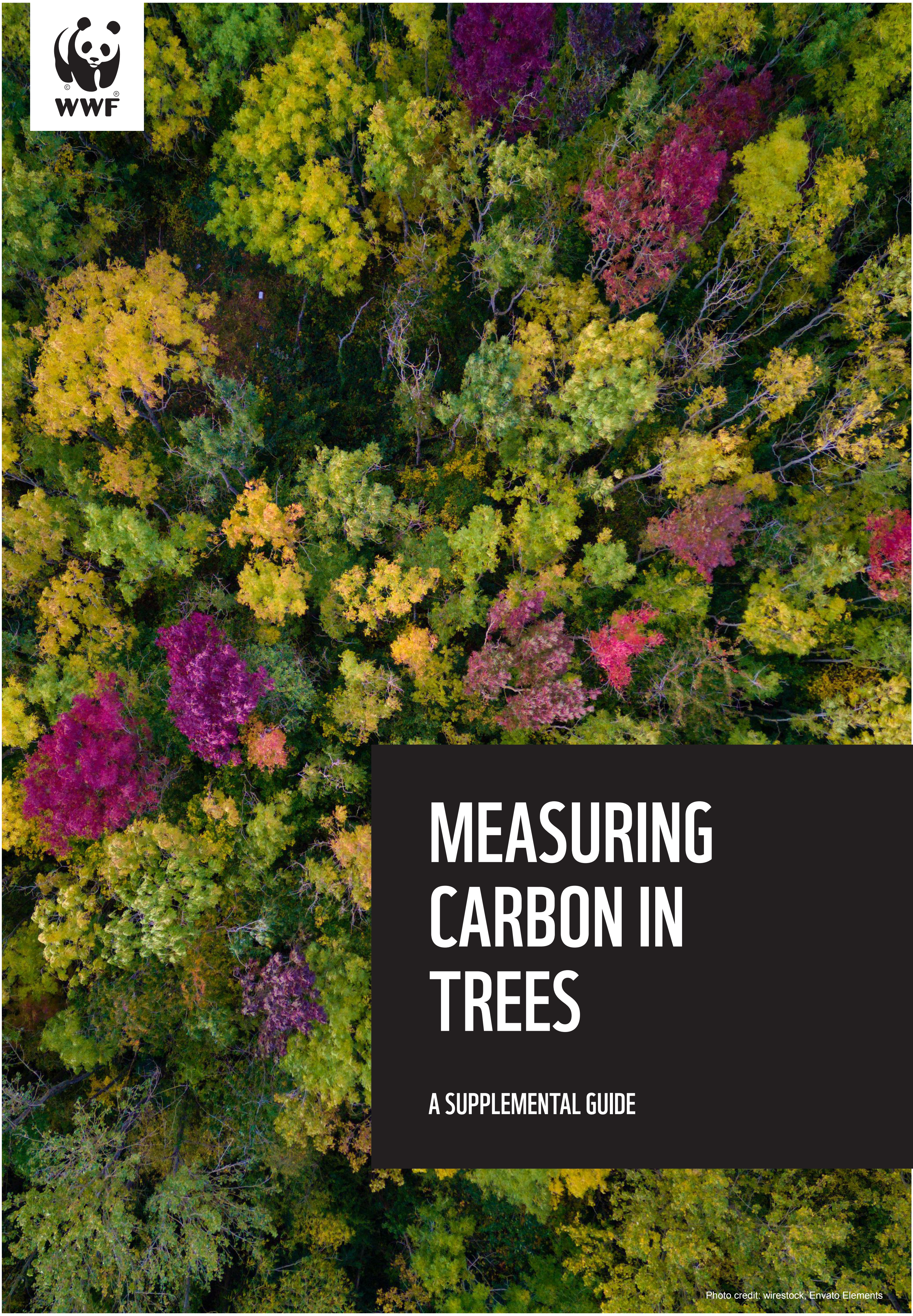


MEASURING CARBON IN TREES

A SUPPLEMENTAL GUIDE

Photo credit: wirestock, Envato Elements

Photo credit: Evan Holt

CONTENTS

1

SITE SELECTION AND EQUIPMENT

INTRODUCTION

Across Canada, forest biomass is estimated to store 21 billion tonnes of carbon. This carbon is absorbed primarily by woody vegetation through photosynthesis. Forests also provide other essential ecosystem services, such as climate regulation, flood abatement and water filtration.

Quantifying our forests' ability to store carbon is key to understanding how to protect and restore them. A common method of quantifying the carbon stock of a forest is to do tree surveys, where a subset of trees in a study area is identified and measured.

In this guide and its corresponding video, we demonstrate how to establish study areas to systematically survey trees in a forested landscape, including how to conduct in-field measurements. We will also describe how to convert this tree survey data into values of forest carbon. Please note that the guidelines presented here are best suited to small projects (e.g., <50 hectares).

SITE SELECTION

Before conducting tree surveys, it is important to think about site selection: where plots are to be set up, how many plots are needed and what materials are required. It's also important to consider the types of analyses being performed on the data. This will largely depend on the research questions, the logistical challenges and the available budget.

STUDY AREA

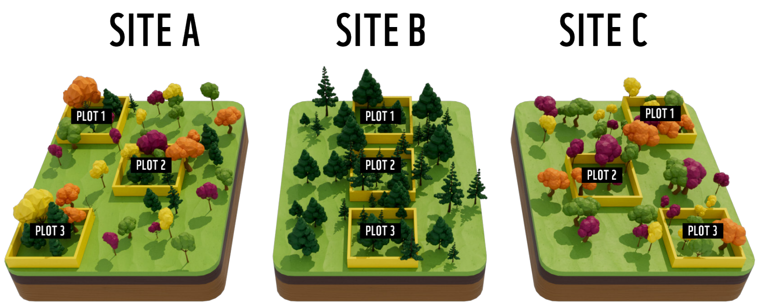
THE ENTIRE AREA THAT YOU WISH TO INVESTIGATE

The **study area** encompasses the entire area to be investigated. Within this large area, specific, smaller **study sites** are identified to capture the variation of the area. Sites can be distinguished by changes in vegetation cover, elevation, ecosystem type or other geographical features that may vary across the study area.

