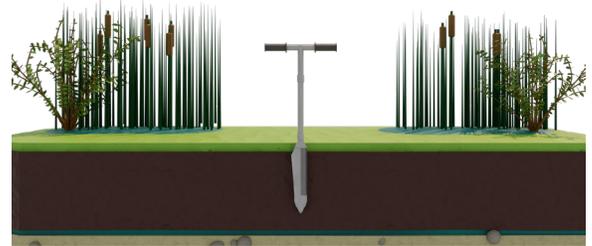
6. Place samples in a cooler.

COLLECTING SAMPLES IN WETLAND SOILS

If the soil is heavily saturated by water, such as in a bog, fen or swamp ecosystem, then the soil will be too unconsolidated to use an open soil corer and the water level will be too high to dig a soil pit. Therefore, specialized sampling tools are required. A tool called a Macaulay peat corer is recommended to extract soil samples from wetlands.

STEP 1:
EXTRACT A CORE SAMPLE

- With the corer in the "open" position, align the corer as straight as possible in the coring spot and push it into the ground.

MARK THE DEPTH ON THE CORER WITH DUCT TAPE

DO NOT PUSH THE CORER ANY DEEPER THAN THE DESIRED SAMPLE DEPTH

- Continue pushing the corer into the ground to its desired depth, which can be marked with tape on the corer itself.
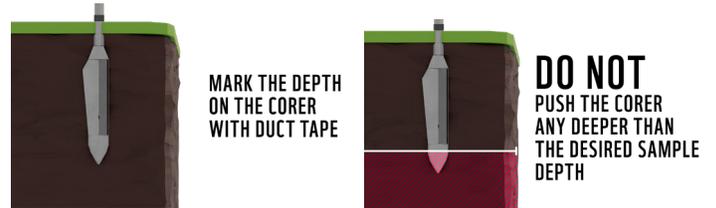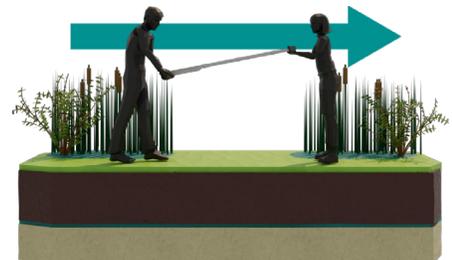

- Turn the corer handle 180 degrees into its "closed" position.

- Lift the corer out of the ground, clasping the barrel and the guard together as it is pulled from the ground.

- Turn the corer horizontally with the core barrel facing upwards and transport to the processing area.

STEP 2:
REVEAL THE CORE

- Lay the corer flat on the tarp with the barrel facing upwards.

- Keeping the sample inside the corer facing upwards, reveal the core by opening the guard and turning the corer. Lay the corer back on the tarp with the sample exposed.

- Record the:
  - **core length (cm)**
  - any transitions in **soil colour** or **texture**
  - any visibly **large materials**
  - **gaps** in the sample
  - **water saturation** (mucky, semi-saturated, dry, etc.)
  - label poster board and PVC-pipe cutouts (see Step 3 below) "top" and "bottom"

STEP 3:
PACKAGE THE CORE

- Line the PVC pipe with aluminum foil and plastic wrap.

- Place the PVC pipe over the core, with the top (closest to the surface) and bottom label in the appropriate position.

- Flip the corer and PVC pipe over so that the core sample falls inside the PVC pipe. Use a knife to separate the sample from the corer if needed.

- Wrap the sample in plastic wrap and aluminum foil.

- Place a piece of poster board over the sample, ensuring the "top" and "bottom" labels are in the right position, and secure it with duct tape.

- Transport the sample to a cooler for short-term storage.

- Wash the corer and tools before taking another core sample.

COLLECTING SEDIMENT CORES IN COASTAL ECOSYSTEMS

Although this region does not contain an oceanic coastline, there is a bounty of freshwater wetlands forming in the transition zones between terrestrial and aquatic systems. A mix of freshwater marshes and swamps line the rivers and lakes of this region, and these systems typically contain large carbon stocks in their mineral sediments. To measure the carbon in these ecosystems, consider the PVC-corer method outlined below.

