Step by Step Guide to PPC Tree Monitoring

Covers content found in sub-protocols 2 and 4 of the PPC Monitoring Framework

Part 1: Office

Done before going to the field

Overview: What's done/covered in this part?

- Background
- Step 1: Determine size and characteristics of site
- Step 2: Calculate number of monitoring plots and control plots needed
- Step 3: Consider if all plots should be permanent, or only ½
- Step 4: Place plots – generate GPS coordinates
- Step 5: Download KoboCollect – access the survey
- Step 6: Prepare to go to the field

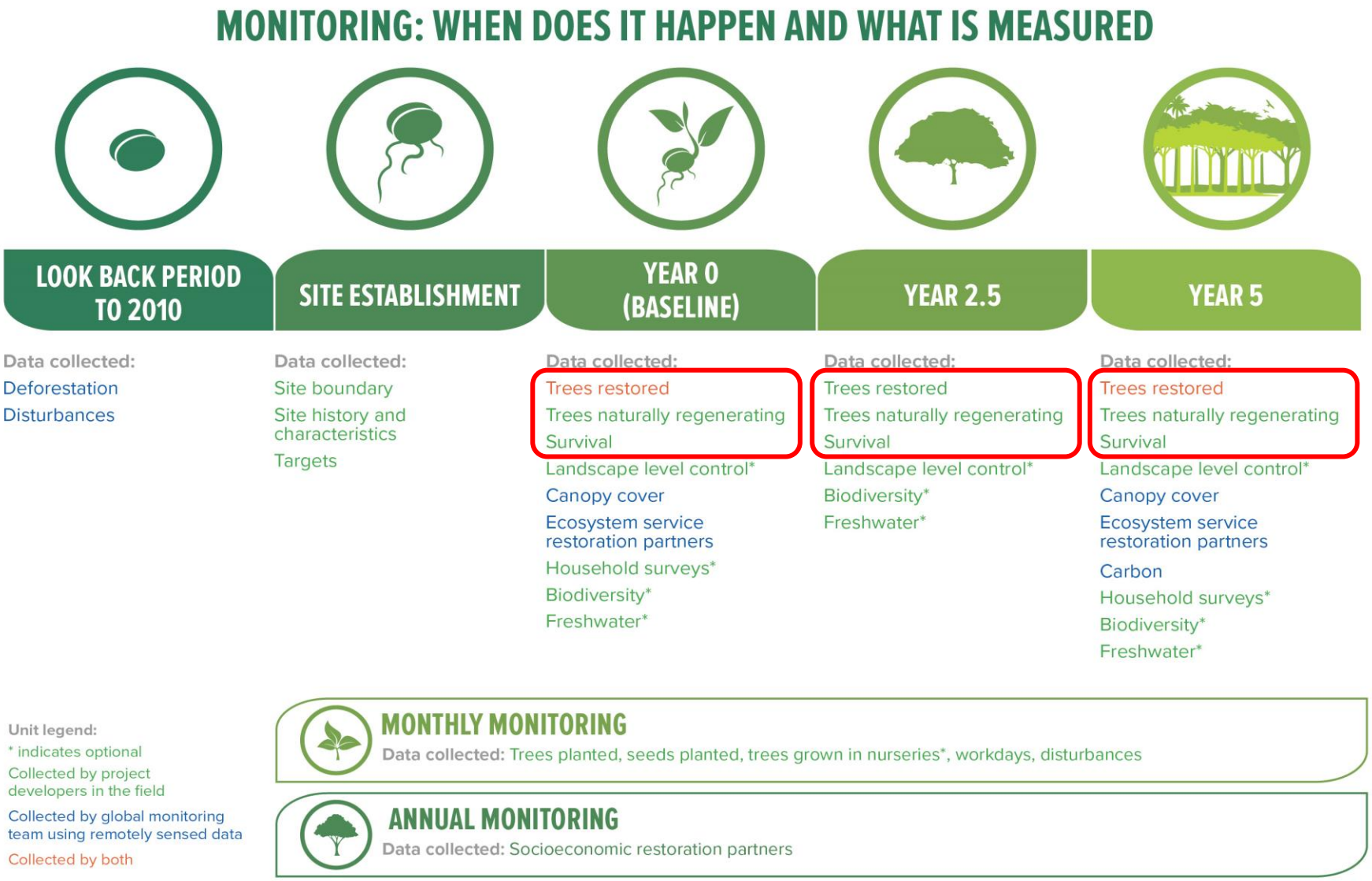
Priceless Planet Coalition: Program Monitoring

- What sets it apart:
  - Monitoring “Trees restored," not just planted, including natural regeneration (5-year timeframe).
  - Nineteen (19) indicators w/detailed protocols for data collection & processing, designed to function across geographies, scales, and restoration strategies.
  - Integration of remote sensing including the Trees in Mosaic Landscapes (TML) dataset for tree cover monitoring.

Priceless Planet Coalition: Program Monitoring

- Importance of Tree Monitoring:
  - Tree Monitoring allows us to calculate overall diversity and species richness of planted and regenerating trees in restoration sites, compared to sites without restoration (control).
  - Inform potential adaptive management, especially in situations where the planted tree species have low survival rates.
  - Learnings about restoration methods, adaptability and selection of species for future enrichment plantings.

Monitoring Time Frame



PPC Program Indicators

Metric Category	Indicator per intervention site
Forests: Tree density and diversity	Impact Indicator A: # of trees restored (survived and crowded in at year 5) 1. # of trees planted 1.1.1 disaggregated by species 1.2 # of trees naturally regenerating 1.2.1 disaggregated by species (Optional)1.3 # of trees grown in nurseries
Forests: Tree cover	Impact Indicator B: % attainment of target canopy cover 1.4 % change in tree crown canopy
Forests: Tree survival	1.5 % survival of planted trees 1.6 # of major disturbances observed
Carbon Benefits	2. Estimated # tons of CO_2 sequestered (by year 5)
Social/Community Benefits	3.1. # of socioeconomic restoration partners 3.1.1. # of Person-days of work created 3.2. # of ecosystem service restoration partners (Optional) 3.2.1 # people directly benefitting from improved freshwater quality or quantity
Management	4.1. # of hectares under restoration, by ecosystem type and restoration intervention 4.2. $ cost per tree grown by restoration intervention type
Biodiversity (all optional)	5.1. % change in species richness by class 5.2 Average % change in abundance by class 5.3 Wildlife Picture Index

Integrating Data from Multiple Sources

- From field data
- From Remote Sensing (RS) data
- From field and remote sensing (RS) data
- Vegetation Monitoring contribution