STUDY SITES

1-5 PLOTS PER SITE

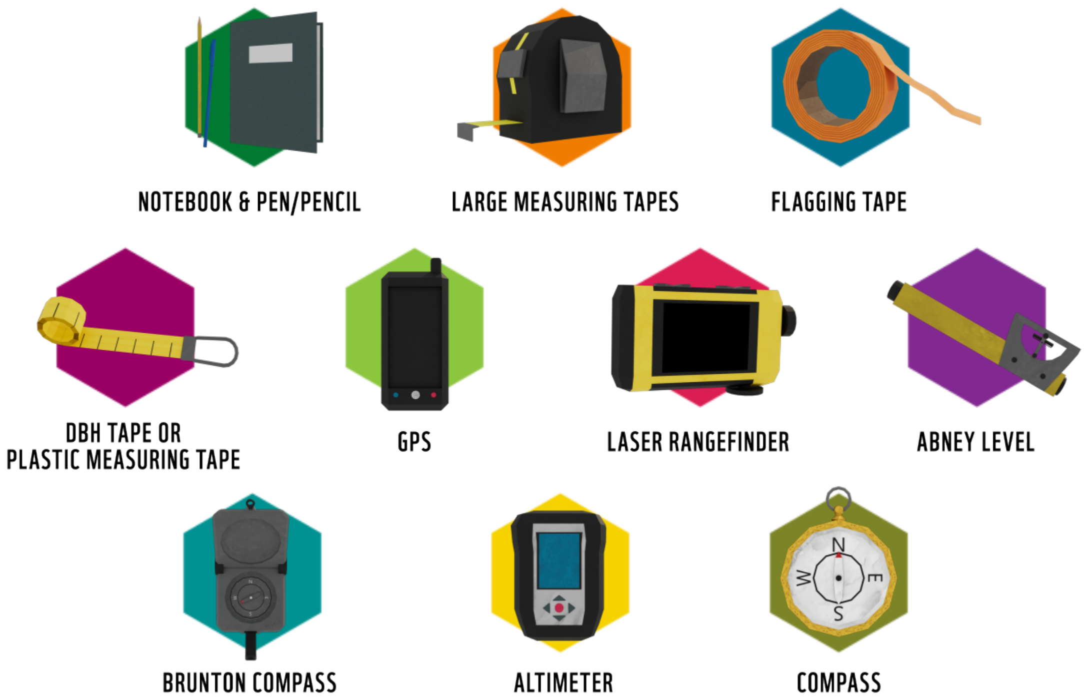
To sample within each site, **plots** are laid out to obtain a representative sample of the entire site. It is within these plots that vegetation will be surveyed. Within each site, one to five plots can be established, depending on the nature of the site. For instance, larger projects (e.g., >10,000ha) may require 12-15 permanent plots per site, with five to ten sites per study area — though the exact number depends on the variability and the size of the site. The more natural variation that exists across a site, the more plots that are required. The layout of the plots might also differ. If the sites exist along a slope, a linear or stratified plot layout is recommended. Otherwise, a random, or scattered, plot layout is best.



In the above example of a study area, Sites A and C show a scattered plot layout, while Site B shows a linear plot layout.

Once the study area, sites and plot locations have been defined, tree data collection can begin.

HERE'S WHAT YOU'LL NEED:



2

PLOT AND SAMPLING DESIGN

SETTING UP PERMANENT SAMPLE PLOTS

PSPs are a type of plot used to monitor an area of forest over time. Monitoring activities in PSPs include collecting measurements to determine carbon stock and sequestration. The goals for each carbon monitoring project will determine if PSPs should be used.

The location of PSPs should capture the variation within the forest study area being monitored (changes in elevation, edge effects, topographic features, etc.). As a result, the PSP will not be representative of the entire study area.

Once the site locations are chosen, the plot centre can be marked with a metal stake and sign indicating a unique plot identifier and coordinates for future reference. Access to each PSP should also be documented through notes and logged waypoints. Additional permanent signage may aid in the location of PSPs in the future.

With the plot centre documented, follow the steps in the next section of this guide to finish setting up the plot. PSPs require that numbered tags be nailed into each tree with a DBH measuring 9 centimetres (cm) or greater. Nail the tags at 1.3 metres (m) from the ground, leaving room for radial growth. These metal tags will ensure the correct identification of trees belonging to the PSP in future years.

For additional guidance on tagging, refer to Canada's National Forest Inventory Ground Sampling Guidelines. These guidelines will be especially useful if monitoring other metrics in PSPs.

Individual plots can be set up as squares, rectangles or circles, depending on the landscape, research question and tools available.

STEP-BY-STEP PROCESS TO SET UP THE PLOT

1. Obtain GPS coordinates for the longitude, latitude and elevation of the plot centre.
2. Using a laser rangefinder, measure out the border of the plot:
   a. Circular plots should have a radius of 11.28m. For circular plots, have someone hold the measuring tape at the plot centre. Measure outwards by 11.28m and walk in a circle around the centre point. While walking, use flagging tape to mark which trees along the plot border* fall inside the plot.
   b. Linear plots are square, with dimensions of 20 by 20m, or rectangular, with dimensions of 10 by 40m. For square and rectangular plots, one person will stand along each side of the perimeter to measure and direct another person to place flagging tape or markers accordingly at each corner. While walking, use flagging tape to mark which trees along the border fall inside the plot. Note that all plots following these dimensions will have an area of $400m^2$ and are termed "large vegetation plots."

*__Note:__ If a tree lies right on the border line, its inclusion in the plot depends on whether the centre point of the tree is within the border. If the tree is branching or split, find the centre point below where the branching or split occurs.