STEP 1:
PREPARE THE SITE

In a notebook or datasheet, **record**:
- date and time
- site conditions
- weather
- tidal conditions (if applicable)

STEP 2:
INSERT THE CORER

- Align the corer in the coring spot and push it into the ground.
- Place a piece of lumber over the corer and hammer the PVC-tube into the ground to the desired depth.
- Measure core compaction by taking two measurements and **record them in a notebook**:
  - outside of the core from top of corer to the ground surface
  - inside of the core from the top of corer to the top of the core

STEP 3:
EXTRACT THE CORE

- Release the core from the suction of surrounding sediment by digging around the core or gently rocking the PVC pipe.
- Once the bottom of the core is revealed, place an end cap on the bottom of the core.
- Keep the core in an upright position while transporting the core to the processing location.

STEP 4:
SECTION AND PACKAGE THE CORE

- Place the core in position over the core-extruding device.
- Place the PVC collar in position at the top of the corer and push the PVC tube downward so that the sediment appears at the top. Keep pushing until the sediment is in line with the top of the PVC collar.
- Cut between the PVC collar and the top of the corer to slice off a subsection (i.e., the sample).
- Place the cut sample in a resealable bag, and **record the sample name and depth**.

* For field datasheets specific for each method, please find the accompanying materials in WWF-Canada's Carbon Measurement Learning Library.
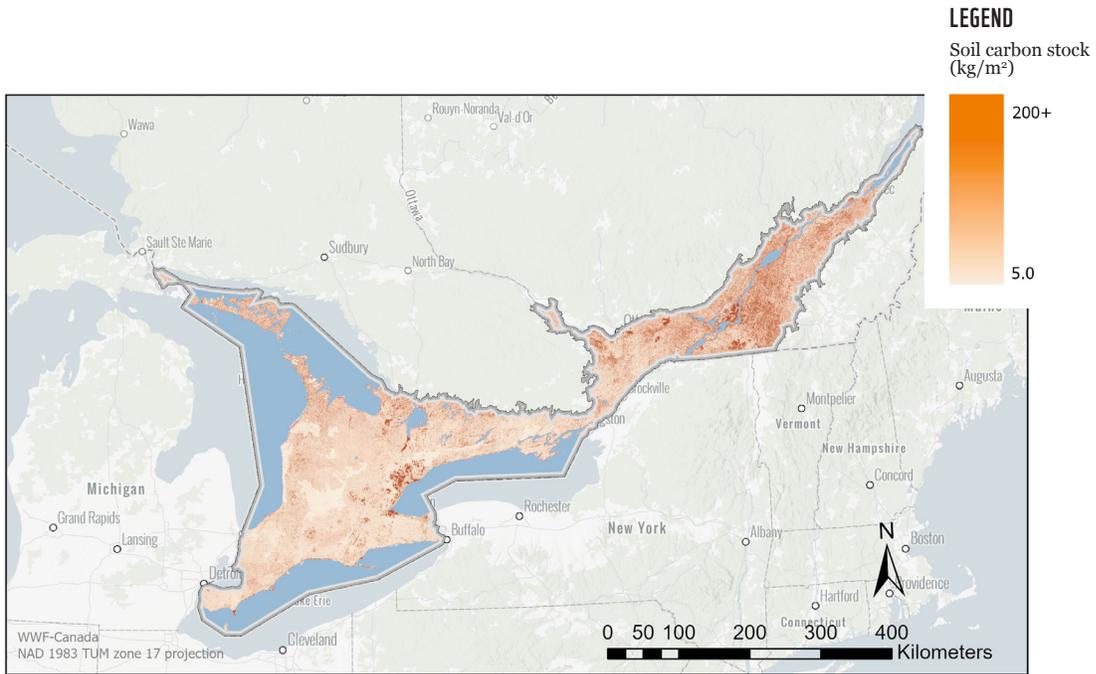
Figure 6: *Soil carbon stock (to 1m depth; kg/m²) for Southern Ontario–St. Lawrence (data from Sothe et al., 2022).*
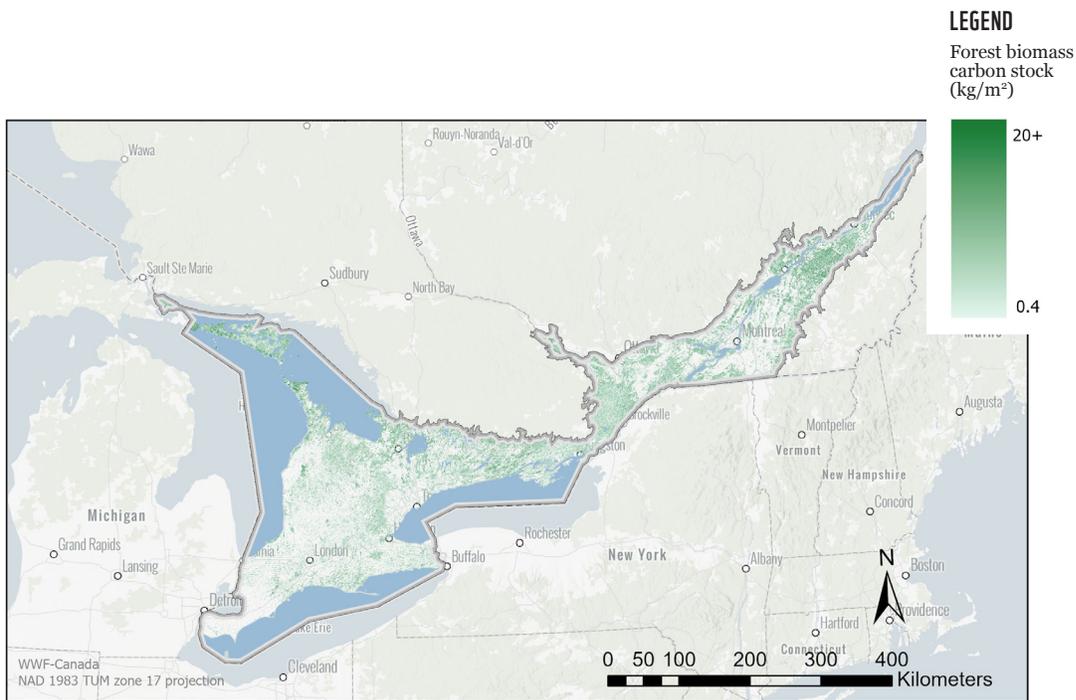

