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Student Workbook

Name:

Date:

Measuring Marvellous Mangroves

using Rapid Long Plots (RLPs)

a.k.a. transects

Methods provided by Dr Norm Duke & Jock Mackenzie

@MangroveWatch and Earthwatch

Booklet created by Gail Riches

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More resources available at: https://earthwatch.org.au/research/wetlands-reefs/wetlands-education-resources
EarthWatch Australia School programs; https://earthwatch.org.au/education/school-programs

Interested persons are invited to contact the author for information or to indicate errors and omissions.

This booklet was created by Gail Riches following a teacher PD at Boyne Island Environmental Education Centre in August 2023 as part of EarthWatch Australia's '*Protecting Wetlands for the Future*' program.

Mangrove Watch

@mangrovewatch @earthwatch_aus @GreatBarrierReefFoundation.
Department of Climate Change, Energy and Water.

earthwatch AUSTRALIA

The '*Protecting Wetlands for the Future*' program is proudly supported by partnerships between the Australian Government Reef Trust and the Great Barrier Reef Foundation Citizen Science for Change Grants.

#lovethe reef #ReefTrust #TeachLive #ProtectingWetlandsForTheFuture #mangrove #CitizenScience #education #professionaldevelopment #greatbarrierreef #wetlands #mangroves #conservation #teachers #STEM #stemeducation #environment #conservation #benanddiphotography #BIEEC #MarineEducation

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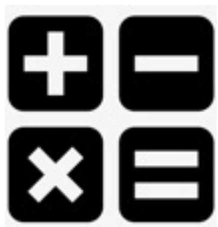
Multi disciplinary

Name/s:

Date:

This booklet is used to teach science and math, plus many more subjects

Science (yr5-10)



Mathematics

Cross-curriculum priorities: Aboriginal and TS Islander Histories and Culture; and Sustainability

ART

Biology (yr11&12)

Earth & Environmental Science (yr11&12)

Marine Science (yr11&12)

Aquatic Practices (yr11&12)

Artwork by Lily Hass https://bluethumb.com.au/lily-hass

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Carbon Super Stores

Name/s:

Date:

Mangroves trap carbon 50 times faster than any other forest!

How?

Mangroves have adapted to living in very salty environments by dropping lots of leaves (containing salt) *all* the time.

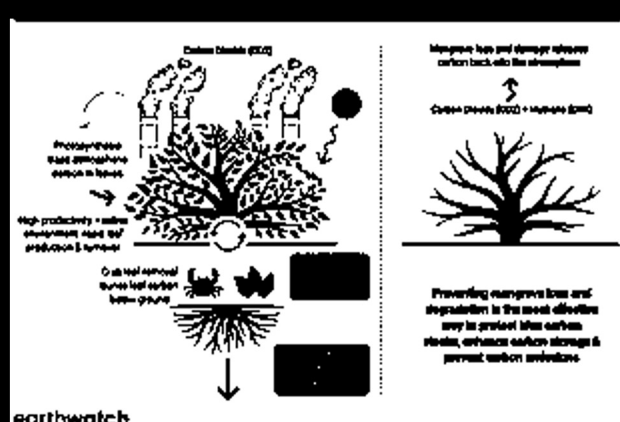
This rapid leaf production and leaf turnover rates trap more carbon than any other forest.


Photo: Fidler Crab © Our Wild World

Hence, mangrove forests store 4-10 times MORE carbon than any other forest!

Walk into a mangrove forest.
Is there a healthy population of crabs?
Can you see lots of burrows?
How many leaves do you see?
Not many?

Crabs are super efficient at burying the leaves.
Lots of crabs = very few leaves (now buried and stored as carbon under the ground).



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Jock Mackenzie

The scientist for this program

Name/s:

Date:

HELP JOCK save the mangroves!

Jock Mackenzie
Wetlands Program Manager and MangroveWatch Coordinator @ Earthwatch Institute Australia Mangrove and Saltmarsh Conservation and Management through Citizen Science. Founder and Co-Director of MangroveWatch - a community science partnership to educate, engage and empower local communities to protect and improve mangrove habitats through local management initiatives. 15+ years playing in the mangrove mud.

Mangrove Watch

earthwatch AUSTRALIA

Jock will turn your data into *meaningful* outcomes for mangroves. But he needs more data. He can't do it on his own. Jock developed this methodology so you can help him collect the data he needs to save the mangroves. It's easy and it's fun! Email your data to him directly at: jmackenzie@earthwatch.org.au

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Equipment

Name/s:

Date:

Step 1: Tick the box to remember what each group has packed in their equipment bag

☐ Transect (tape measure)

☐ GPS to measure location

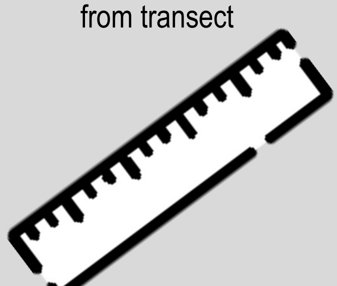
Google Maps

☐ Protractor to measure tree height

☐ Clipboard, pencil and data sheet

☐ Camera to take photos

☐ Meter ruler (or 2m pvc pipe ruler) to measure distance from transect

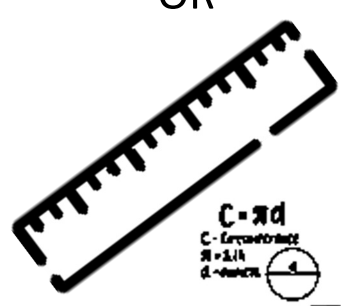


☐ Compass to measure transect direction

☐ Callipers to measure tree girth (circumference)

OR

OR



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Data SHEET

Name/s:

Date:

Date:	Start Time: End Time:	Location: Forest Type:
Collectors:		Plot number:
GPS Start Coordinates:		Distance to shore:
GPS End Coordinates:		Plot length: / Plot Width
Compass bearing from START:		
Dead Tree Tally:		Live Canopy Tree Tally:

Stem Number	Tree Number	Multi-stem (a,b ?)	Distance *Along* Tape (in m)	Distance *From* Tape (in m)	Side of transect: Left (L) or Right (R)	Species code	Tree girth (cm)		Tree height (m) to 0.1 decimal point				Lean: (°)	**Position:** Canopy (C) or Sub-canopy (SC) or Emergent (E)	Health score (0-5)	Tree Damage Code
							Diameter (cm) to 0.1 decimal point	Circumference – calculate in class (3.14 x D) to 0.1 decimal point	Degrees to top of tree (protractor)	Height of person (cm)	Distance from person to tree (cm)	Tree height (m) – calculate in class				
1																
2																
3																
4																
5																
6																
7																
8																

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Data SHEET

(make enough copies to record 50 stems)

Name/s:

Date:

Stem Number	Tree Number	Multi-stem (a,b ?)	Distance *Along* Tape (in m)	Distance *From* Tape (in m)	Side of transect: Left (L) or Right (R)	Species code	Tree girth (cm)		Tree height (m) to 0.1 decimal point				Lean: (°)	**Position:** Canopy (C) or Sub-canopy (SC) or Emergent (E)	Health score (0-5)	Tree Damage Code
							Diameter (cm) to 0.1 decimal point	Circumference – calculate in class (3.14 x D) to 0.1 decimal point	Degrees to top of tree (protractor)	Height of person (cm)	Distance from person to tree (cm)	Tree height (m) – calculate in class				

Look the Part

Name/s:

Date:

Step 2: Put on your hat, long-sleeve shirt, long pants & dive booties (or old full-covered shoes)