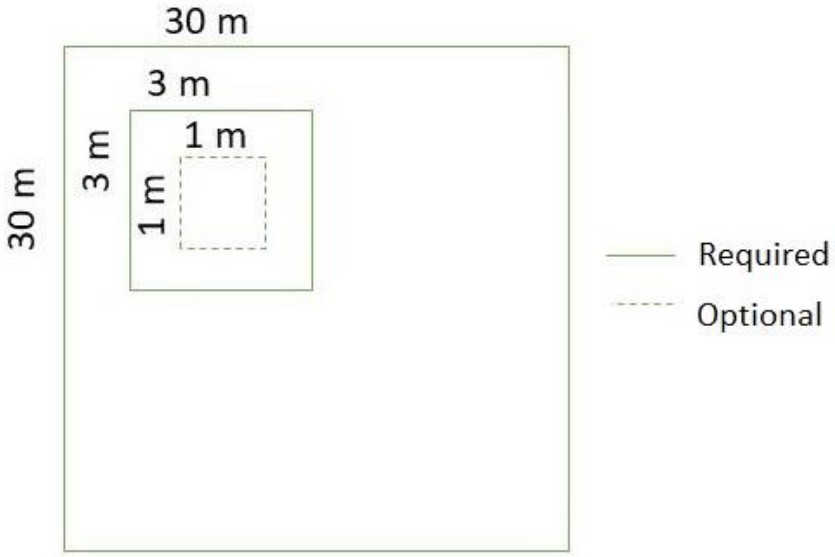
Tree Monitoring Sub-Protocols

- How do we collect this data and implement the tree monitoring?

- Sub-Protocol 2:
  - Control Monitoring, Optional landscape level control sites:
    - Siting and establishment of control plots.
    - Monitoring methods for baseline and following monitoring.
    - (Optional) Siting and establishment of landscape level control units.

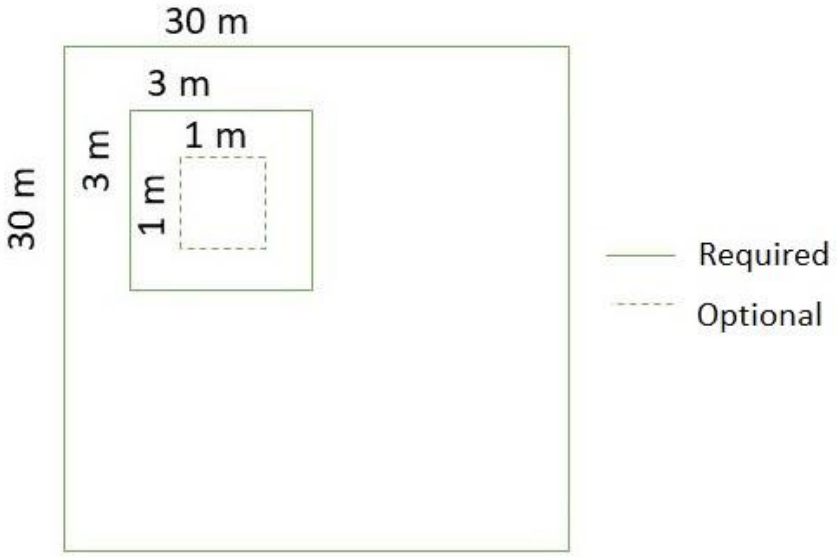
- Sub-Protocol 4:
  - Tree Monitoring:
    - Siting of monitoring plots.
    - Method for field-based tree monitoring suitable at baseline (Y0), Y2.5 and Y5.
    - Monitoring all restoration methods including natural regeneration.
    - Optional guidance for carbon stock assessment.

Tree Monitoring: Data Collected



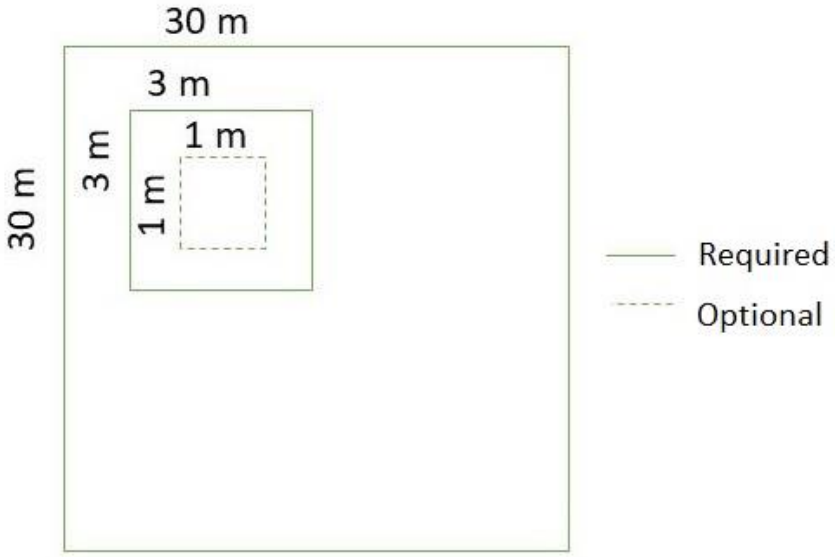
- 30m x 30m plot (re-locate empty plots up to twice in same HA)
  - GPS coordinates of each corner
  - Count of trees >10cm DBH – disaggregated by species and type (planted, naturally regenerated, etc)
  - 4 pictures
  - Background info: is the plot permanent or not, is it on a restoration or control site, what is the planting pattern, etc
  - Count of additional planted trees in permanent plots

Tree Monitoring: Data Collected



- 3m x 3m plot
  - GPS coordinates of centroid
  - Count of trees 1-9.9cm DBH – disaggregated by species and type (planted, naturally regenerated, etc)

Tree Monitoring



- OPTIONAL: 1m x 1m plot
  - Trees smaller than 1cm DBH

- Developers are NOT asked to collect:
- Count of trees across the entire restoration site
- DBH
- Height

Carbon Benefits

- The methods outlined in sub-protocols 2 and 4 are not adequate for calculating carbon to a crediting standard. However, sub-protocol 4 highlights specific ways that this the PPC methodology can be adapted for carbon.
- Calculations of carbon from data collected in the field are not required within the PPC program.

Step 1: Determine size and characteristics of site

- Use your site shapefile/kml to calculate the number of hectares in your site.
- Ask yourself, does this site have any strata? Strata are submitted in the Site Establishment form.
  - That's important if there are multiple vegetation types (i.e. bare ground vs. grass vs. secondary growth) or multiple types of restoration (i.e. agroforestry, ANR) applied in the area.