Figure 7: *Forest biomass (above-ground biomass, below-ground biomass and down-woody biomass) carbon stock (kg/m²) for Southern Ontario–St. Lawrence (data from Sothe et al., 2022).*

APPENDIX

Table 3: *Examples of protocols, programs and plans that may be relevant to carbon measurement and monitoring in forests and managed lands of Southern Ontario–St. Lawrence. These systems involve a mix of government and non-governmental organizations, with projects ranging from local community land management projects to global climate agreements. They work together to ensure consistency and reliability in carbon measurements across different scales.*

LEVEL OF GOVERNANCE	NAME OF ORGANIZATION	RELEVANT PROJECTS	SUMMARY
International (global)	Intergovernmental Panel on Climate Change (IPCC) Verra (verified carbon standard, MRV)	Sixth Assessment Report (Agriculture, Forestry, and Other Land Uses (AFOLU)) Methodology for Improved Forest Management Using Dynamic Matched Baselines from National Forest Inventories, v1.1	International guidelines of managed lands for the benefit of biodiversity and climate mitigation Carbon crediting system with published carbon monitoring protocols in conformity with monitoring, reporting and verification (MRV) systems
National (Canada)	Canadian Council of Forest Ministers (CCFM) Environment and Climate Change Canada (ECCC)	National Forest Information System (NFIS) National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS) ECCC reports NFCMARS to IPCC under Agriculture, Forest, and Other Lands Uses (AFOLU) within the Greenhouse gas national inventory report	Ground observations, aerial surveys and carbon budget models to estimate carbon in Canada's forests (soils and vegetation) Reports greenhouse fluxes in Canada's managed forests and utilizes field observations and carbon budget modelling tools Values are incorporated in the AFOLU report which the ECCC compiles and reports yearly to the IPCC
Provincial (Ontario and Quebec)	Government of Ontario, Ministry of the Environment and Climate Change Government of Quebec Department of Agriculture, Environment and Natural Resources	Ontario's Climate Change Action Plan "Agriculture, forests and lands: Productive, sustainable, and a pathway to creating offsets" Government of Quebec's Plan for a Green Economy	Provincial legislation under Bill 198 "Ontario Climate Change Adaptation and Resilience Act, 2024" to address greenhouse gas balance of the province Provincial framework to reduce the province's net greenhouse gas balance and adapt to climate change through the management of forests and other land-use areas