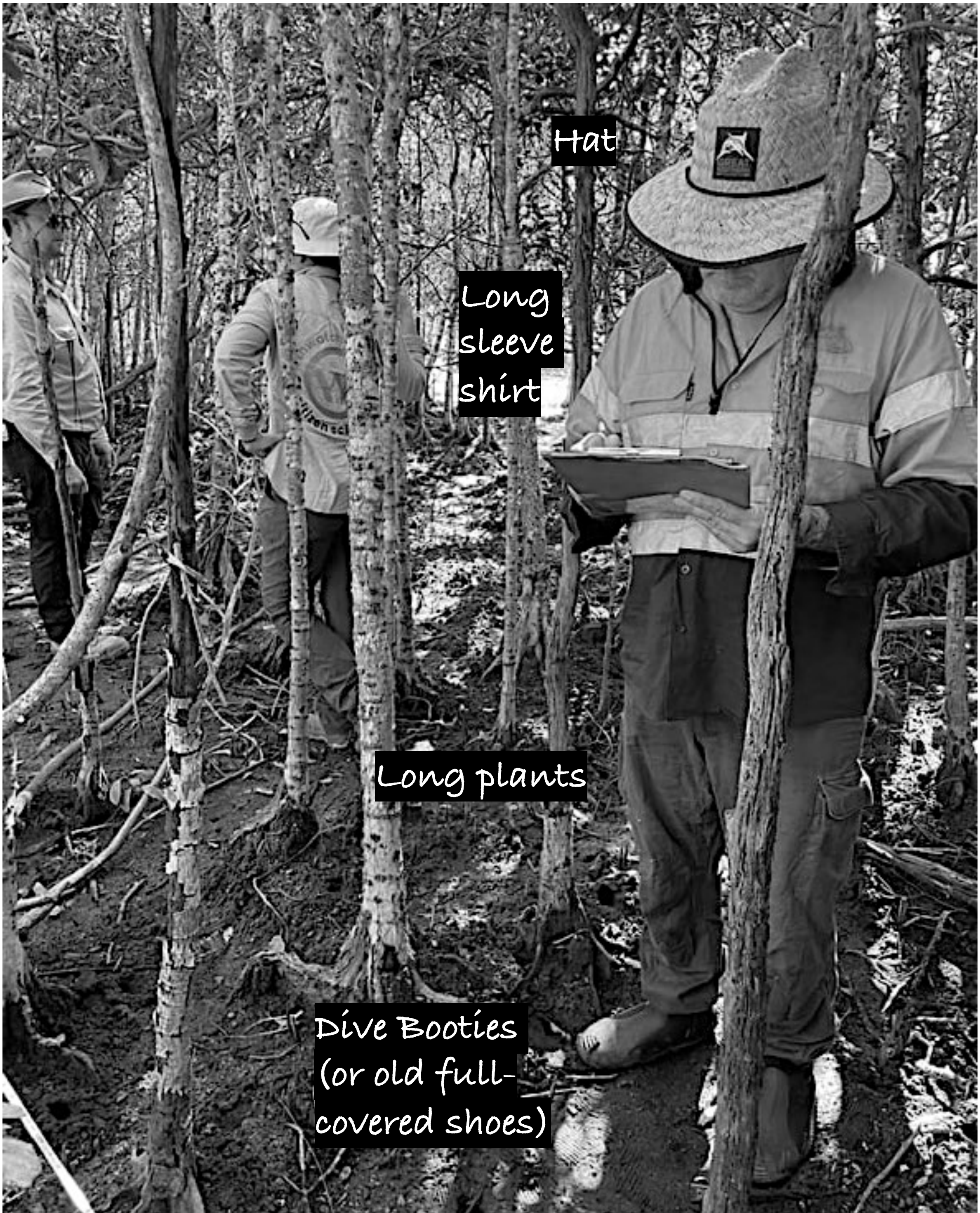

Photo © BenAndDi. On location in Yellow Mangrove Forest at EarthWatch's 'Protecting Wetlands for the Future' program, Boyne Island Environmental Education Centre August 2023. From left to right: Jock MacKenzie (MangroveWatch, EarthWatch), Liz Irvine (EarthWatch) and Danny Hudson (Pioneer Catchment & Landcare Group Inc.)

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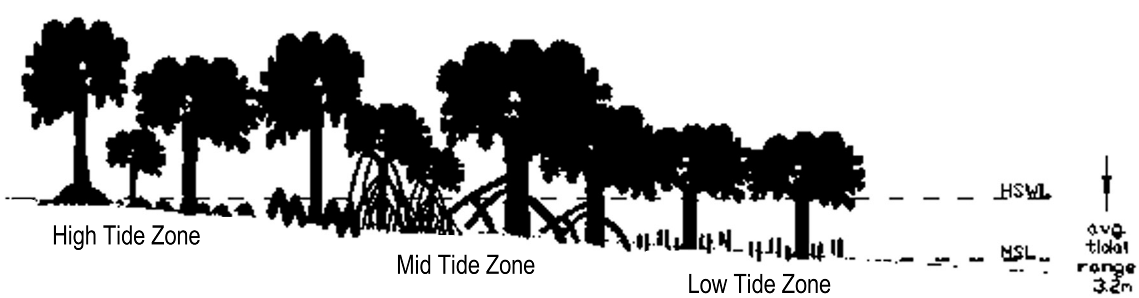
Select a Mangrove Forest

Name/s:

Date:

Photo: Louise Jasper/Blue Ventures

Check the tides BEFORE you go – organize your day around the tides



Yellow Mangrove *Ceriops australis* have *'**buttress roots'***

River Mangrove *Aegiceras corniculatum is a short tree or **shrub-like** mangrove*

Orange Mangrove *Bruguiera gymnorhiza* have '***knee roots***'

Red Mangrove *Rhizophora stylosa* have very distinctive '***stilt-like roots***'

Cool fact: The tall stilt-like roots of red mangrove trees enable them to remain above water during mid-high tides (and thus avoid drowning). Hence, why they often dominate in the low tide zone!

Grey Mangrove *Avicennia marina* have pneumatophores or *'**peg-type snorkel roots**'*

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Position the Plots PARALLEL to shore

Name/s:

Date:

START TIME:		**LOCATION:**	

Step 3: Select a *dense* part of the mangrove forest *parallel* to the shoreline to put your first transect (tape measure). Pick a spot that is representative of the dominant vegetation zone.

PLOT Nº:		**DISTANCE FROM SHORE:**		**FOREST TYPE:**	

Plot Number (transect or group number): Number each transect as plot 1, 2, 3, etc. *Hint:* 4 people/transect works well.
Distance from Shore: How close are you to water (when it's low tide)? 10 metres? 30 metres? 50 metres?
Forest Types: What is the dominant type of vegetation? E.g. Red mangrove forest, grey mangrove forest, etc.

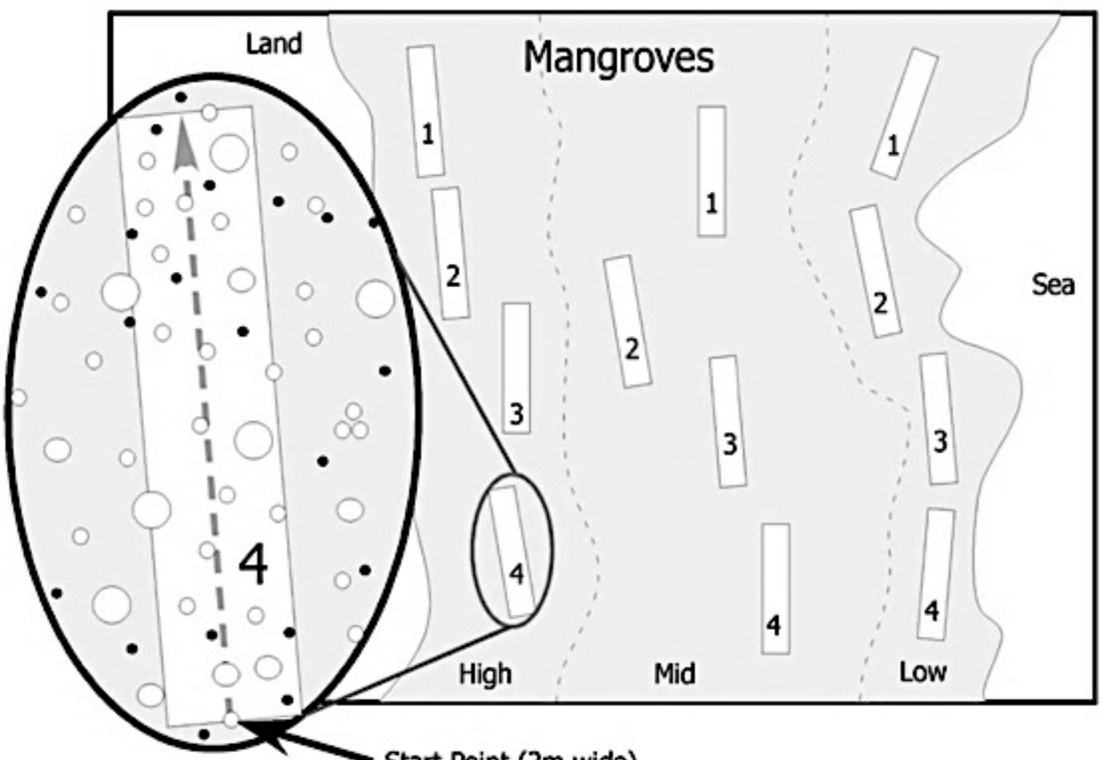

Image 1: Long plot rapid sampling

Experimental Design

Long plots are ***line transects*** set up ***parallel*** to the shore in (the middle of) each zone of a mangrove forest (e.g. low-tide zone, mid-tide zone, high-tide zone) ideally with a similar number of trees left and right of the transect line. **Teams of 4 people** measure 1-2 long plots each (one at a time).
Pictured above is the ideal scenario, with 4 long plots in each zone, making a total of 12 long plots. Each long plot takes approximately 1-2 hours to measure (after learning the method and finding your groove by creating a system that works best for you). Therefore, this is a full day excursion.

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Tag a Tree

Name/s:

Date:

Step 4: Pick a tree to be the start of the transect. It can NOT be too thin.
If the tree is >10cm in circumference or >3.2cm in diameter, write number “1” on the tree trunk with chalk. This is tree number 1 !!! This is the START of your transect/long plot.

Step 3: Attach the tape measure to tree 1 and record your GPS location (on google maps)

A global positioning system (GPS) is a network of satellites and receiving devices (e.g. you phone) used to determine the location of something on earth. GPS coordinates pinpoint your start & end point.

Latitude (N or S)   Longitude (E or W)

Q: What is the GPS reading for LATITUDE? Ans.		S
Q: What is the GPS reading for LONGITUDE? Ans.		**E**

Reel out the Line

Name/s:

Date:

Step 5: Roll out the tape measure approximately 10-20m. The length of each transect will be determined by the density of the forest, but is required to include at least 25 canopy trees (trees that reach the top of the canopy).

Step 5: Take a compass bearing of the direction of the transect line

Your compass bearing is the clockwise angle between north and your point of reference (i.e. the direction of the transect line).