CIRCULAR PLOTS

MEASURE

11.28m

FROM THE CENTRE

SQUARE PLOTS

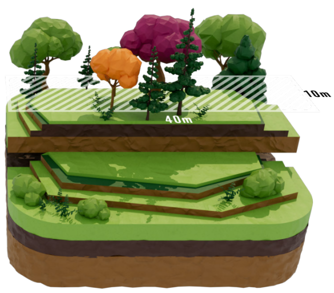
MEASURE

20m x 20m

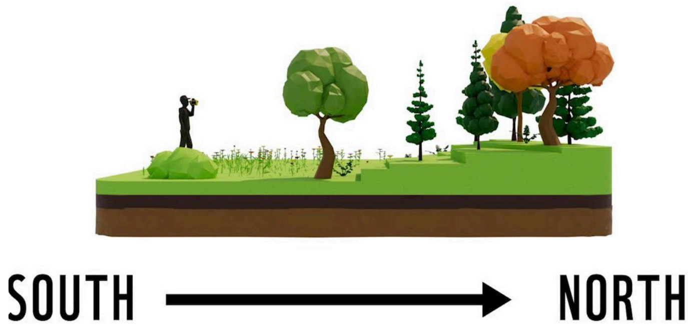
RECTANGULAR PLOTS

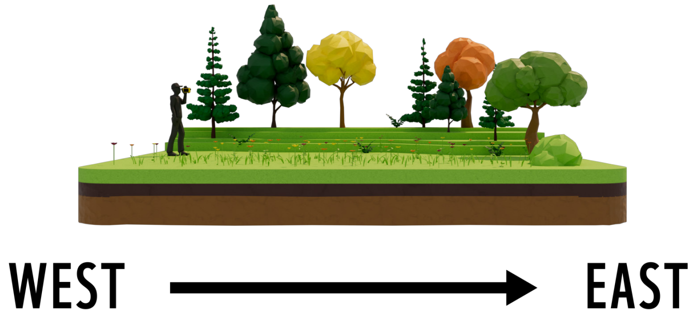
MEASURE

10m x 40m



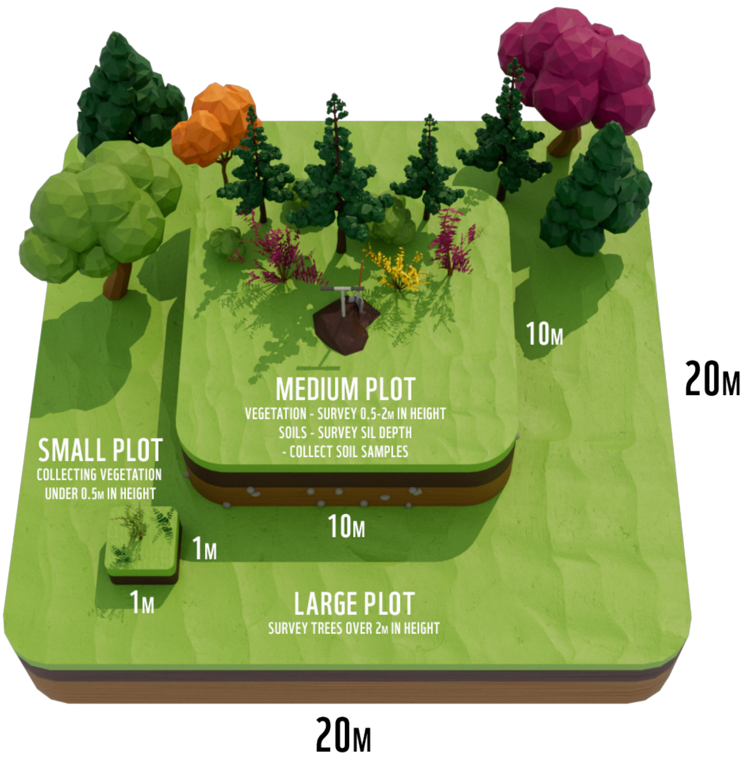
3. If a compass is available, align the width of the plot along the east/west axis, and align the length of the plot along the north/south axis.
4. With a laser rangefinder, stand on the south side of the plot and aim north to obtain the slope of the plot. Record this angle in a notebook.
5. Next, stand on the west side of the plot and aim east, measuring the slope of the plot from this direction. Record this angle in a notebook.





The team might be interested in sampling multiple carbon pools (e.g., sampling for trees, small vegetation and soils) from the same area. One method of accomplishing this is to use a nested/integrated plot design. This means setting up plots for each carbon pool that overlaps in a study area.

Nested/integrated plot design involves mapping out plots for large vegetation, medium vegetation, small vegetation and soil carbon before beginning sampling. In PSPs, where carbon monitoring surveys are going to be repeated at the same location over multiple years, ensure that soil carbon samples and any other "destructive" sampling techniques are being completed outside of plot areas where non-destructive sampling takes place (e.g., vegetation plots; see the document "Supplemental Guide: Sampling Design," in the online Learning Library). Peat sampling is a destructive sampling technique; as a result, vegetation surveys must be completed before soil samples are collected in all plot types.



SECTION SUMMARY: PLOT AND SAMPLING DESIGN

- **Record the date, location, plot ID, latitude, longitude and elevation of the plot centre.**
- **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 the slope in both the north-south and east-west directions.**
- **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.**

EXAMPLE DATA SHEET:

Data Sheet for Large Vegetation Tree Surveys

Plot Description		Notes:
Date:	17/01/2024	
Location:	Peawanuk	
Plot ID:	PE - S2 - P3	
Longitude:	85°29'13.1"W	
Latitude:	54°59'18.9"N	
Elevation (m above sea level):	125m	
Plot shape:	square	
S-N inclination:	+6.4 degrees	
E-W inclination:	-3.5 degrees	

Survey Data		Tree Species Identification	Tree Measurements	
Plot ID	Tree ID	Tree Species Common Name	Diameter at Breast Height (DBH, cm)	Tree Height (m)
PE - S2 - P3	1	Deciduous	5	5
PE - S2 - P3	2	Conifers	5	5
PE - S2 - P3	3	All	5	5
PE - S2 - P3	4	Balsam fir	5	5
PE - S2 - P3	5	Balsam poplar	5	5
PE - S2 - P3	6	Basswood	5	5
PE - S2 - P3	7	American beech	5	5
PE - S2 - P3	8	Black ash	5	5
PE - S2 - P3	9	Black spruce	5	5
PE - S2 - P3	10	Douglas fir	5	5
PE - S2 - P3	11	Eastern hemlock	5	5