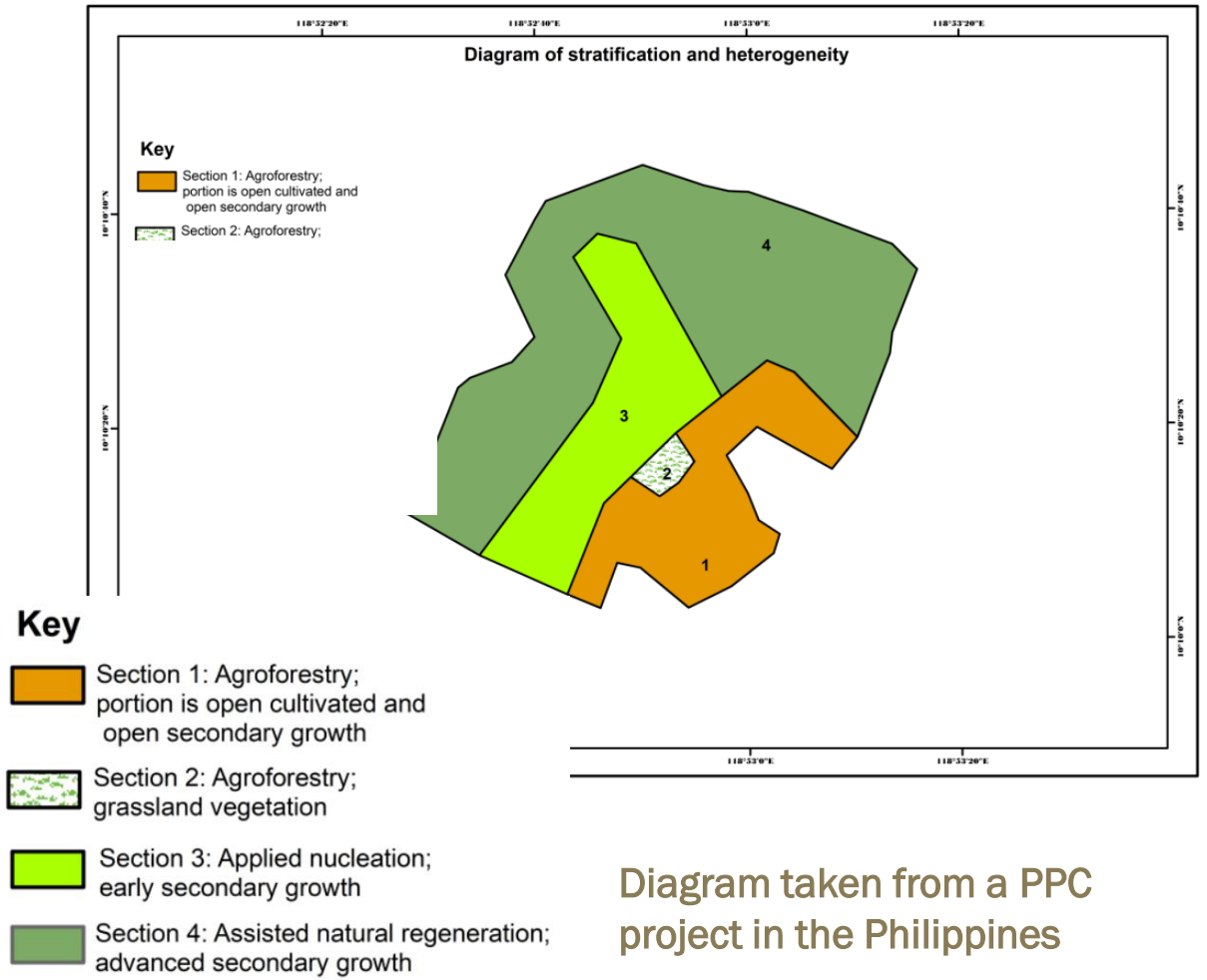


Diagram taken from a PPC project in the Philippines

Example from Brazil

Diagram taken from a PPC project in Brazil

- As shown in the picture to the left, the strata on this site follow the density of vegetation
- The planting strategy is determined by the strata
  - Enrichment planting is done in areas with existing vegetation
  - Planting in a 3x3 grid is done in areas with sparse vegetation

Step 2: Calculate number of monitoring plots and control plots needed

- **Monitoring plots -** Use table from slides/protocol or do power analysis.
  - The number of monitoring plots cannot be less than the required minimum, unless the method is approved and the number of plots agreed with the global monitoring team.

Restored Area (ha) = A	Number of Plots (minimum PPC standard)
A ≤ 50	1 per hectare
A > 50 ≤ 100	1 per ha for 1st 50, 1 per 2ha for 2nd 50
A > 100	1 per ha for 1st 50, 1 per 2ha for 2nd 50, 1 per 5ha for all over 100

Step 2: Calculate number of monitoring plots and control plots needed

- **Control plots –** minimum 1 per strata per site

  - Same size as regular monitoring plots (30m x 30m).
  - Should be mapped, marked, and monitored in the same manner as the restoration monitoring plots (all control plots are permanent).
  - If a site is less than ½ a hectare in size, no control plot is required.
  - If a site is very small (½ to 1 ha), then the control plot can be 10m x 10m instead of 30m x 30m.

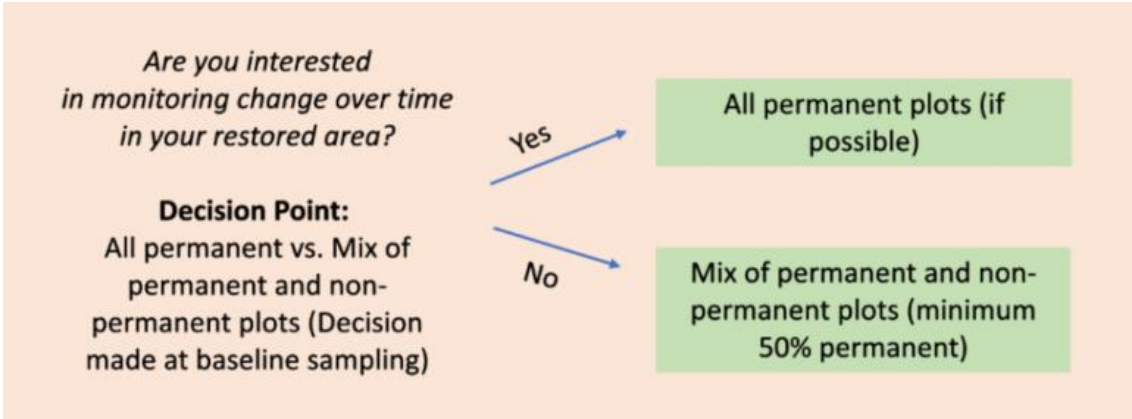
  - If there is significant variation (strata) in the restoration site, then multiple control plots are needed to encompass that variation.