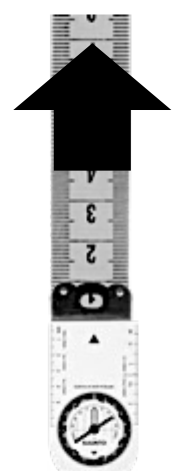
Instructions on how to take a magnetic compass bearing

Step 1: hold the compass flat so the red part of the compass needle points to NORTH.

Step 2: stand in the direction you wish to measure (in this case, the direction of the transect line).

Step 3: turn the bezel so that zero degrees is on NORTH (the needle always points to North).

Step 4: read the bearing (where the lubber line intercepts the bezel) and write that down.



Q: What is the compass bearing of the transect line? Ans. ________ degrees

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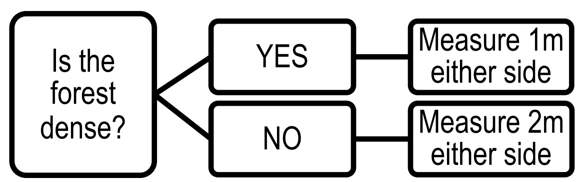
Snap a Pic

Name:

Date:

Step 6: Take a photo of your transect.

Step 7: Decide the width of your transect (how far either side of the tape measure you will be measuring). Choose between 1m (dense forest) or 2m (less dense forest).

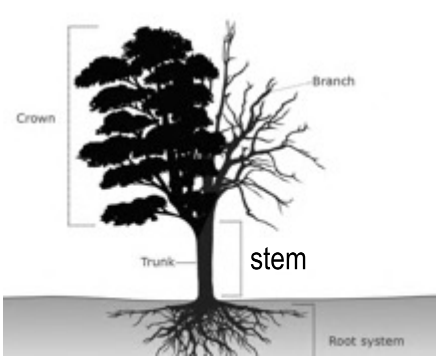


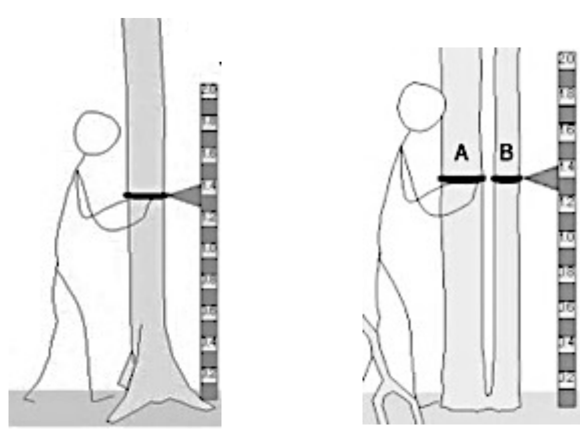
Q: What is your PLOT WIDTH going to be? Ans:	1m either side	or	2m either side

Trees with multiple stems

Some mangrove trees have more than one stem, a.k.a. trunk. For example, the stem in the ground splits in two stems at some point (not to be confused with branches). We count each stem as a separate entity. On multi-stem trees, we call the first stem “a” and the second stem “b” and so on.

Parts of a Tree





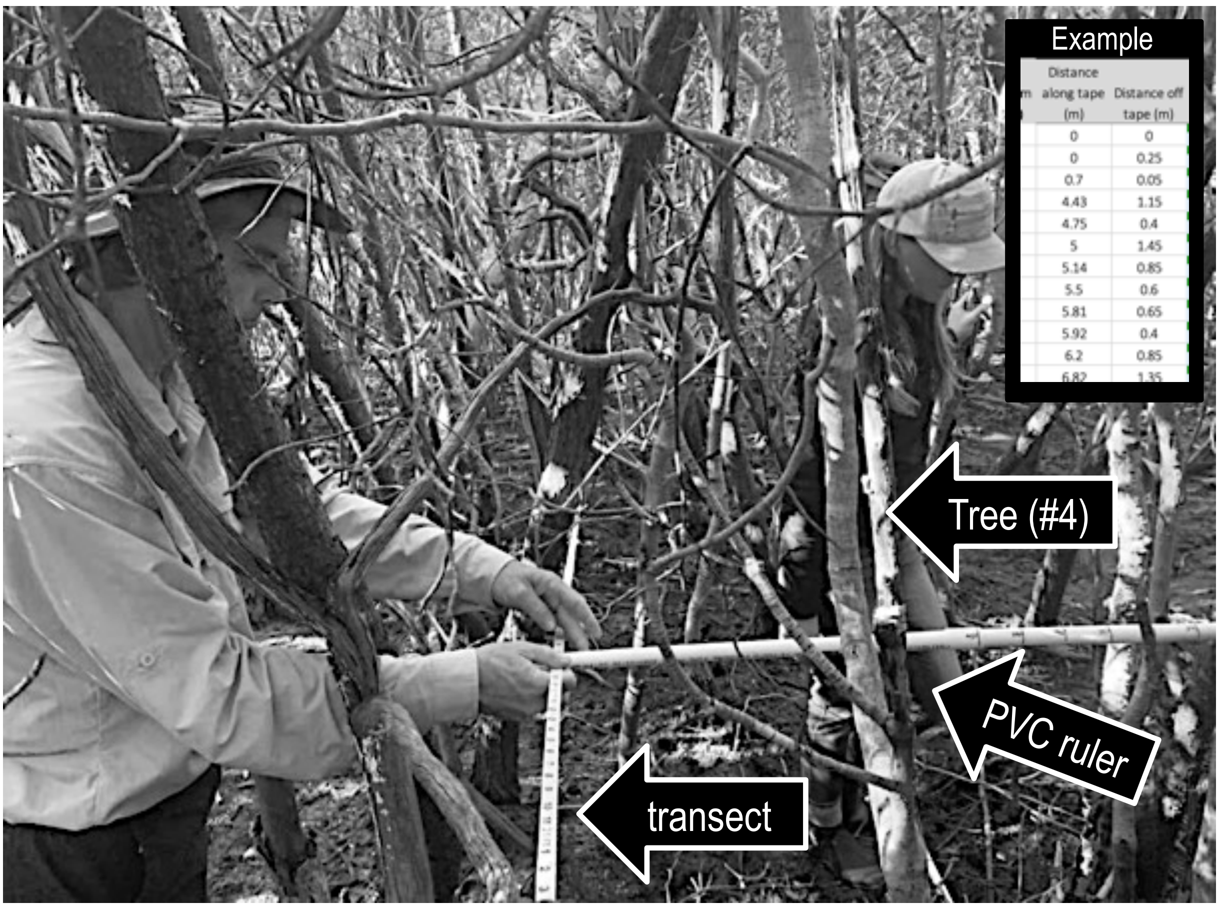
Measure distance (m)

Name:

Date:

Step 8: Measure distance *along,* and distance *from* the tape measure.

For every tree, you will measure:
(1) how far along the tape measure it is (distance *along* tape in metres), and
(2) how far left or right it is from the tape measure (distance *from* tape in metres) pictured below.



Q: How far is tree 1 from the start of the tape measure (m)? Ans. 0m

Q: What far left or right is tree 1 from the tape (m)? Ans. 0m LEFT RIGHT

***Hint:* Tree #1 will always be at the *start* of the tape measure and neither left nor right.**

Do NOT spend too much time measuring this EXACT distance. You only need to give the measurement to one decimal place in meters. In the picture above, you can see the person is *not* using a meter ruler, but instead has made his own (2m) ruler using PVC pipe from bunnings (25mm) that works well too!

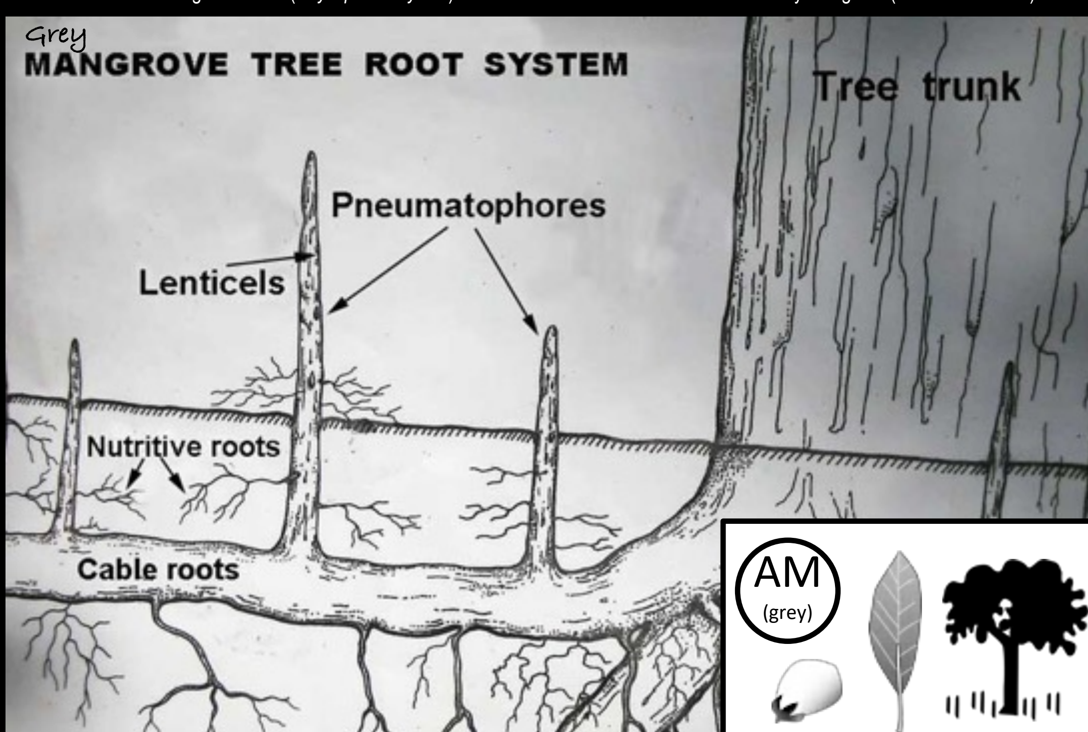
ID the Tree

Name/s:

Date:

Step 9: Identify the Genus and Species of the Mangrove Tree. Remember, Red Mangrove trees (*Rhizophora stylosa* or RS) have large stilt-like prop roots to breathe and Grey mangrove trees (*Avicennia marina* or AM) have snorkel-like pneumatophores to breathe ☺

Photo above: Red Mangrove Trees (*Rhyzophora stylosa*) © GBR Foundation [1]   Photo below: Grey Mangrove (*Avicennia marina*)



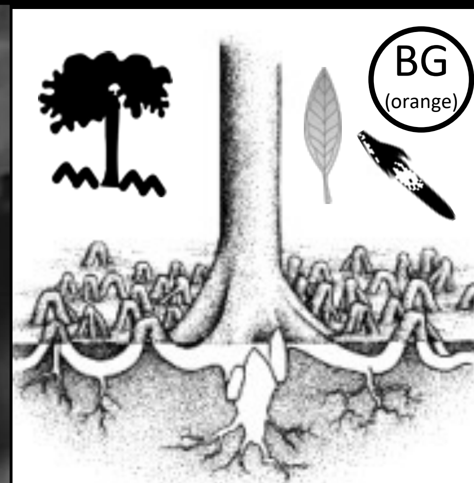
[1] Project News (2022). Citizen Science project wrap: Stories of impact. Accessed Sept 4th 2023 from: https://www.barrierreef.org/news/project-news/kickstarting-blue-carbon-projects-in-the-asia-pacific

ID the Tree

Name/s:

Date:

Orange Mangrove Trees *Bruguiera gymnorhiza* (BG) have very distinctive 'knee roots'



Yellow Mangrove Trees *Ceriops australis* (CA) have very yellow leaves and distinctive 'buttress roots'. They are often found in the high tide zone & above (less muddy to walk!)

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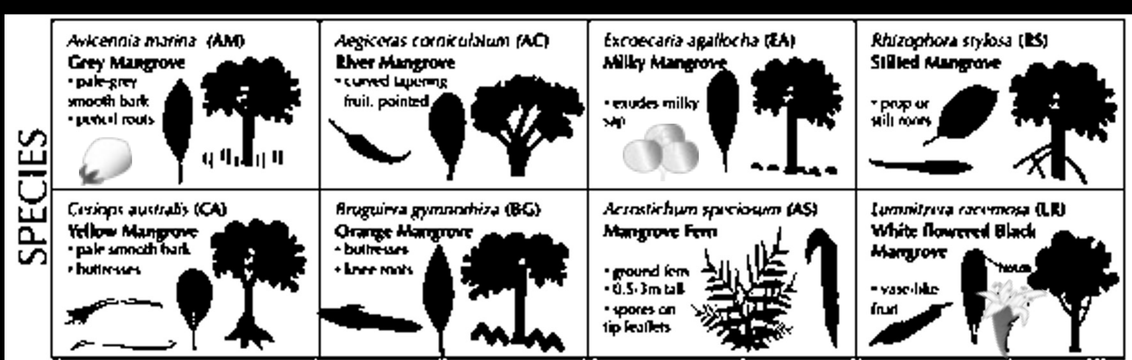
ID the Tree

Name/s:

Date:

River Mangrove Trees *Aegiceras corniculatum* (AC) occur as a bushy shrub 2 to 3 m high.

Photos: Col Grant @inaturalist



Species Index: Black Mangrove *Lumnitzera racemosa* (RS); Blind-Your-Eye Mangrove *Excoecaria agallocha* (EA); Cannonball Mangrove *Xylocarpus granatum* (XG); Cedar Mangrove *Xylocarpus mekongensis* (XM); Club Mangrove *Aegialitis annulate* (AA); Freshwater Mangrove *Barringtonia racemose* (BR); Grey Mangrove *Avicennia marina* (AM); Holly Mangrove *Acanthus ilicifolius* (AI); Large-Leafed Orange Mangrove *Bruguiera gymnorrhiza* (BG); Looking-Glass Mangrove *Heritiera littoralis* (HL); Mangrove Apple *Sonneratia caseolaris* (SC); Mangrove Fern *Acrostichum speciosum* (AS) Mangrove Lily *Crinum pedunculatum* (CP); Mangrove Palm *Nypa fruticans* (NF); Myrtle Mangrove *Osbornia octodonta* (OO); Native Hibiscus *Hibiscus tiliaceus* (HT); Red Mangrove *Rhizophora stylosa* (RS); River Mangrove *Aegiceras corniculatum* (AC); Small-Leafed Orange Mangrove *Bruguiera parviflora* (BP); Tall-Stilted Mangrove *Rhizophora apiculate* (RA); Wrinkle Pod Mangrove *Cynometra iripa* (CI); Yellow Mangrove *Ceriops australis* (CA).

Example

Species Code
RS
AA
AA
AM
AA
AM
AA
AA
AA
RS
AA
AA

Q: What is the species code (first letter of Genus & Species) of Tree 1? Ans.

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Measure tree GIRTH

a.k.a. circumference

Name/s:

Date:

Save the mangrove trees and help save the planet!

During these transect (long plot) studies you will be doing lots of measuring. Dr Jock Mackenzie converts your measurements of tree girth (circumference) and tree height to estimate the amount of carbon dioxide the mangrove forest removes from the atmosphere (via photosynthesis) every year. This information is used to preserve and protect mangrove forests. By measuring the trees and sending that information to Jock, you will be directly helping to reduce carbon emissions by saving the mangrove trees.

Step 10: Measure tree thickness ABOVE the roots and BELOW the lowest branch

You can measure tree thickness two ways:

(1) Wrap the measuring tape around the tree to measure its girth (circumference); or

(2) Use a set of vernier calipers (or ruler) to measure tree DIAMETER - and later in class, convert all measurements of diameter (D) to circumference (C) using the formula: C = 3.14 x D.

Diameter (cm)	Girth (cm)
7.3847894	23.2
4.9656342	15.6
8.0850711	25.4
6.8436626	21.5
5.1566202	16.2
6.2070428	19.5
10.31324	32.4
5.2521131	16.5
4.6473243	14.6

Photo: Global Mangrove Alliance

Q: What is diameter of Tree 1 (if applicable)? Ans.

Q: What is the circumference of Tree 1? Ans.
exact, to one decimal point

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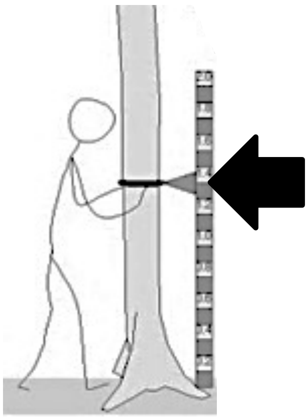
Importance of accuracy

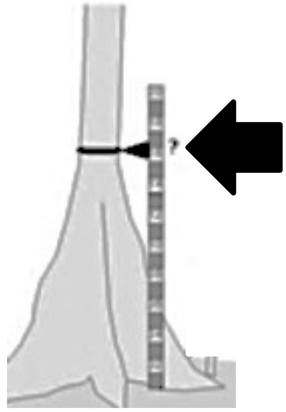
Name/s:

Date:

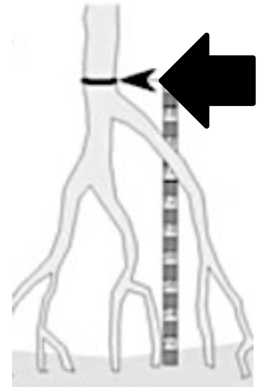
To estimate biomass as accurately as possible, it is important to measure girth correctly