3

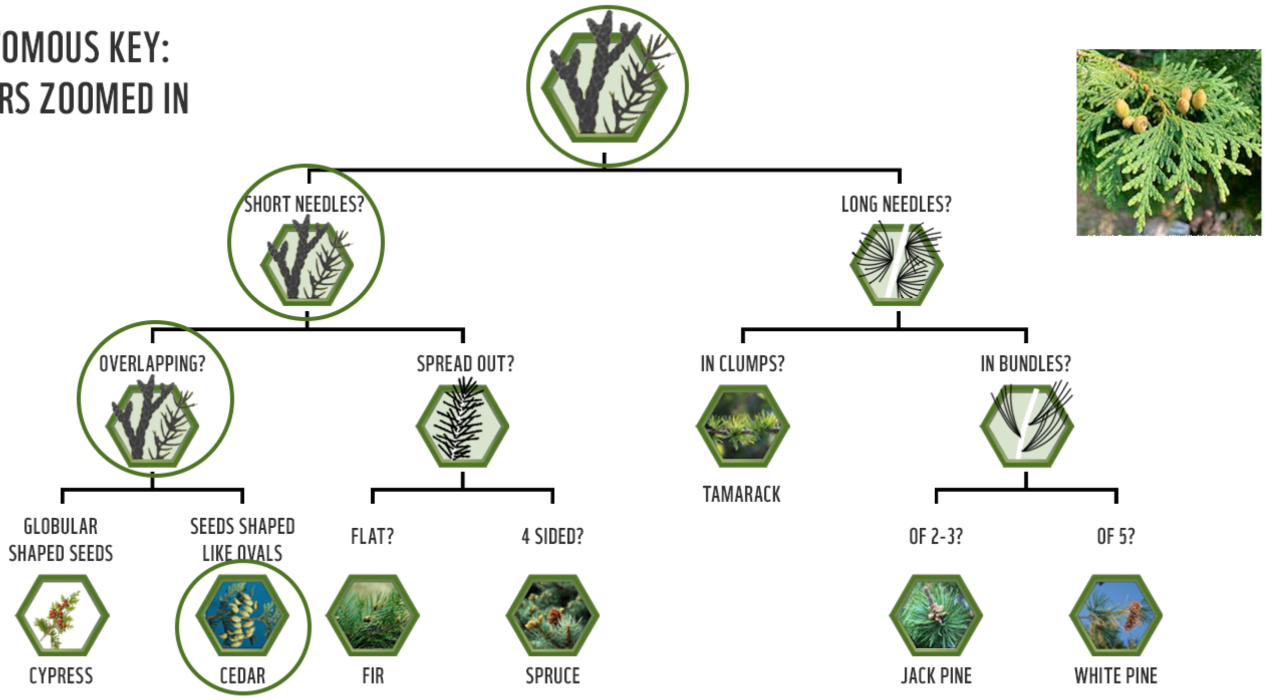
TREE IDENTIFICATION AND MEASUREMENTS

TREE IDENTIFICATION AND MEASUREMENTS

Each study area supports unique tree communities made up of different species, which will need to be identified. If unsure of the tree species, use a dichotomous key or mobile application to help. A dichotomous key (meaning to “divide into parts”) is a method of identifying an organism based on the species’ observable traits. The method requires answering a series of statements with one of two options. Together, the statement answers lead to the correct species identification. For trees, these statements use unique properties of individuals and groups of species that can easily be identified, such as leaf shape, bark colour and branching pattern.

It also helps to become familiar with the local plant communities before doing surveys, as species identification can initially be tedious. Some mobile applications are designed to recognize various tree attributes that can help with species identification. Some mobile applications are Google Lens, LeafSnap, vTree and Seek by iNaturalist. There are several online resources available to find this information for each area.

DICHOTOMOUS KEY: CONIFERS ZOOMED IN



Instead of identifying species in the field, the field team may instead choose to take well-documented photos of each species (including the leaf, branching structure, bark and any buds, flowers or seeds) for later identification. Make sure to record in a notebook a unique photo identifier (such as photo number) alongside the measurements of each plant measured.

The above image depicts a dichotomous key for common tree species found throughout Canada. Beginning at the top, a series of yes-or-no questions are followed in a “tree-like” manner, which leads to the next “branch” until we arrive at the species identification. Here, the answers for the species photo at the top right are highlighted by green circles. Following the key, the unknown species is determined to be “cedar.”

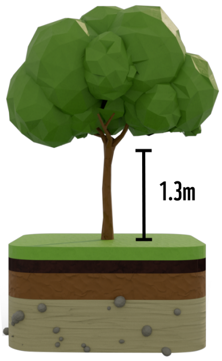
STEP-BY-STEP PROCESS TO MEASURE TREES

1. For each tree over 2m in height within the plot, identify the species.
   a. To keep track of trees, start by doing a lap around the plot, marking each tree over 2m in height with flagging tape. Remove the tape for each tree when measuring is complete to ensure trees are not counted twice.
2. Using a flexible measuring tape or DBH tape, measure the circumference in **centimetres** of each tree at 1.3m above ground height.
   a. This measurement is called the diameter at breast height, or DBH. A DBH tape is a measuring tape with values that convert the circumference of an object to its diameter.
   b. If a DBH tape is not available, use a regular tape measure to measure the tree's circumference and record in a notebook. Important: Once back in the lab, be sure to convert the circumference to diameter by dividing this value by pi (3.14).
3. Record the total height of the tree in metres using a laser rangefinder.
   a. Stand far enough away from the tree so that both the bottom and top of the tree are visible through the laser rangefinder.
   b. Measure the distance in metres and record this measurement in a notebook.
   c. Measure the angles while looking at the top and bottom of the tree.
   d. The laser rangefinder will automatically calculate the tree's height in metres.
   e. Record the tree height in metres in a notebook.
   f. Repeat this for all large vegetation greater than 2m in height within the plot.

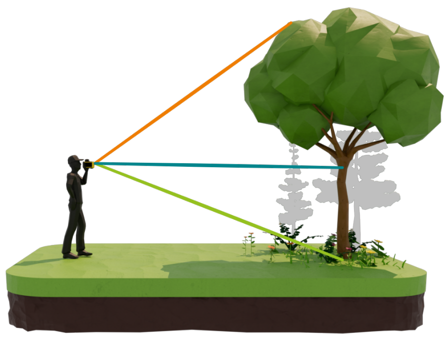
MEASURE THE TREE'S CIRCUMFERENCE AT

1.3m

ABOVE THE GROUND



TREE HEIGHT REQUIRES THREE MEASUREMENTS



1. YOUR DISTANCE FROM THE TREE (IN METRES)
2. ANGLE TO THE TREE TOP
3. ANGLE TO THE TREE BASE

SECTION SUMMARY: TREE IDENTIFICATION AND MEASUREMENTS

- **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 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 the plot.**

4

FROM IN-FIELD MEASUREMENTS TO CARBON STOCK

Species identification, diameter at breast height and total height for each tree can now be used to calculate the carbon stored in these trees. Converting the field measurements to carbon values is a two-part process, with each part containing multiple steps.

PART 1: CONVERT IN-FIELD MEASUREMENTS TO BIOMASS

1. Calculate the above-ground biomass (AGB) of each individual tree.
2. Calculate the below-ground biomass (BGB) for each individual tree.
3. Calculate total biomass (above-ground + below-ground) and convert it to carbon stock for each individual tree.

***Note that all the field data can be entered into the accompanying datasheet to automatically calculate the above-ground biomass, below-ground biomass and carbon stock for each tree. The methods for these calculations are as follows:**

ABOVE-GROUND BIOMASS

1. Calculate the above-ground biomass of each individual tree.

Please see the accompanying datasheet, which automatically calculates the carbon stock of the trees measured using the inputs for species ID, DBH and/or height. To do the calculations manually, follow the steps below.

First, calculate the above-ground biomass of each tree using the measurements collected and each species' publicly available carbon coefficients (see biomass calculator link below).

Calculations for these equations all follow the same format, where the measured diameter of the tree is converted to biomass for four components of the tree: wood, bark, foliage and branches.