  - **Plot-level control x landscape level control (optional):** It is ideal to have both controls, however, choosing a control type should be dependent on the resources available.

Step 3: Consider if all plots should be permanent, or only ½

- At least ½ the tree monitoring plots should be permanent, and all control plots are permanent.
- The other ½ are up to you to decide if they are permanent or not.
  - Permanent plots are recommended if the focus is scientific research or when the funding comes from banks or official agencies.

- Consider what type of materials you need to mark your permanent plots (Note: you'll need to find them in 5 years).

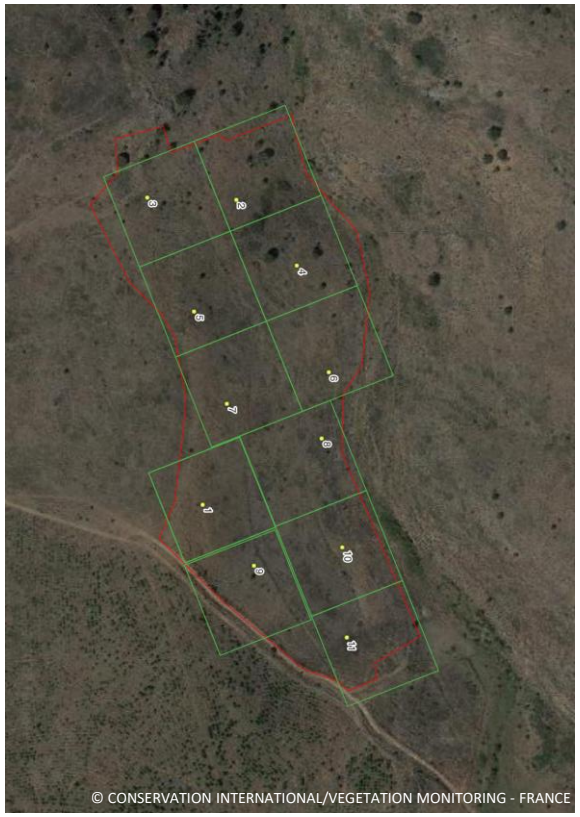


Step 4: Place plots – generate GPS coordinates

- Recommend to place a 1HA grid over the site and randomly place a plot within each grid + randomly place control sites (1 per strata):
  - Generate randomized "plot centroids" in ArcGIS or using a random number generator to determine where the plot should be placed.
  - Correct the randomized placement distribution if necessary to ensure that the right fraction are in each stratum.

- Plots should also not be placed within 5 meters of the restoration site's boundary, to avoid edge effects.

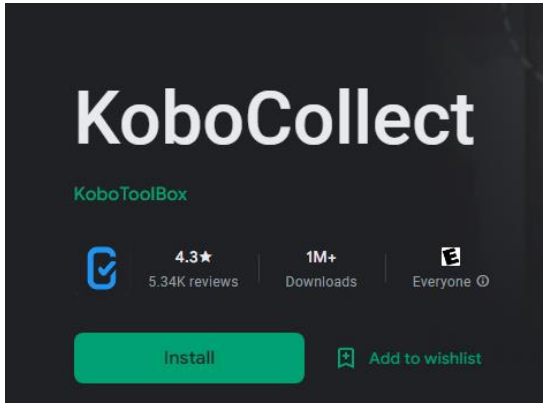
- Download GPS points to find your plots in the field. Adding the points to a GPS makes it easier to locate the plots.



If in doubt about the proper location of control plots, please contact the global monitoring team. We welcome conversations around proper control design and are available to help determine the right specifications for any given site.

Step 5: Download KoboCollect – access the survey

- Available on Android smartphones and tablets (Google Play Store).
- Access the PPC survey (same survey used for control and restoration plots)
- Survey available in English, Spanish, French and Portuguese.



Step 5: KoboCollect – How to access the survey

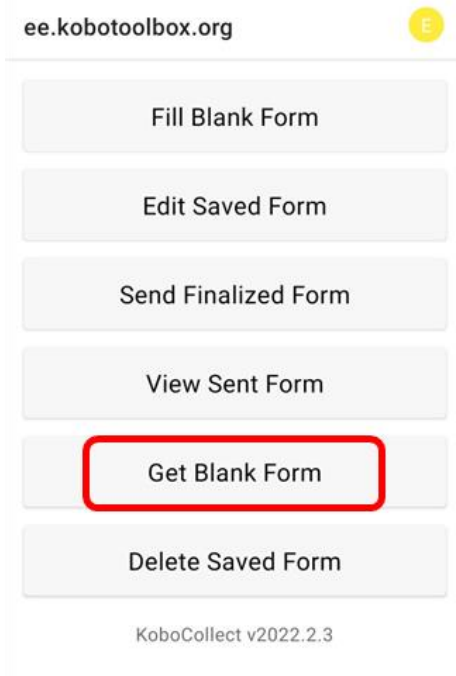
1) Open KoboCollect and Select Configure with QR code enter project details.

2) Point your cellphone camera to the QR code.

3) Make sure you have access to the tree monitoring survey and your device is connected to the internet.

4) Select Get Blank Form from the home menu.

Vegetation Monitoring form QR Code access



Step 5: KoboCollect – How to access the survey

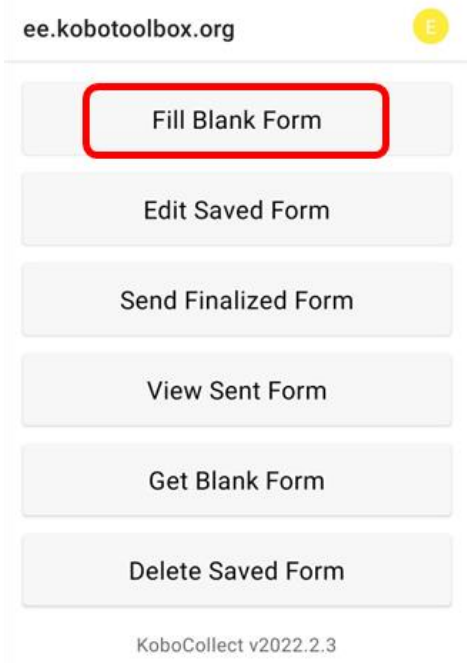
5) The Tree Monitoring survey should appear.