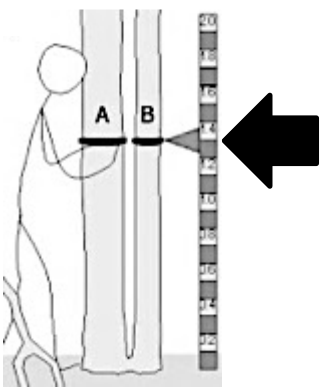
High stem



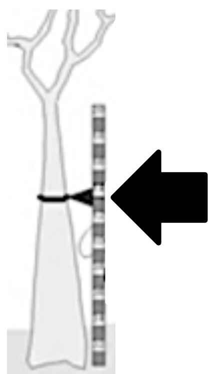
Buttress roots



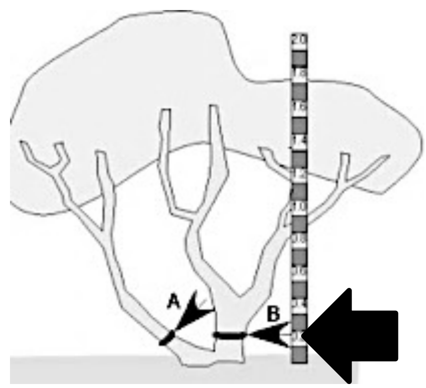
Stilt-like roots



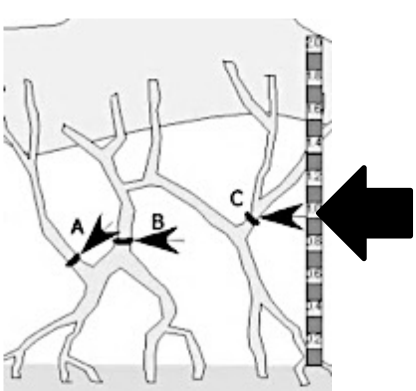
Multi-stem tree



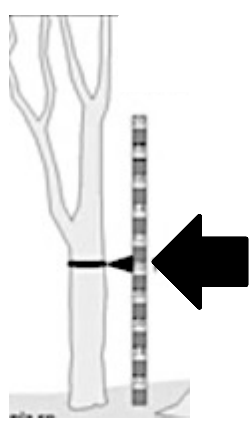
Tapered stem



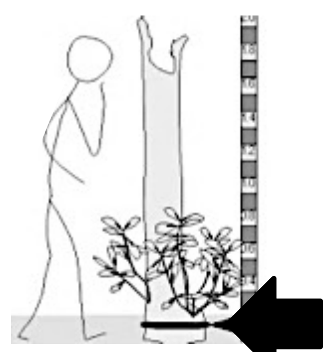
Shrub



Sprawling Rhizophora (stilted red mangrove)



Low branching



Sprouting foliage at base of dead stump – use stem below

Remember, measure tree thickness ABOVE the roots and BELOW the lowest branch

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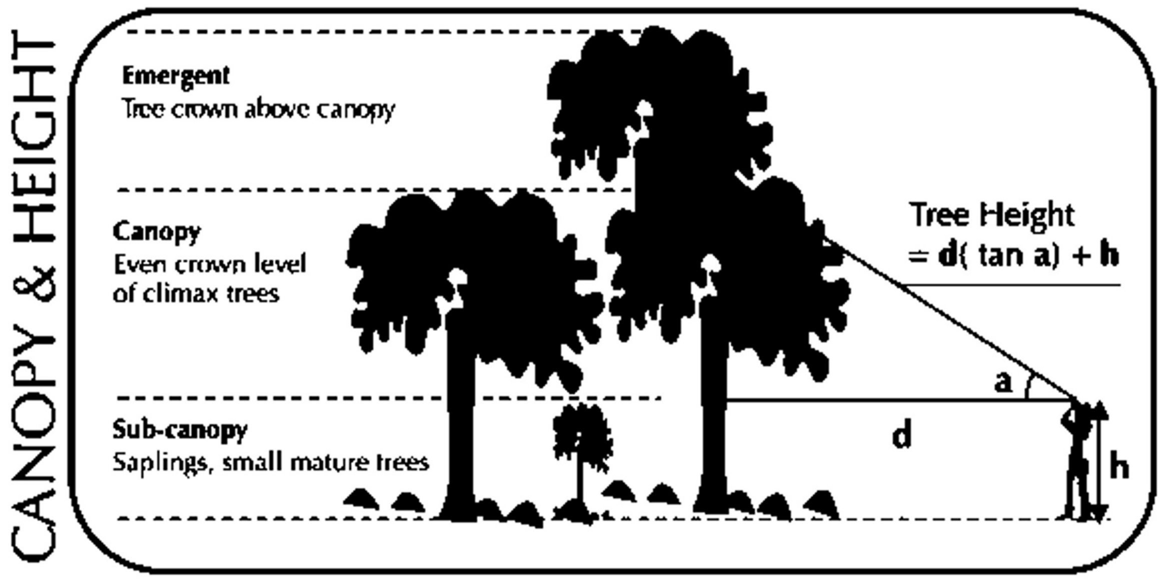
Measure tree HEIGHT

Name/s:

Date:

Step 11: Measure the height of the tree

How do you to calculate the height of the tree when it's all the way up there? It MUST be as accurate as possible, and exact to one decimal of a meter, for Jock to get his biomass estimates correct. If you have a ruler or pole (of known length) high enough to reach, great! Otherwise, use your protractor and apply some maths to calculate tree height. See below:



How to calculate tree height when your measuring stick doesn't reach…

1. Determine the highest point of the tree (you may need to shake the tree to see it).
2. Measure the distance (d) from you and the point directly beneath the tree's highest point.
3. Measure the angle (a) between your eye level and the top of the tree (use your protractor).
4. Apply the formula above*, not forgetting to add your own height (h).

**Hint:* record d and a on your data sheet, and do the calculations when you return to school.

Working area:

Q: What is the HEIGHT of Tree Nº. 1? Ans. (to one decimal point)

Step 12: Decide if the tree is sub-canopy (short) canopy (forest roof) or emergent (extra tall)

Q: Is the tree a sub-canopy, canopy or emergent tree? Ans.

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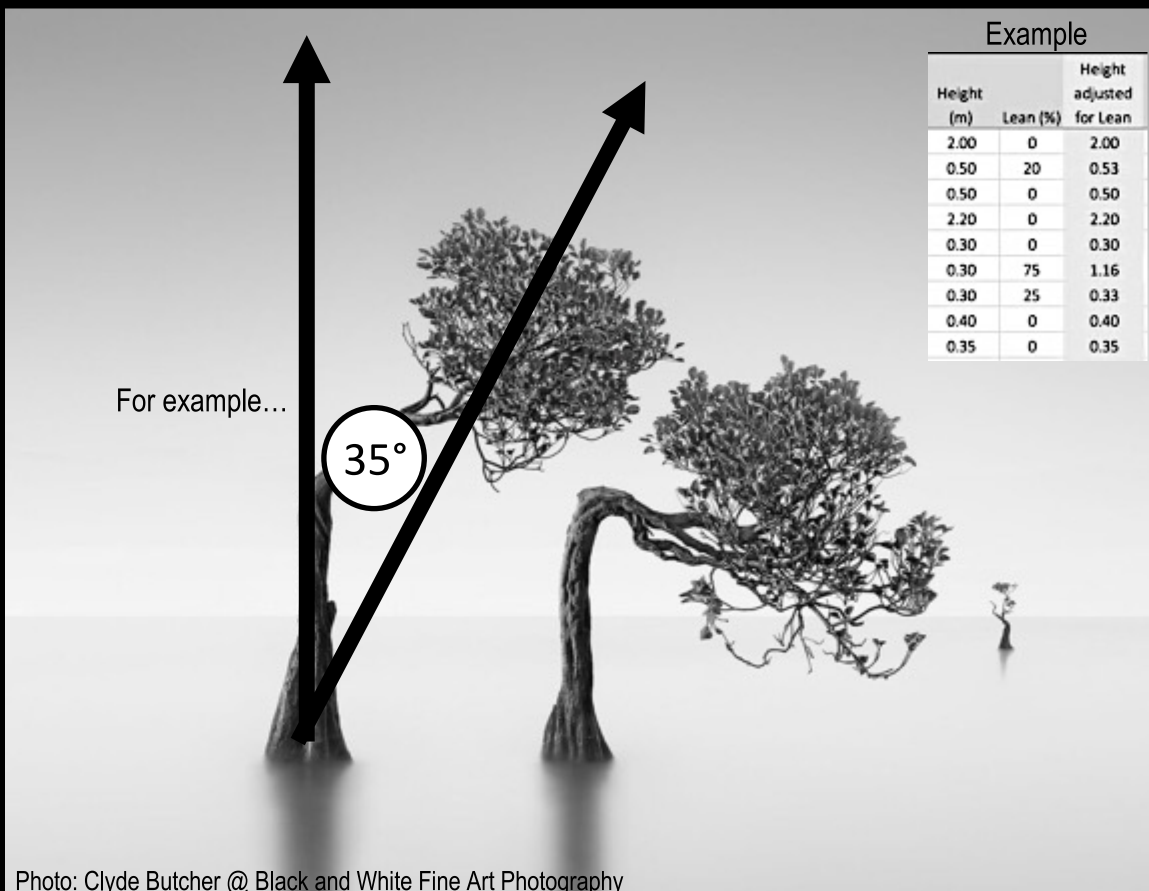
Measure tree LEAN

Name:

Date:

Step 12: Measure the lean (off vertical) of tree 1. How much is it leaning over? Estimate the lean between the base of the tree (looking straight up) and the top of the tree, in degrees.

Note: overall percent lean is measured to adjust any trigonometric calculations related to (height and thus) biomass



Height (m)	Lean (%)	Height adjusted for Lean
2.00	0	2.00
0.50	20	0.53
0.50	0	0.50
2.20	0	2.20
0.30	0	0.30
0.30	75	1.16
0.30	25	0.33
0.40	0	0.40
0.35	0	0.35

Photo: Clyde Butcher @ Black and White Fine Art Photography

Q: What is the average LEAN on tree 1? Ans.

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WHY measure these?

Name/s:

Date:

Tree girth, height and lean are used to calculate total standing biomass (carbon capture)

Tree girth and stem diameter

The reason for measuring the stem diameter of trees and shrubs is to use those measurements as proxies of their standing biomass (to estimate the mass of all the wood and leaves etc. in the forest). The standing biomass is directly related to the amount of carbon stored in the trees and below the ground.