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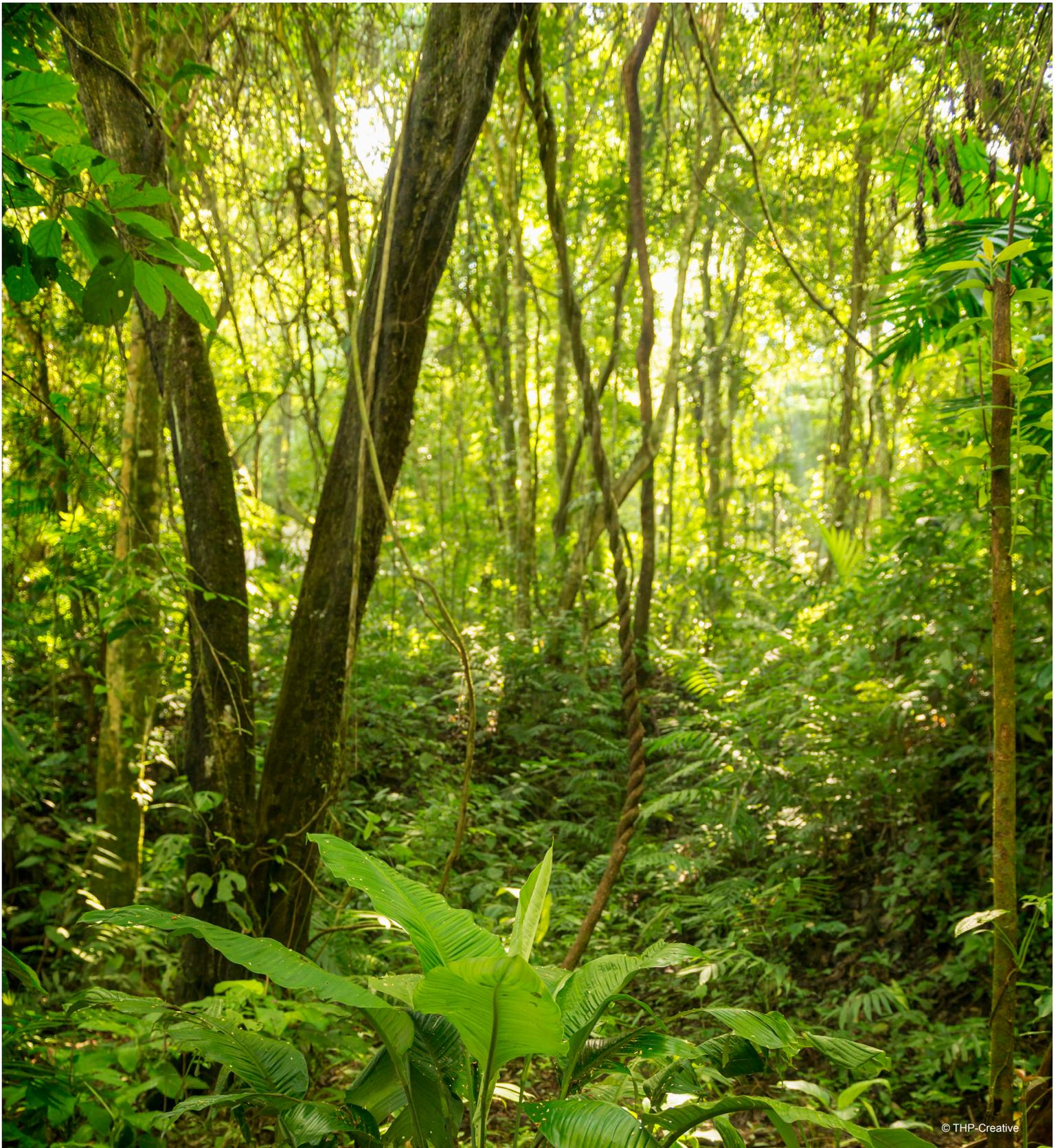
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