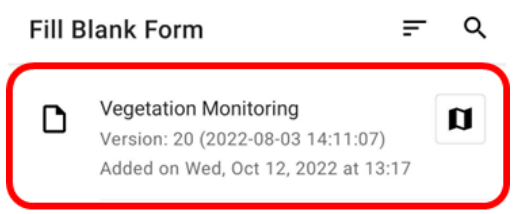
6) Select the Tree Monitoring survey form by selecting them manually. Then click Get Selected.

7) Once you have blank form(s) in the app, you will no longer require an internet connection to collect data.

8) Select Fill Blank Form from the home menu.

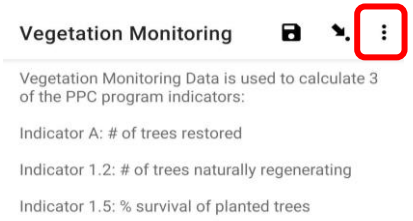
9) Select the survey form that you want to use to start collecting data.



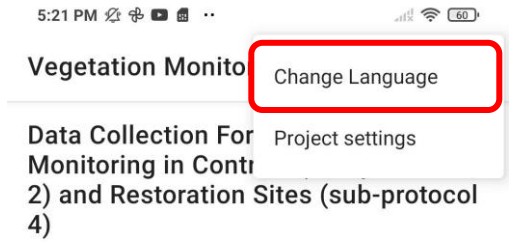


Step 5: KoboCollect – How to set up a different language

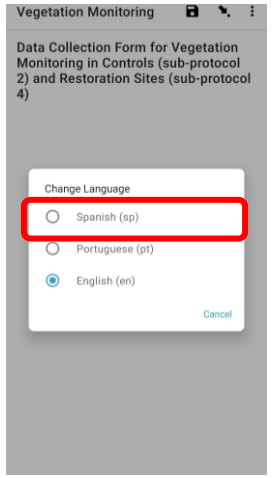
1) Click and open Form options



2) Select Change Language



3) Select the language



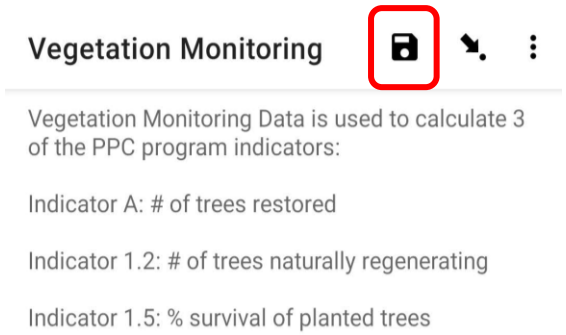
4) Tree Monitoring Form in English, Spanish, Portuguese and French

*KoboCollect Form

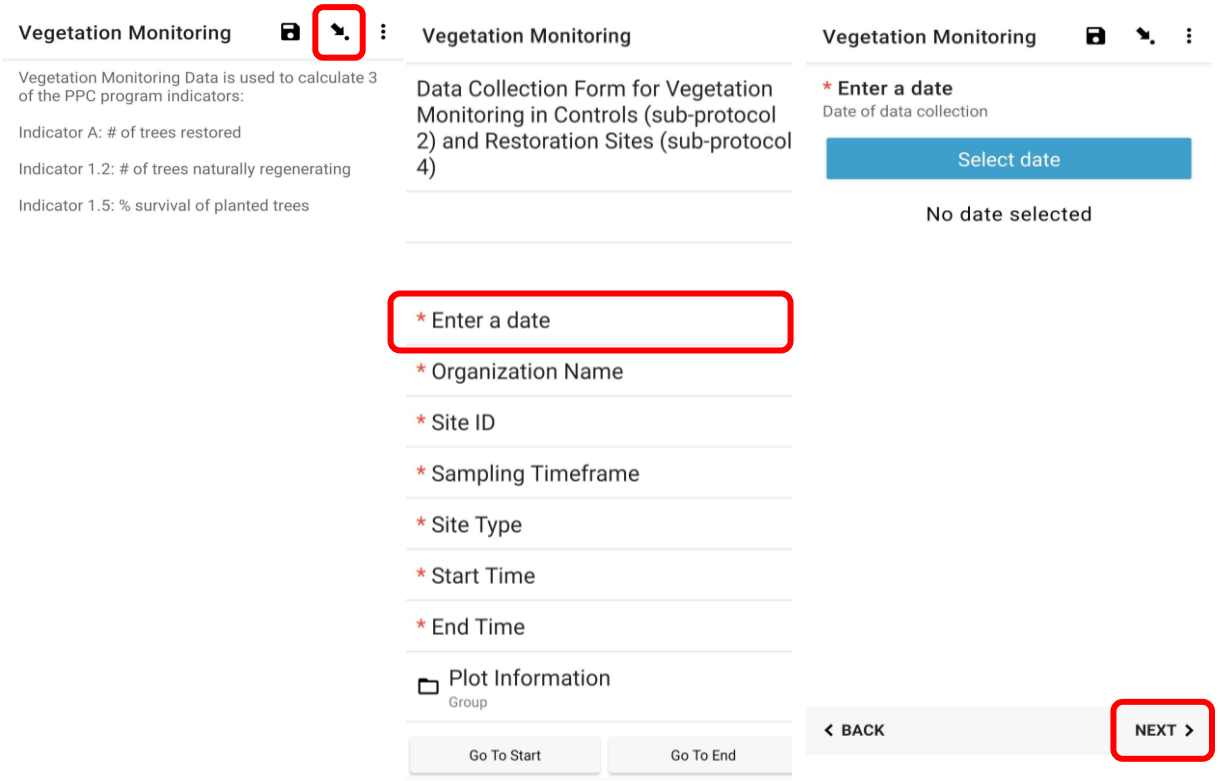
Step 5: KoboCollect – How to navigate within the form

1) Click and save your form.

- Don't forget to save your data!



2) Tree Monitoring Form Overview:



*KoboCollect Form

Step 6: Prepare to go to field

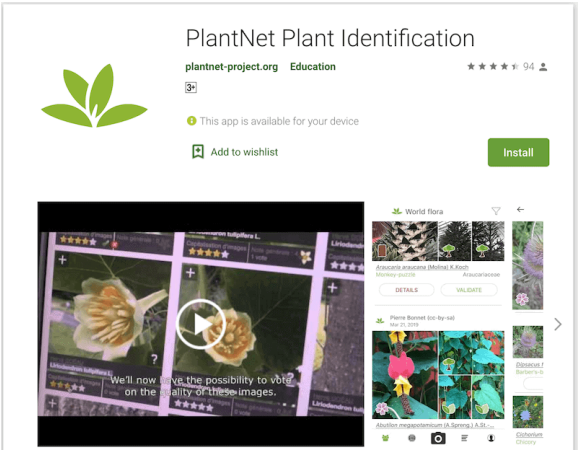
- Obtain materials for marking permanent plots.