Tree height

Height data is used to verify (check) biomass calculations, particularly for species *without* specific allometric equations (that estimate biomass using tree girth and diameter), and for small trees. Tree height, therefore, like tree girth and diameter, should be determined with as much accuracy as possible. Up to 5 metres in height, a height pole is the best method. For taller trees, trigonometric methods or a laser device is useful.

Tree lean

If trees are leaning over, the height measurement could be misleading (i.e. biomass estimate comes up short). Therefore, the overall percent lean is measured to adjust any trigonometric calculations related to biomass. E.g. tree lean is recorded to enable calculation of the total length of the trunk.

Below are graphs that highlight the importance of your work towards protecting mangroves

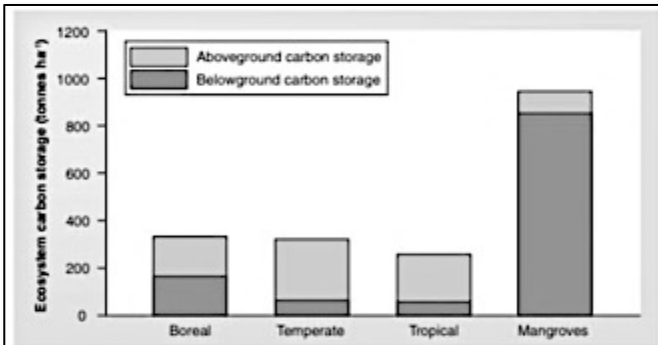

Figure 1. Differences in whole-ecosystem carbon stocks among boreal, temperate and tropical terrestrial forests, and subtropical and tropical mangrove forests.
Reprinted with permission from Macmillan Publishers Ltd: *Nature Geoscience* [21] © (2011).
Mangrove data taken from supplementary data [102] in [21], and [48,50–54].

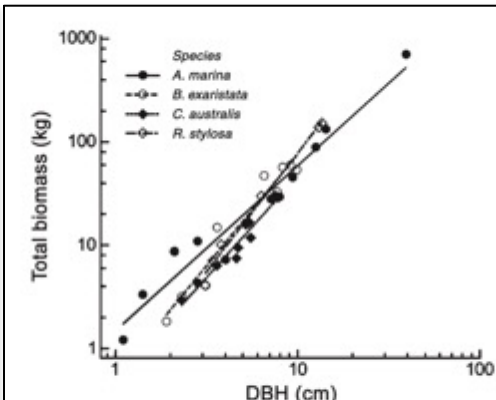

Fig. 1. Relationship between total biomass and diameter at breast height (DBH) for all species.[1]

Mangroves are one of the most carbon-rich ecosystems on earth. In order for mangroves to be included in carbon offsets, it is necessary to know how much carbon they store and sequester. Mangroves use atmospheric carbon to grow. Some carbon is locked up in their trunks, branches and roots. But even more is isolated in the forest soils. The deep muddy soils that mangroves live in provide ideal conditions for preventing decomposition of carbon, keeping it locked up for millennia.

Below are some ideas of what you can do with YOUR data to help save the mangroves

AIM: The aim of this study is to assess mangrove forest condition and forest structure within the fringing mangroves of [your location].

Data collected during this study will contribute to three long-term outcomes;

- Development of a map of [your location's] mangrove biomass to contribute to assessment of mangrove values (needed as justification for their protection).
- Monitoring mangrove condition in different mangrove zones in [your location] over time.
- Validation of MangroveWatch shoreline condition data collected previously.

During this study you will be helping to answer the following questions:

1. Do field observations of mangrove forest structure and condition match previous assessments?
2. Is the condition of fringing mangrove forest representative of overall forest condition?
3. Which mangrove zone has the greatest mangrove biomass (carbon storage)?
4. Has mangrove biomass and forest condition changed over time? If so, how?

LET's KEEP GOING!!!

[1] Comley, B. W. T. and McGuinness, K. A. (2005). *Above- and below-ground biomass, and allometry, of four common northern Australian mangroves*. Australian Journal of Botany. 53, 431–436.

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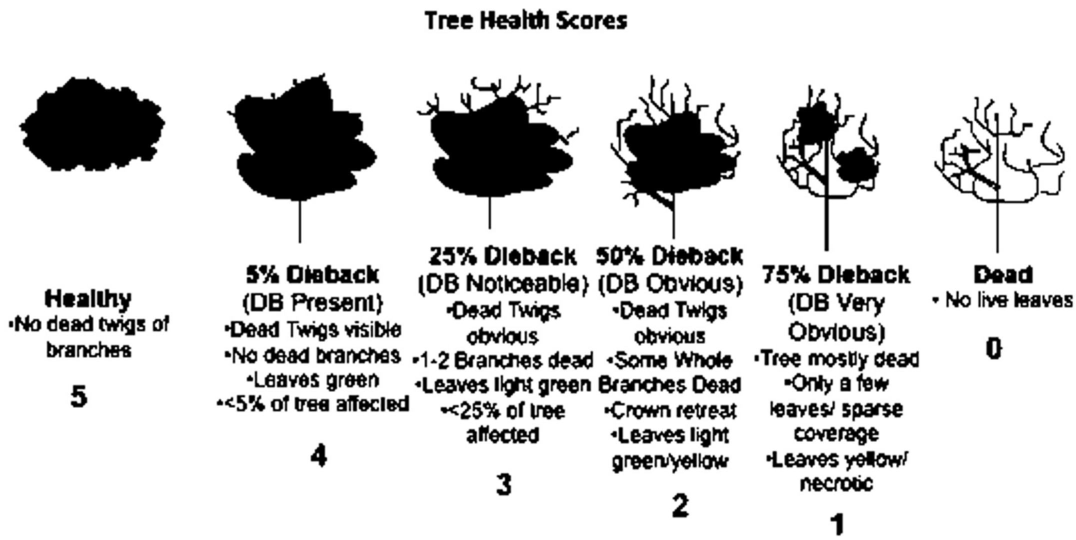
Measure tree HEALTH

Name:

Date:

Step 13: Measure tree health (1-5) for the *entire* tree. For example, 5 is healthy, 3 is *half* dead



Q: What is the tree health code for tree 1? Ans.

Step 14: Measure tree damage (see codes below). You can choose more than one code.

Live Trees		Dead Trees	
LTW	Live with dead twigs	DTW	Dead with twigs
LDB	Live with dead branches	DB	Dead with branches
LC	Live with low canopy cover	DT	Dead trunk (no branches)
ID	Live with insect damage (herbivory)	ST	Dead stump (<1m tall)
LF	Live Fallen Tree	DF	Dead fallen
LBT	Live Broken Trunk	DC	Dead cut
LHD	Live with Cut or Trimmed Branches	STC	Dead stump cut (<1m tall)
LSD	Live with grazing damage (e.g. cows)		

Note: A dead tree (or dead branch) will have NO GREEN. If you're not sure if the tree (or branch) is dead or alive, take a finger nail and scratch the bark. If you see no green, assume that part of the tree is dead. Green is an indicator of photosynthesis – yes, mangrove trees carry out photosynthesis in their trunks (as well as their leaves). Pretty cool huh.

Q: What is the tree damage code/s for tree 1? Ans.

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Designate Roles

Name:

Date:

Step 14: Now you know what to do….designate jobs to people in your group so you can complete the remainder of the transect as fast as possible. Complete the table below.

Job	Name of Group Member
Record data on data sheet (and be the boss person)	
Write tree number (and letter) on tree with chalk	
Measure distance *along* tape	
Measure distance *from* tape	
Determine LEFT or RIGHT side	
Measure girth or diameter	
Measure tree HIEGHT	
Measure tree LEAN	
Decide on Position (canopy, sub-canopy, emergent)	
Identify the tree (Genus species code)	
Determine the HEALTH score (0-5)	
Determine the TREE DAMAGE CODE	

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Complete the data sheet

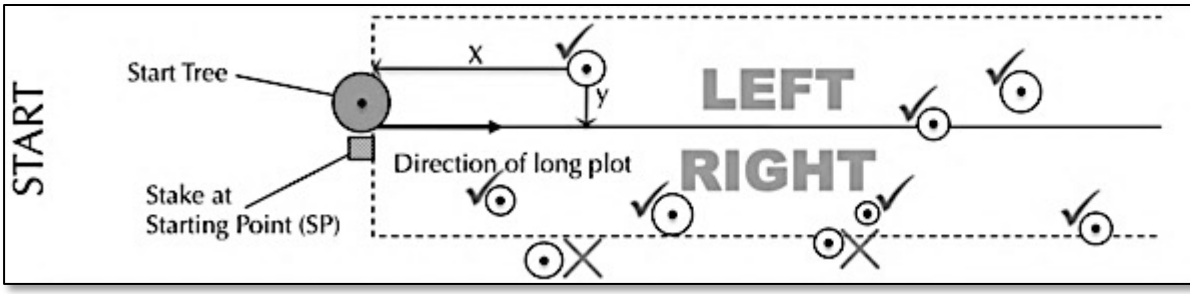
Name:

Date:

Step 15: Select your next (closest) tree (>10cm girth)…label it with chalk as tree number '2'

IN or OUT?

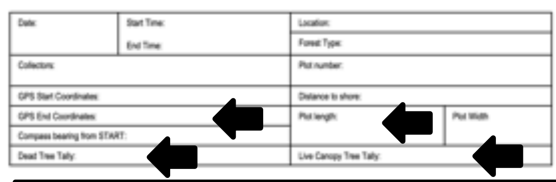
Only measure trees *inside* the long plot area. More than 50% of it's stem must be *inside* the long plot.