Calculate biomass for the wood, bark, foliage and branches of each tree (i.e., do the calculation four times) and then add these values together to get total biomass. Note that this is done for each individual tree.

AGB (kg) of component i = B^{i1} $(DBH)^{Bi2}$ * $(height)^{Bi3}$

i = either wood, bark, foliage or branches

B^{i1}, B^{i2}, B^{i3} = measured coefficients for each species (*from Natural Resource Canada's biomass calculator)

DBH = in-field measurement (in centimetres)

Height = in-field measurement (in metres)

AGB of tree (kg) = AGB(wood) + AGB(bark) + AGB(foliage) + AGB(branches)

ABOVE-GROUND BIOMASS

Input tree measurements into the Natural Resource Canada biomass calculator to obtain biomass estimates.

2. Calculate the below-ground biomass for each individual tree.

Estimate below-ground biomass using the known root-to-shoot ratio of different plants. (Below-ground biomass accounts for 18–30% of total biomass in trees, but this percentage varies depending on species type and environmental stress levels. For example, tundra plants can have a root-to-shoot ratio of 4.8, whereas tropical plants can have ratios as low as 0.2.)

Estimate the below-ground biomass by multiplying above-ground biomass by the established root-to-shoot ratios for either hardwood or softwood species.

The equation for hardwood species is:
BGB of tree (kg) = 1.576 x (AGB of tree [kg]$^{0.615}$)

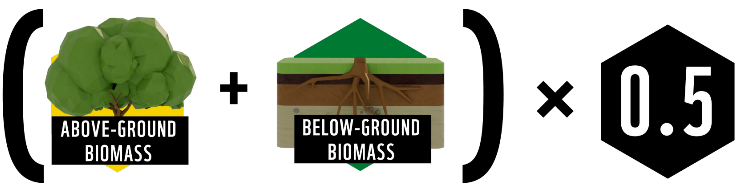
The equation for softwood species is:
BGB of tree (kg) = 0.222 x AGB of tree (kg)

3. Calculate total biomass and convert it to carbon stock.

To calculate the total carbon stock (kg) per tree, add the above-ground biomass (kg) calculated for each tree to the below-ground biomass (kg) calculated for each tree. This value is equal to the total tree biomass (kg). Multiply this figure by a carbon conversion factor of 0.5 to obtain the carbon stock per tree. Do these calculations for all the trees in the 400m² plot.

BELOW-GROUND BIOMASS

TOTAL CARBON PER TREE



Total carbon stock of tree (kg) = (AGB of tree [kg] + BGB of tree [kg]) x 0.5

SECTION SUMMARY: CONVERTING IN-FIELD MEASUREMENTS TO BIOMASS

- **Input the field data into the datasheet to automatically calculate the biomass and carbon stock for each tree.**
- **Alternatively, input tree data into the above-ground biomass equations provided.**
- **Using the above-ground biomass values, calculate the below-ground biomass of each tree using the equations provided.**
- **Add together above-ground biomass and below-ground biomass to obtain total tree biomass for each tree in the plot.**
- **Multiply the total biomass of each tree by 0.5 to obtain an estimate for the total carbon in each tree.**

PART 2: ESTIMATING CARBON STOCKS

Estimate average and total carbon stock of plots

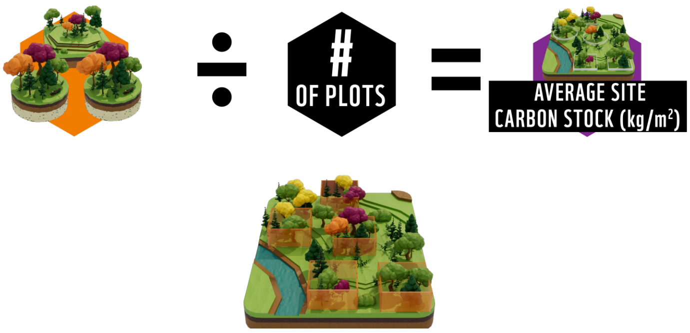
1. Add the total carbon stock (kg) of all individual trees measured and divide this value by the size of the plot (m^2) to obtain the average carbon stock of the plot (kg C/m^2). Complete this calculation for all plots in the site.

***Equation 1:* Average carbon stock of plot (kg C/m^2) = sum of carbon stock of trees (kg C) / plot size (400 m^2)**

Scaling from plot to site to study area

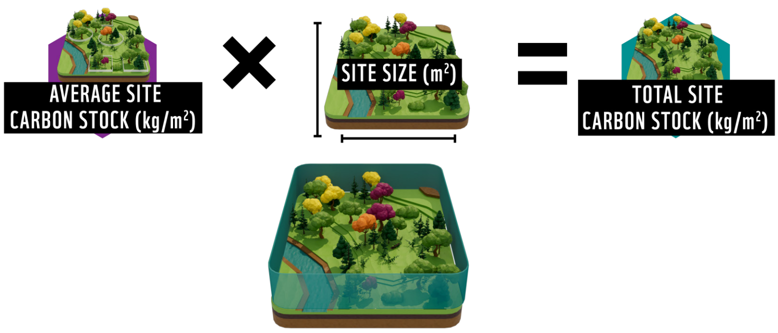
2. For each site, add all the plots' average carbon stocks and divide this value by the number of plots in the site (remember that all the plots are the same size). This is the **average** carbon stock of the **site** (kg C/m^2).

***Equation 2:* Average carbon stock of study site (kg C/m^2) = sum of all the average carbon stocks of plots (kg C/m^2) / number of plots**



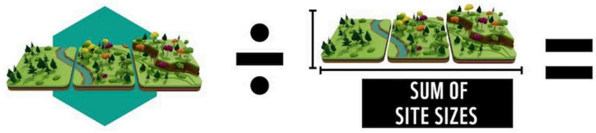
3. Multiply the average carbon stock of the site by the size of the site (in metres square) to obtain the total carbon stock of each site (kg C).

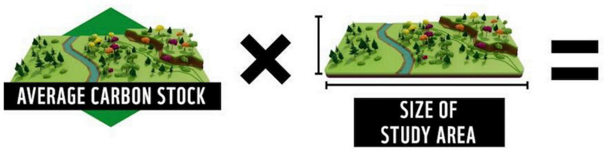
***Equation 3:* Total carbon stock of study site (kg C) = average carbon stock of study site (kg C/m^2) * study site size (m^2)**



4. Add up the total carbon stocks for the sites and divide by the sum of the site sizes. This gives the **average** carbon stock of the study **area** (kg C/m^2).