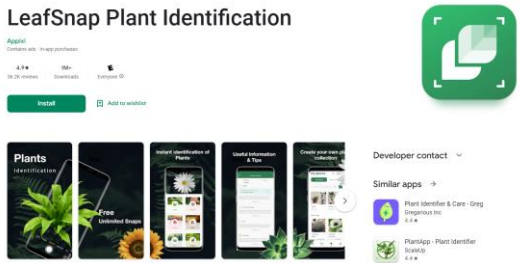
- Obtain other materials need for monitoring, including:
  - Tablet or Android smartphone with the KoboToolbox app.
  - GPS – a GPS linked to the smartphone or tablet is preferred.
  - DBH tape or calipers to measure tree size.
  - Measuring tapes for laying out monitoring plot boundaries.
  - Any resources needed to identify tree species using scientific names.
  - (Optional) 1m x 1m squares for the smallest sub-plot, if applicable.

- Before going to the field, substitutes can be created, such as homemade calipers or measuring lengths on rope if no measuring tapes accessible.

Step 6: Prepare to go to field

- Trees species identification requires some expertise:
  - Have a list of the species scientific names in your project helps to identify your species.
  - Botanists may be able to support on site or remotely with samples.
  - Herbaria could be created/improved upon with additional support.
  - Consider smartphone applications:
    - In Mexico, the platform "Enciclo Vida" created by CONABIO has the information of +113,000 species.
    - "Pl@ntNet" has the option to identify plants with pictures. It is organized in different thematic and geographical floras.
    - Explore applications specific to your area.





Part 2: Field

Overview: What's done/covered in this part?

- Step 1: Go to the GPS coordinates of your first plot (take all the materials you need)
- Step 2: Do you need to resample?
- Step 3: Open survey in KoboCollect – fill in background info
- Step 4: Lay out and mark your 30m x 30m plot – record
- Step 5: Take GPS points of the 4 corners and take pictures – record
- Step 6: Count all trees greater than 10cm DBH – record
- Step 7: Lay out your 3m x 3m plot – record trees greater then 1cm DBH
- Step 8: Record planted trees in 30m x 30m that haven't already been counted
- Step 9 (optional): Lay out 1m x 1m plot and count all trees of all sizes - record
- Step 10: Check over all data in KoboToolbox survey - submit

Step 1: Go to the GPS coordinates of your first plot (take all the materials you need)

- KoboCollect: Available on Android smartphones and tablets (Google Play Store).

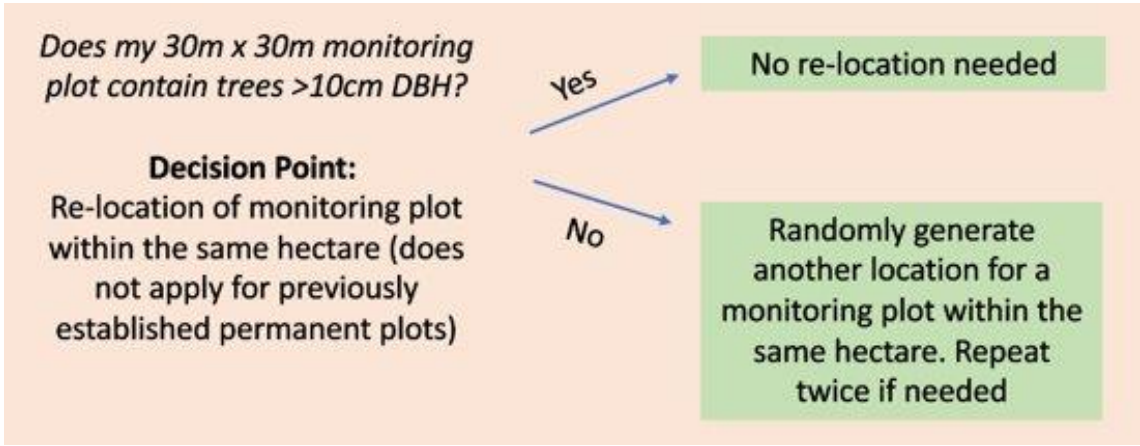
- Access the PPC survey (same survey used for control and restoration plots).

- Survey available in English, Spanish, French and Portuguese.

Step 2: Do you need to resample?

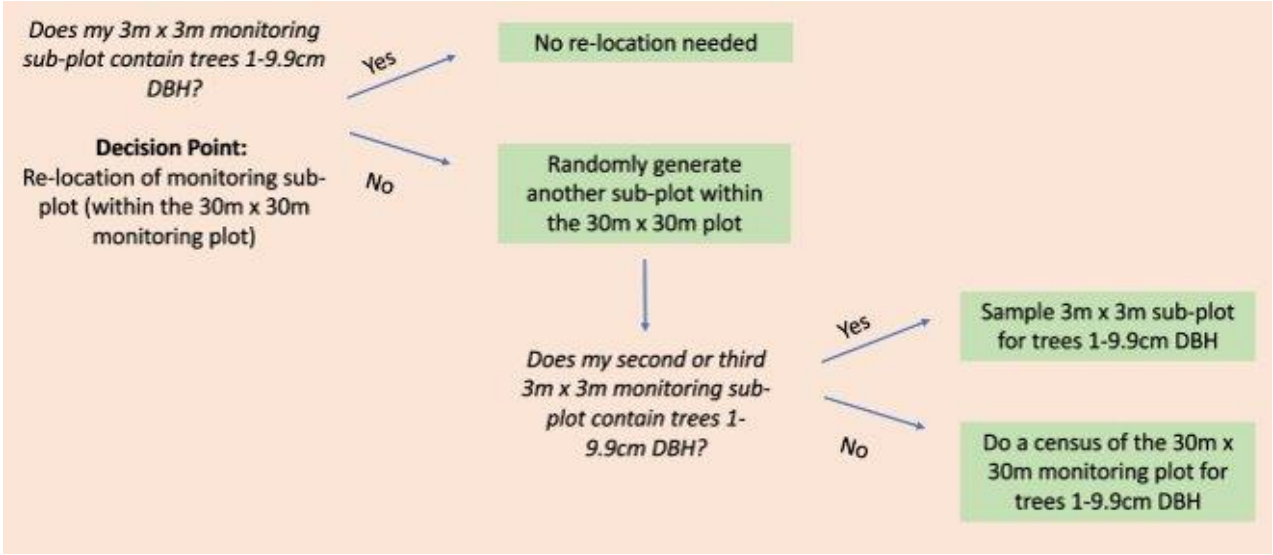
- A resampling (relocation of the plot within the same hectare) occurs if there are no trees >10cm DBH in the plot. Does not apply to permanent plots except at baseline.