Step 16: Complete the remainder of the data sheet (remember to add tree #1 data).

Record at least 30 live trees, including at least 25 live *canopy* trees.

Take photos of transect *and* canopy every 10m



At the end, remember to measure…

- **Length of entire transect (plot length)**
- **GPS coordinates at the very last tree**
- **Tally the number of dead trees**
- **Tally the number of live canopy trees**

Q: What is the length of the entire transect? Ans.

Q: What is the LATITUDE of the last tree? Ans. S

Q: What is the LONGITUDE of the last tree? Ans. E

Q: What is number of DEAD trees? Ans.

Q: What is the number of live canopy trees? Ans.

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What happens next?

Name/s:

Date:

Examples of processed data & results kindly shared by students at Pioneer Valley (Mackay)

AUSTRALIA End GPS: INSERT Lat# INSERT Long#

SITE #: Plot 1
LOCATION: Barnes Creek
DATE: 26-04-18
COLLECTORS: MCC

Compass bearing from START: S 12904 E149.18974
Plot Total Width (m)= 4
Total Plot Length (m)= 13.6
AREA m2= 54.2

ρ = wood density (g/cm3)

Rhizophora apiculata	0.827	Lumnitzera littorea	0.64	Excoecaria agallocha	
Lumnitzera littorea	0.64	Xylocarpus granatum	0.605	Avicennia marina	

Canopy Weighted Height
Lorey's Height (m) = 4.49
Stand BA (m2/ha) = 32.8

Field Measures / **Derived Measures** / **Wood Density**

Tree#	Stem#	Dist - SP in metres	Species Code	Girth cm	Height m	Lean off Vert degrees	Log Length	Multi-stem count	COMMENT	Canopy	Tree Diameter cm	Basal Area cm2	BA*H	Wood Density	CHAVE 2005 Above ground kg (ρDH)	CHAVE 2005 Above ground kg (ρD)	KOMIYAMA Above ground kg (ρD)	KOMIYAMA Below ground kg (ρD)
	Mean=	13.55		22.7	3.8			#DIV/0!			4.9	1736.9	7802		7.7	16.9	24.6	11.5
34	50	eg. 5.6	eg. 80	eg. 51.5 (±0	eg. 1 (±1)	eg., 0.25	Lean OFFSET	eg. 5	eg., Dead, st	eg., Canopy, SubC				<INSERT Spp	<INSERT Wood Density		<INSERT Wood Density	
1	1	0	AM	25	5.6	0	6		50	C	8.0	49.7	279	0.765	13.8	21.6	31.6	15.6
2	2	1.5	RS	7.5	1.5	0	2			UC	2.4	4.5	7	0.765	0.3	1.1	1.6	1.1
3	3	1.7	AM	32.4	5.6	30	6			C	10.3	83.5	468	0.765	23.2	40.9	59.7	27.8
3	4	1.7	AM	40.6	2	0	2		Dead trunk	N/A	12.9	131.2	262	0.765	13.0	71.5	104.1	45.9
4	5	1.7	AM	23.5	3.2	30	4			C	7.5	43.9	141	0.765	7.0	18.5	27.1	13.6
5	6	3.2	AC	14	2.3	0	2			UC	4.5	15.6	36	0.765	1.8	5.2	7.6	4.3
5	7	3.2	AC	12	2.3	0	2				3.8	11.5	26	0.765	1.3	3.5	5.2	3.1
5	8	3.2	AC	6	2.3	0	2		Stem broken	UC	1.9	2.9	7	0.765	0.3	0.6	0.9	0.7
6	9	3.8	AM	37.5	4.8	20	5			C	11.9	111.9	537	0.765	26.6	58.7	85.6	38.5
7	10	4.1	CA	14.4	2.85	0	3			UC	4.6	16.5	47	0.765	2.3	5.5	8.1	4.6
8	11	4	EA	15.8	2.2	10	2			UC	5.0	19.9	44	0.765	2.2	6.9	10.2	5.6
9	12	1.75	EA	14.4	1.8	0	2			UC	4.6	16.5	30	0.765	1.5	5.5	8.1	4.6
10	13	4.23	EA	14.5	3.1	0	3			UC	4.6	16.7	52	0.765	2.6	5.6	8.3	4.7
11	14	4.18	EA	13.5	3.1	0	3			UC	4.3	14.5	45	0.765	2.2	4.7	6.9	4.0
12	15	4.3	EA	9	3.1	0	3			UC	2.9	6.4	20	0.765	1.0	1.7	2.6	1.6
13	16	4.25	EA	13.5	3.3	10	3			UC	4.3	14.5	48	0.765	2.4	4.7	6.9	4.0
14	17	4.4	EA	26	2.5	10	3		top branch d	UC	8.3	53.8	134	0.765	6.7	23.8	34.8	17.1
15	18	4.37	EA	17.4	3.9	0	4			UC	5.5	24.1	94	0.765	4.7	8.8	12.9	7.0
16	19	4.47	EA	29.6	5.9	0	6			C	9.4	69.7	411	0.765	20.4	32.7	47.8	22.7
17	20	4.5	EA	12	1	45	1			UC	3.8	11.5	11	0.765	0.6	3.5	5.2	3.1
18	21	4.75	EA	21	5.8	10	6			UC	6.7	35.1	204	0.765	10.1	14.0	20.6	10.6

TEMPLATE | EXAMPLE | Plot 1 | Plot 2 | Plot 3 | Plot 4

NOTE: AGB = above ground biomass; BGB = below ground biomass; TotalB = AGB + BGB

SUMMARY FORMAT

BARNES CREEK #1 2018 — CHAVE 2005

Av tree biomass (kg) AGB	BGB	TotalB	Total tree biom (kg) AGB	BGB	TotalB	Biomass (kg/m2) AGB	BGB	TotalB	Carbon (tC/ha) AGB	BGB	TotalB	Av tree biomass (kg) AGB/H	AGB	Total tree biom (kg) AGB/H	AGB	Biomass (kg/m2) AGB/H	AGB	Carbon (tC/ha) AGB/H	AGB
24.6	11.5	36.1	1198.4	557.6	1756.0	22.11	10.29	32.40	110.6	51.4	162.0	7.7	16.9	373.0	821.2	6.88	15.15	34.4	75.8

Mean AGB (t	55.1
BGB (tC/ha)	110.6
Carbon	165.63683
AGB	110.17
BGB	221.10821
Total Biomass	331.27

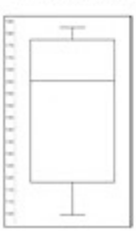
Mangrove Wood Density Chart (g/cm3)

SPECIES CODE	WOOD DENSITY (g/cm3)
AA	0.639
AC	0.7
AM	0.765
BC	0.836
BE	0.839
BG	0.78
BP	0.79
BS	0.685
BR	0.6475
CA	0.752
CP	0.975
CT	0.872
CS	0.4725
CI	0.8
DL	0.7
DS	0.5
EA	0.618
HL	0.848
LL	0.64
LR	0.65
OO	0.85
PA	1.055
RA	0.827
RM	0.867
RS	0.855
SH	0.9
SA	0.638
SC	0.52
XG	0.605
XM	0.647

Carbon storage in the Pioneer Valley

(tons of carbon per hectare)

Plot	tC/ha
1	162.0
2	104.6
3	182.4
4	158.6



Population size: 4
Median: 160.3
Minimum: 104.6
Maximum: 182.4
First quartile: 118.1
Third quartile: 177.3
Interquartile Range: 59.2
Outliers: none

Standard deviation (σ): 28.78558667111

Thursday

Soil Sample

Site 1 S21.12934
E149.18974

surface
a – 0-2cm
b – 14-16cm
c – 28-30cm

pH – 6.19, 6.34
Salinity – 23.3 ppt
Temp – 24.6°C, 24.5°C
do – 6.49.5

Site 2 S21.12986
E149.18990

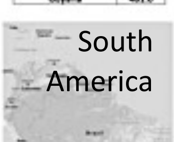
a – 0-2cm
b – 14-16cm
c – 28-30cm

Salinity
pH – 6.75
Temp – 24.7
do – 6
Salinity – 23.8ppt

Soil Abiotic factors:
- pH
- Salinity
- Temperature
- Dissolved Oxygen (DO)

Carbon storage compared to other regions

Region	tC/ha
Pioneer Valley	151.9
Aklan	146.9
Bataan	317.6
Palawan	235.5
Samar	300.0
Guyana	481.0



Thanks:
- Mackay Christian College for making this possible
- Janelle Plant for her passionate undertaking to make this work
- Year 11 Biology class for their admirable participation despite a hostile environment
  - Emma Stam
  - Alex Oosterbroek
  - Grace Watson
  - Mikayla Patullo
  - Sarah Daniel
  - Ocean George-Cawte
  - Ellisa Kay