Equation 4: Average carbon stock of study area (kg C/m^2) = sum of total carbon stocks of sites (kg C) / sum of site sizes (m^2)





TOTAL CARBON STOCK OF THE STUDY AREA

5. To get the <u>total</u> carbon stock of the study <u>area</u> (kg C), multiply the average carbon stock of the study area by the size of the study area (in metres square).

Equation 5: Total carbon stock of study area (kg C) = average carbon stock of study area (kg C/m^2) * study area size (m^2)

*The carbon values calculated here are in units of "C."
If interested in units of "CO_2 equivalents," multiply by 3.67.

SECTION SUMMARY: ESTIMATE AVERAGE AND TOTAL CARBON STOCK FOR THE STUDY AREA

Calculate the average carbon stock (kg C/m^2) of each plot.

Equation 1: Average carbon stock of <u>plot</u> (kg C/m^2) = sum of carbon stock of trees (kg C) / plot size (400m^2)

Calculate the average carbon stock of all the plots in the site.

Equation 2: Average carbon stock of study <u>site</u> (kg C/m^2) = sum of all the average carbon stocks of plots (kg C/m^2) number of plots

Calculate the total carbon stock of the site.

Equation 3: Total carbon stock of study <u>sites</u> (kg C) = average carbon stock of study site (kg C/m^2) * study site size (m^2)

Calculate average carbon stock of the study area.

Equation 4: Average carbon stock of study <u>area</u> (kg C/m^2) = sum of total carbon stocks of sites (kg C)

Calculate total carbon stock of the study area.

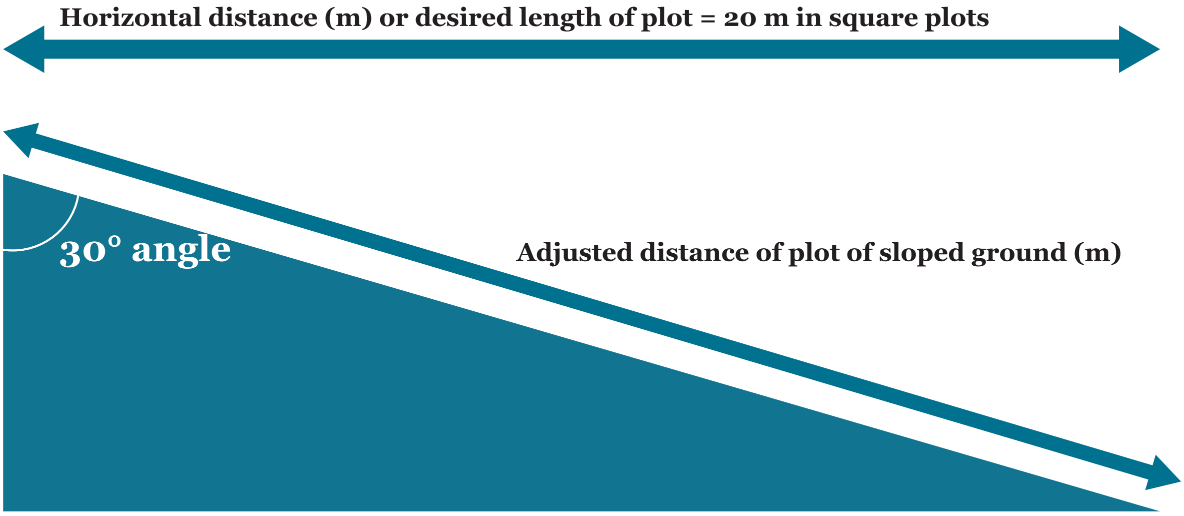
Equation 5: Total carbon stock of study <u>area</u> (kg C) = average carbon stock of study area (kg C/m^2) * study area size (m^2)

APPENDIX

Calculating slope allowances is necessary on plots with slopes. Depending on the specific model, some laser rangefinders or vertex hypsometers have a built-in features that determine this allowance. If using a more basic laser rangefinder or a clinometer, refer to the table below (Cyril Lundrigan, 2003) to calculate the adjusted plot size.