- If there are no trees > 10 cm DBH found in the initial 30 x 30 m plot:
  - Plot should be counted as 'empty' and a new plot selected in a new random location within the same 1 ha sampling area. This may be done twice.
  - If 2 additional empty plots are found, then, the 3rd plot should be monitored, even if it is empty.
  - If this 3rd plot is also devoid of any trees > 10 cm DBH, this can be noted in the data sheet.



Step 2: Do you need to resample?

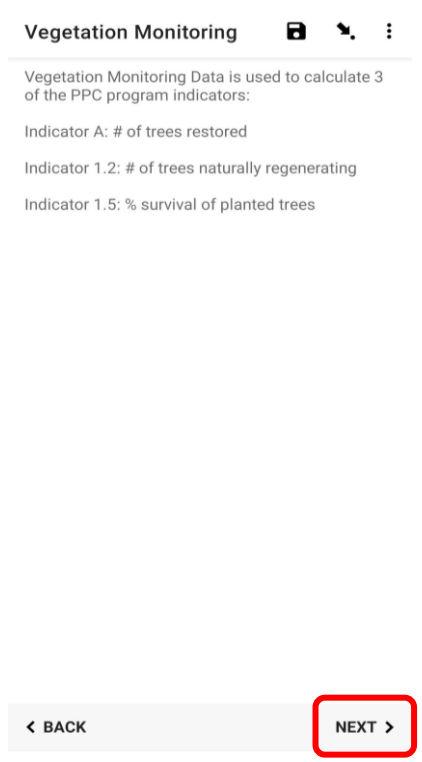
- The nested 3 x 3 plot should then be checked for trees 1-9.9cm:
    - If there are none, then, the nested plot should also be counted as empty and a new plot selected in a new random location within the 30x30m plot. Again, this may be done twice.
    - If 2 additional empty plots are found, then, a full census count of the 1-9.9cm size class should be done in the entire 30x30m plot.

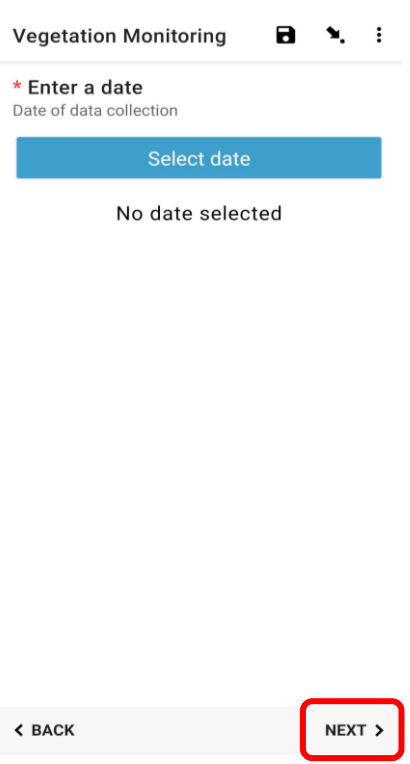


Step 3: Open survey in KoboCollect – fill in background info

- Tree Monitoring Form – Background info:
  - Date
  - Country
  - Organization Name
  - Site ID
  - Sampling Timeframe (Y0, Y2.5, Y5, Other)
  - Site Type (Control, Restoration)
  - Start time of data collection
  - End time of data collection

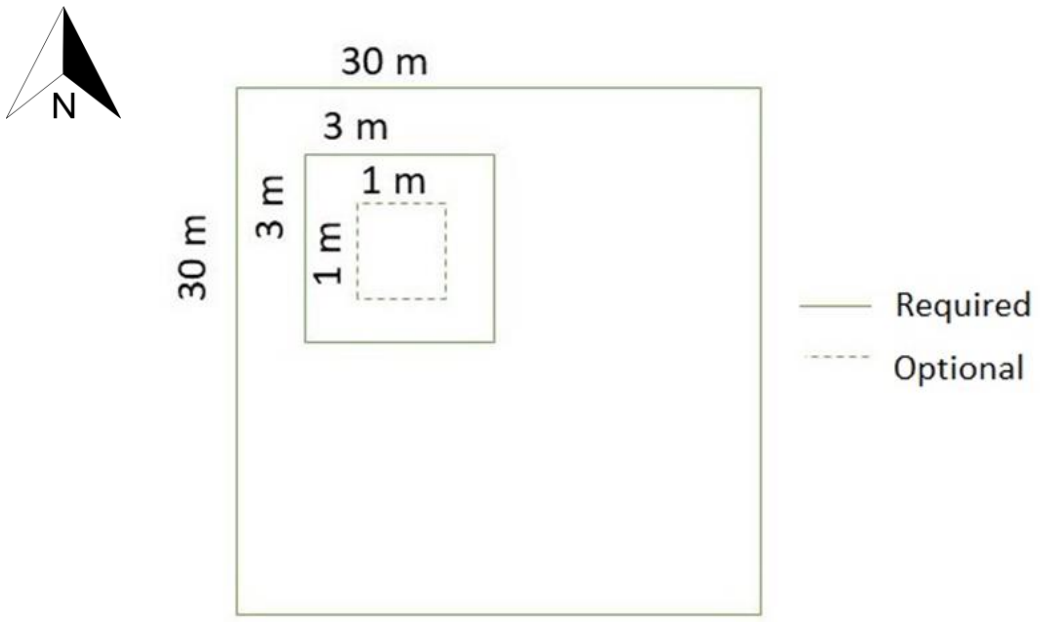
- KoboCollect can be used offline, and data can be shared later when returning to Wi-Fi or cellphone service.