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Email Jock Mackenzie

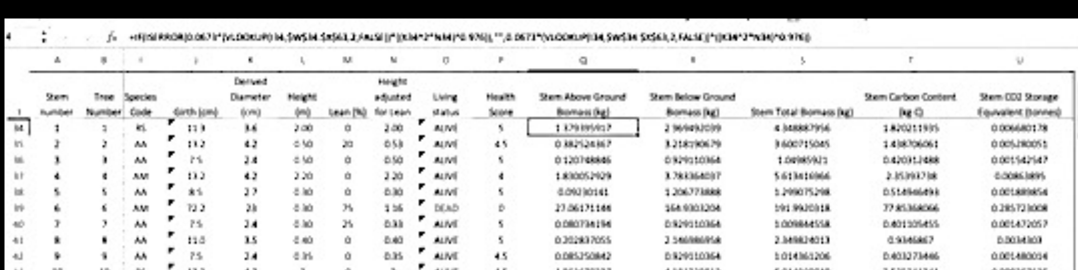
Name/s:

Date:

Last step: Email your datasheet and photos to…

jmackenzie@earthwatch.org.au

Jock will send you an excel spreadsheet that will include pre-filled formulas used to calculate: Stem Above Ground Biomass (kg), Stem Below Ground Biomass (kg), Stem Total Biomass (kg), Stem Carbon Content (kg C) and Stem CO_2 Storage Equivalent (tonnes).
From there, you can make any graph you need!
For example:



=IF(ISERROR(0.0673*(VLOOKUP(I34,$W$34:$X$63,2,FALSE))*((K34^2*N34)^0.976)),"",0.0673*(VLOOKUP(I34,$W$34:$X$63,2,FALSE))*((K34^2*N34)^0.976))

	Stem number	Tree Number	Species Code	Girth (cm)	Derived Diameter (cm)	Height (m)	Lean (%)	Height adjusted for Lean	Living status	Health Score	Stem Above Ground Biomass (kg)	Stem Below Ground Biomass (kg)	Stem Total Biomass (kg)	Stem Carbon Content (kg C)	Stem CO2 Storage Equivalent (tonnes)
34	1	1	RS	11.3	3.6	2.00	0	2.00	ALIVE	5	1.379895917	2.969492039	4.348887956	1.820211935	0.006680178
35	2	2	AA	13.2	4.2	0.50	20	0.53	ALIVE	4.5	0.382524867	3.218190679	3.600715045	1.438706061	0.005280051
36	3	3	AA	7.5	2.4	0.50	0	0.50	ALIVE	5	0.120748846	0.929110364	1.04985921	0.420312488	0.001542547
37	4	4	AM	13.2	4.2	2.20	0	2.20	ALIVE	4	1.830052929	3.783364037	5.613416966	2.35393738	0.00863895
38	5	5	AA	8.5	2.7	0.30	0	0.30	ALIVE	5	0.09230141	1.206773888	1.299075298	0.514946493	0.001888854
39	6	6	AM	72.2	23	0.30	75	1.16	DEAD	0	27.06171144	164.9303204	191.9920318	77.85368066	0.285723008
40	7	7	AA	7.5	2.4	0.30	25	0.33	ALIVE	5	0.080734194	0.929110364	1.009844558	0.401105455	0.001472057
41	8	8	AA	11.0	3.5	0.40	0	0.40	ALIVE	5	0.202837055	2.146986958	2.349824013	0.9346867	0.0034303
42	9	9	AA	7.5	2.4	0.35	0	0.35	ALIVE	4.5	0.085250842	0.929110364	1.014361206	0.403273446	0.001480014
43	10	10	RS	13.2	4.2	2	0	2	ALIVE	4.5	1.863670237	4.181229812	6.044900049	2.525241341	0.009267636

This booklet was created by Gail Riches following a teacher PD at Boyne Island Environmental Education Centre in August 2023 as part of EarthWatch Australia's '*Protecting Wetlands for the Future*' program
@mangrovewatch @earthwatch_aus @GreatBarrierReefFoundation. Department of Climate Change, Energy and Water.

The '*Protecting Wetlands for the Future*' program is proudly supported by partnerships between the Australian Government Reef Trust and the Great Barrier Reef Foundation Citizen Science for Change Grants.

#lovethe reef #ReefTrust #TeachLive #ProtectingWetlandsForTheFuture #mangrove #CitizenScience #education #professionaldevelopment #greatbarrierreef #wetlands #mangroves #conservation #teachers #STEM #stemeducation #environment #conservation #benanddiphotography #BIEEC #MarineEducation

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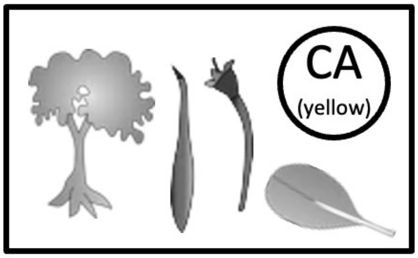
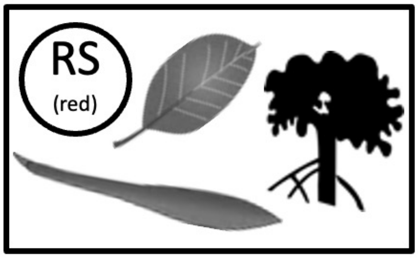
Marvellous Mangroves

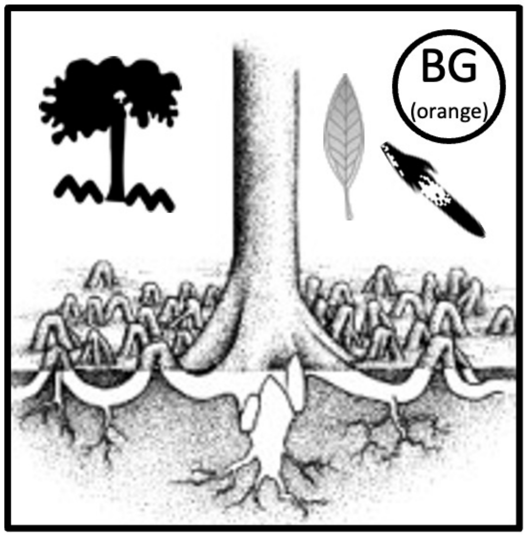
Cheat sheet

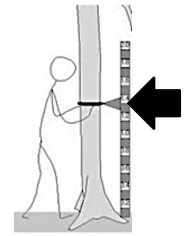
Name/s:

Date:

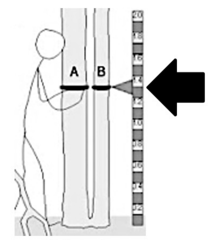




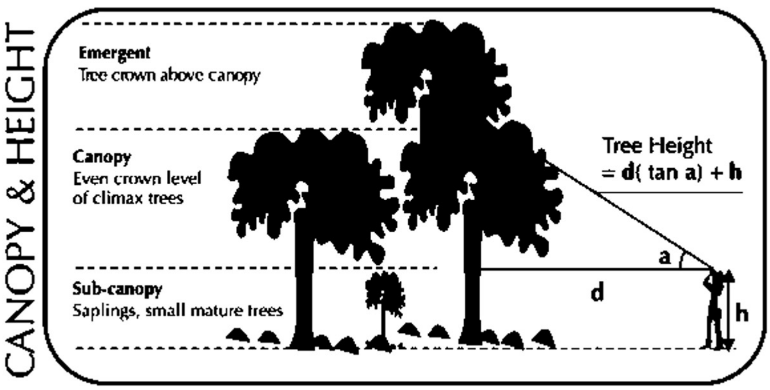




High stem



Multi-stem tree



Live Trees	
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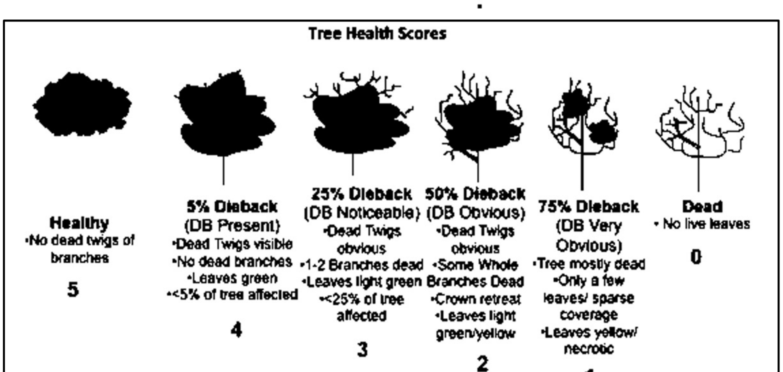
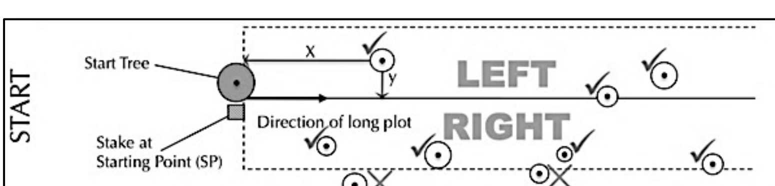
LDB	Live with dead branches
LC	Live with low canopy cover
ID	Live with insect damage (herbivory)
LF	Live Fallen Tree
LBT	Live Broken Trunk
LHD	Live with Cut or Trimmed Branches
LSD	Live with grazing damage (e.g. cows)

Dead Trees	
DTW	Dead with twigs
DB	Dead with branches
DT	Dead trunk (no branches)
ST	Dead stump (<1m tall)
DF	Dead fallen
DC	Dead cut
STC	Dead stump cut (<1m tall)





Record at least 30 live trees, including *at least* 25 live *canopy* trees and 50 stems.

Multi-stems >10cm circumference.
Multi-stems = 1 tree.

Take photos of transect *and* canopy every 10m