SLOPE ALLOWANCES												
					Transect Pt							
			Plot Size		7 & 8	6 & 9	5 &10	4 & 11	3 & 12	2 & 13	1 & 14	0 & 15
% Slope	**Factor**	**5.64**	**10.00**	**11.28**	**1.00**	**3.00**	**5.00**	**7.00**	**9.00**	**11.00**	**13.00**	**15.00**
2	1.000	5.64	10.00	11.28	1.00	3.00	5.00	7.00	9.00	11.00	13.00	15.00
4	0.999	5.64	10.01	11.29	1.00	3.00	5.01	7.01	9.01	11.01	13.01	15.02
6	0.998	5.65	10.02	11.30	1.00	3.01	5.01	7.01	9.02	11.02	13.03	15.03
8	0.997	5.66	10.03	11.32	1.00	3.01	5.02	7.02	9.03	11.03	13.04	15.05
10	0.995	5.67	10.05	11.34	1.01	3.02	5.03	7.04	9.05	11.06	13.07	15.08
12	0.993	5.68	10.07	11.36	1.01	3.02	5.04	7.05	9.06	11.08	13.09	15.11
14	0.990	5.70	10.10	11.39	1.01	3.03	5.05	7.07	9.09	11.11	13.13	15.15
16	0.987	5.71	10.13	11.42	1.01	3.04	5.07	7.09	9.12	11.14	13.17	15.20
18	0.984	5.73	10.16	11.46	1.02	3.05	5.08	7.11	9.15	11.18	13.21	15.24
20	0.981	5.75	10.20	11.50	1.02	3.06	5.10	7.14	9.17	11.21	13.25	15.29
22	0.977	5.77	10.24	11.55	1.02	3.07	5.12	7.16	9.21	11.26	13.31	15.35
24	0.972	5.80	10.28	11.60	1.03	3.09	5.14	7.20	9.26	11.32	13.37	15.43
26	0.968	5.83	10.33	11.66	1.03	3.10	5.17	7.23	9.30	11.36	13.43	15.50
28	0.963	5.86	10.38	11.71	1.04	3.12	5.19	7.27	9.35	11.42	13.50	15.58
30	0.958	5.89	10.44	11.78	1.04	3.13	5.22	7.31	9.39	11.48	13.57	15.66
32	0.952	5.92	10.50	11.84	1.05	3.15	5.25	7.35	9.45	11.55	13.66	15.76
34	0.947	5.96	10.56	11.91	1.06	3.17	5.28	7.39	9.50	11.62	13.73	15.84
36	0.941	5.99	10.63	11.99	1.06	3.19	5.31	7.44	9.56	11.69	13.82	15.94
38	0.935	6.03	10.70	12.07	1.07	3.21	5.35	7.49	9.63	11.76	13.90	16.04
40	0.928	6.07	10.77	12.15	1.08	3.23	5.39	7.54	9.70	11.85	14.01	16.16
42	0.922	6.12	10.85	12.23	1.08	3.25	5.42	7.59	9.76	11.93	14.10	16.27
44	0.915	6.16	10.93	12.32	1.09	3.28	5.46	7.65	9.84	12.02	14.21	16.39
46	0.908	6.21	11.01	12.42	1.10	3.30	5.51	7.71	9.91	12.11	14.32	16.52
48	0.902	6.26	11.09	12.51	1.11	3.33	5.54	7.76	9.98	12.20	14.41	16.63
50	0.894	6.31	11.18	12.61	1.12	3.36	5.59	7.83	10.07	12.30	14.54	16.78
52	0.887	6.36	11.27	12.71	1.13	3.38	5.64	7.89	10.15	12.40	14.66	16.91
54	0.880	6.41	11.36	12.82	1.14	3.41	5.68	7.95	10.23	12.50	14.77	17.05
56	0.873	6.46	11.46	12.93	1.15	3.44	5.73	8.02	10.31	12.60	14.89	17.18
58	0.865	6.52	11.56	13.04	1.16	3.47	5.78	8.09	10.40	12.72	15.03	17.34
60	0.857	6.58	11.66	13.15	1.17	3.50	5.83	8.17	10.50	12.84	15.17	17.50
62	0.850	6.64	11.77	13.27	1.18	3.53	5.88	8.24	10.59	12.94	15.29	17.65
64	0.842	6.70	11.87	13.39	1.19	3.56	5.94	8.31	10.69	13.06	15.44	17.81
66	0.835	6.76	11.98	13.52	1.20	3.59	5.99	8.38	10.78	13.17	15.57	17.96
68	0.827	6.82	12.09	13.64	1.21	3.63	6.05	8.46	10.88	13.30	15.72	18.14
70	0.819	6.88	12.21	13.77	1.22	3.66	6.11	8.55	10.99	13.43	15.87	18.32
72	0.812	6.95	12.32	13.90	1.23	3.69	6.16	8.62	11.08	13.55	16.01	18.47
74	0.804	7.02	12.44	14.03	1.24	3.73	6.22	8.71	11.19	13.68	16.17	18.66
76	0.796	7.08	12.56	14.17	1.26	3.77	6.28	8.79	11.31	13.82	16.33	18.84
78	0.789	7.15	12.68	14.31	1.27	3.80	6.34	8.87	11.41	13.94	16.48	19.01
80	0.781	7.22	12.81	14.45	1.28	3.84	6.40	8.96	11.52	14.08	16.65	19.21
82	0.773	7.29	12.93	14.59	1.29	3.88	6.47	9.06	11.64	14.23	16.82	19.40
84	0.766	7.37	13.06	14.73	1.31	3.92	6.53	9.14	11.75	14.36	16.97	19.58
86	0.758	7.44	13.19	14.88	1.32	3.96	6.60	9.23	11.87	14.51	17.15	19.79
88	0.751	7.51	13.32	15.03	1.33	3.99	6.66	9.32	11.98	14.65	17.31	19.97
90	0.743	7.59	13.45	15.18	1.35	4.04	6.73	9.42	12.11	14.80	17.50	20.19
92	0.736	7.66	13.59	15.33	1.36	4.08	6.79	9.51	12.23	14.95	17.66	20.38
94	0.729	7.74	13.72	15.48	1.37	4.12	6.86	9.60	12.35	15.09	17.83	20.58
96	0.721	7.82	13.86	15.64	1.39	4.16	6.93	9.71	12.48	15.26	18.03	20.80
98	0.714	7.90	14.00	15.79	1.40	4.20	7.00	9.80	12.61	15.41	18.21	21.01
100	0.707	7.98	14.14	15.95	1.41	4.24	7.07	9.90	12.73	15.56	18.39	21.22
102	0.700	8.06	14.28	16.11	1.43	4.29	7.14	10.00	12.86	15.71	18.57	21.43
104	0.693	8.14	14.43	16.27	1.44	4.33	7.22	10.10	12.99	15.87	18.76	21.65
106	0.686	8.22	14.57	16.44	1.46	4.37	7.29	10.20	13.12	16.03	18.95	21.87
108	0.679	8.30	14.72	16.60	1.47	4.42	7.36	10.31	13.25	16.20	19.15	22.09
110	0.673	8.38	14.87	16.77	1.49	4.46	7.43	10.40	13.37	16.34	19.32	22.29
112	0.666	8.47	15.01	16.94	1.50	4.50	7.51	10.51	13.51	16.52	19.52	22.52
114	0.659	8.55	15.16	17.11	1.52	4.55	7.59	10.62	13.66	16.69	19.73	22.76
116	0.653	8.64	15.32	17.28	1.53	4.59	7.66	10.72	13.78	16.85	19.91	22.97
118	0.647	8.72	15.47	17.45	1.55	4.64	7.73	10.82	13.91	17.00	20.09	23.18
120	0.640	8.81	15.62	17.62	1.56	4.69	7.81	10.94	14.06	17.19	20.31	23.44

Calculating plot length adjusted based on angle:



Adjusted distance (m) = horizontal distance / cos(angle)

= 20m / 0.866 = 23.1m

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GLOSSARY

Above-ground biomass: The total mass of organic matter of a plant located in the shoot, or above the soil level.

Altimeter: A device that measures altitude.

Average carbon stock: A measure of the density of carbon in a carbon pool, expressed as carbon mass per unit area, typically reported in kg/m^2 or t/ha.

Below-ground biomass: The total mass of organic matter of a plant located in the roots, or below the soil level.

Biodiversity: The variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biodiversity Index: An ecology index encompassing the number of species and their abundances within an area.

Biomass: The total weight of organic materials contained within a biological organism, population, community or ecosystem.

Carbon pool: A system that has the capacity to store or release carbon.

Carbon sequestration: The processes of capturing and storing atmospheric carbon.

Clinometer: A device that measures slope/aspect.

Diameter at breast height (DBH): Diameter of a plant, usually a tree, measured at 1.3m from the ground.

Dichotomous key: A scientific tool used to identify different organisms based the organism's observable traits. The tool consists of a series of statements with two options that, when selected, lead to the correct species identification.

Ecosystem: The complex of living organisms, their physical environment and all their interrelationships in a particular unit of space.

Ecosystem services: The contribution of an ecosystem to human well-being and quality of life.

Ecoregion: A region where the type, quality and quantity of environmental resources are generally similar, resulting in similar ecosystem structure.

Forest resilience: A measure of a forest's response to a range of stresses, perturbations or disturbances, which reflects the functional integrity of the ecosystem.

Linear sampling: Plot design whereby plots are laid out in a straight line.

Nature-based climate solutions: Strategies that use the unique powers of nature to both capture and store carbon.

Stratified sampling: The act of dividing a study area into subgroups based on a shared set of characteristics and sampling each stratum individually.

Total carbon stock: A measure of the total amount of carbon in a carbon pool, typically presented in kilograms or tonnes.

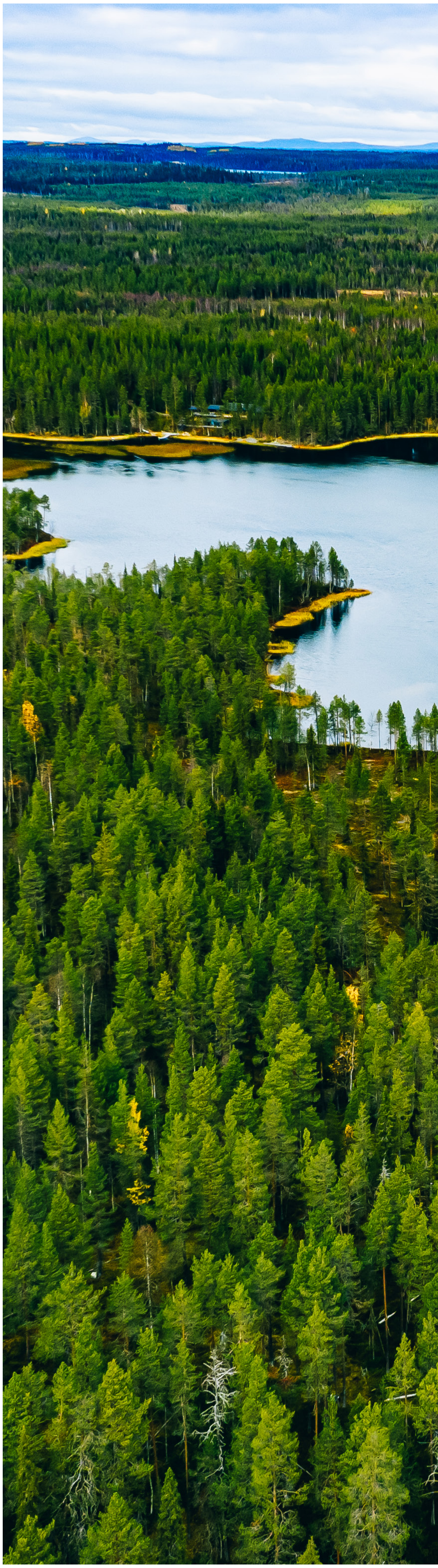
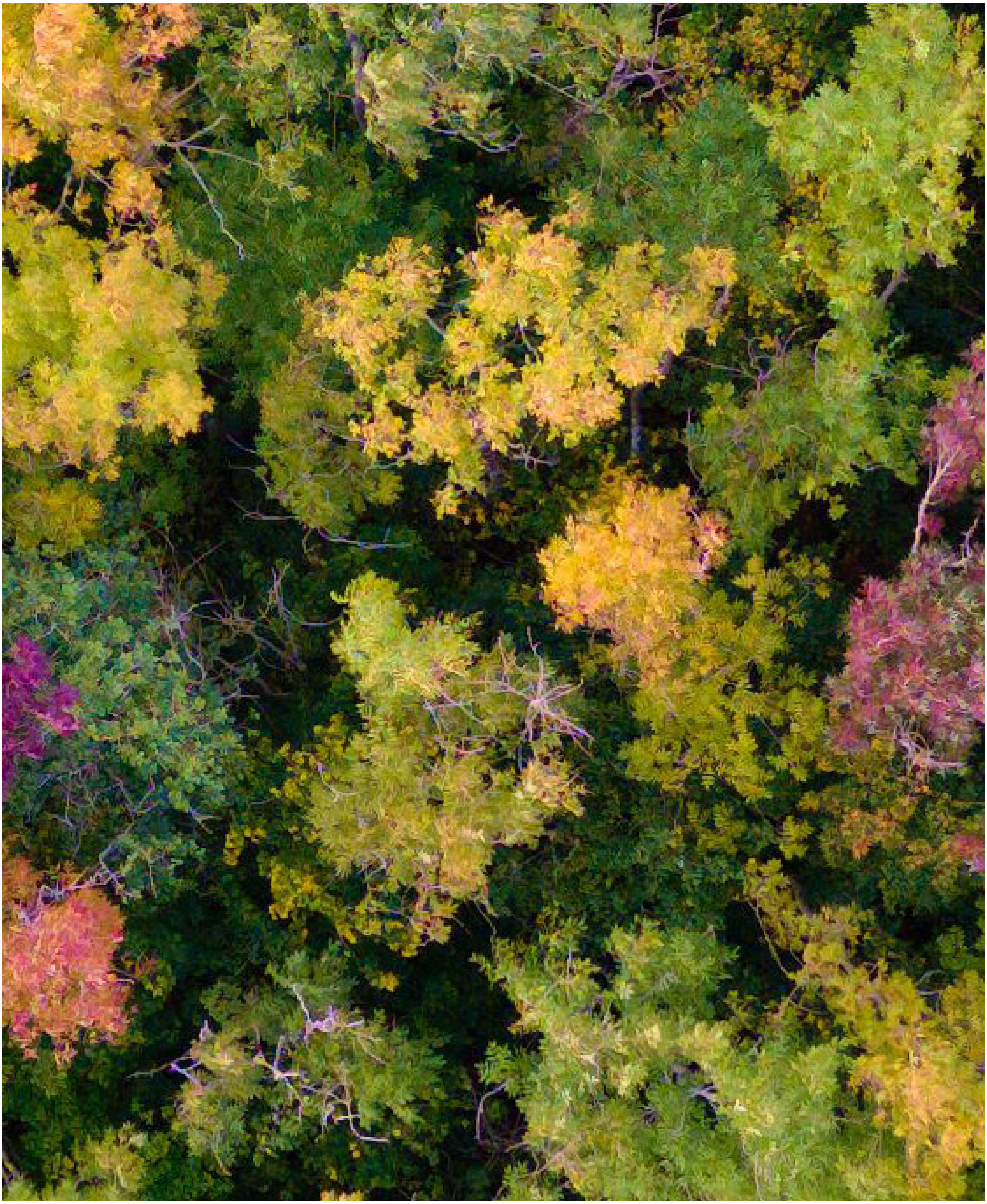



Photo credit: nblxer, Envato Elements



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