*KoboCollect Form

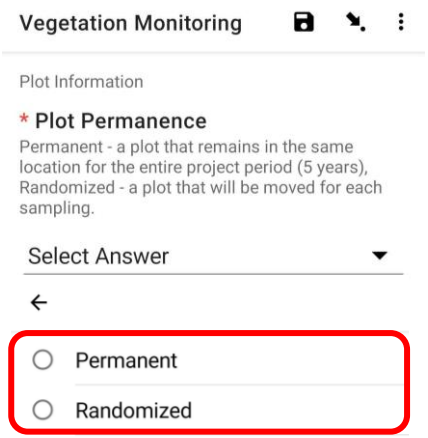
Step 4: Lay out and mark your 30m x 30m plot – record



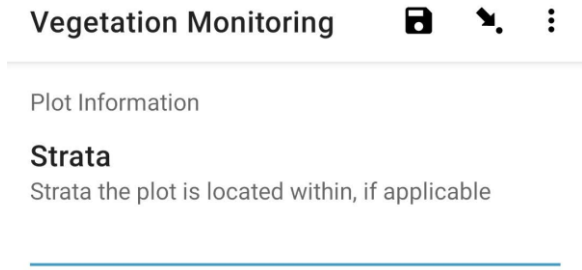
- 30m x 30m plot (re-locate empty plots up to twice in same HA).
- Orient plots north
- GPS coordinates of each corner.
- Background info: is the plot permanent or not, is it on a restoration or control site, what is the planting pattern, etc.
- Count of additional planted trees in permanent plots.

Step 4: Lay out and mark your 30m x 30m plot - record

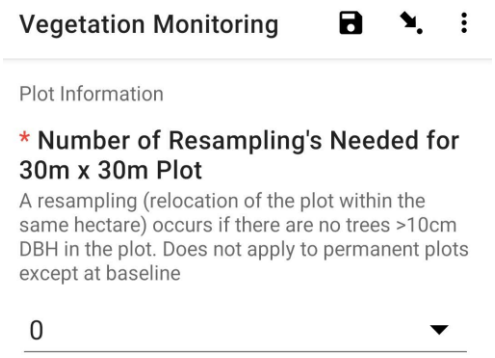
1) Inform if the plots are permanent or non-permanent (Randomized).



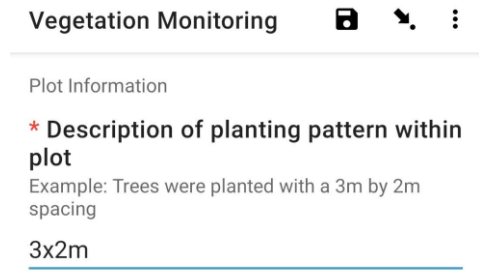
2) Strata the plot is located within, if applicable.



3) Inform the number of Resempling's needed for the plot.



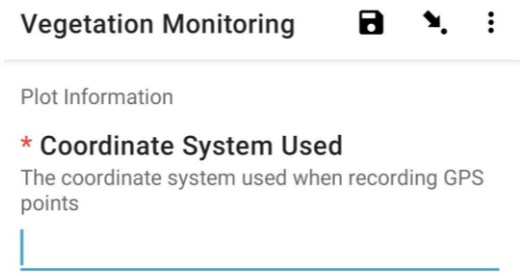
4) Describe the planting pattern within the plot (Example: Planted with a 3m x 2m spacing).

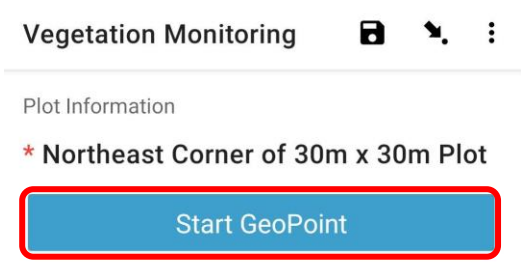


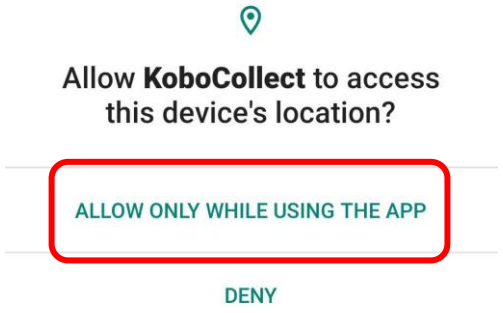
*KoboCollect Form

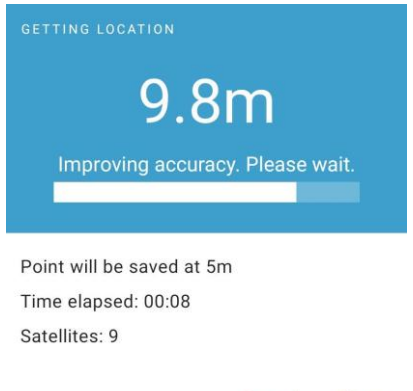
Step 5: Take GPS points of the 4 corners and take pictures – record

- **Permanent plots:** must be georeferenced with landmarks in the ground (wood staking, iron pipes, rebar, or PvE tubing) at 1.2 m in height.
    - GPS corner points and centroids should be recorded along with device margin of error.
- **Non-permanent plots:** Record GPS corner point and centroids. Do not need to be marked with landmarks.









*KoboCollect Form

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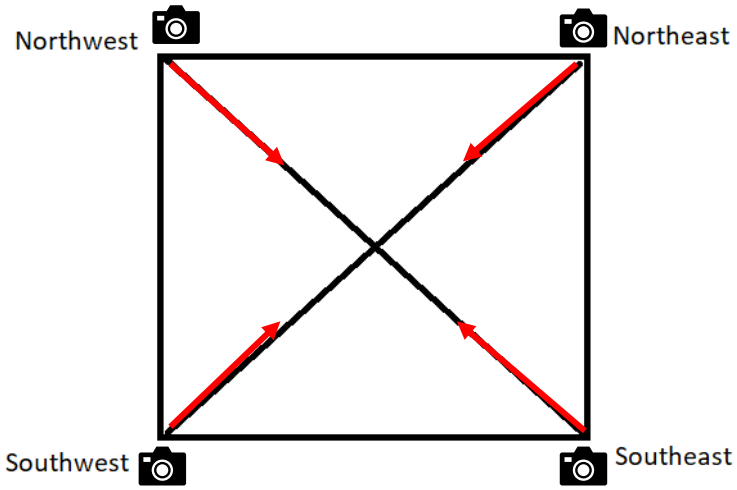
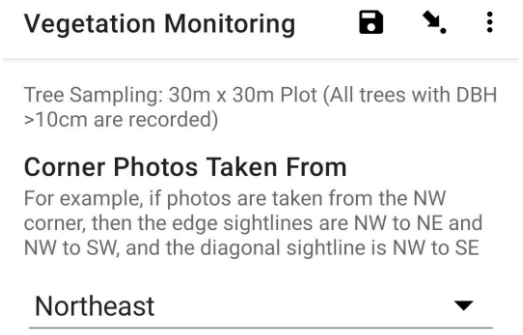
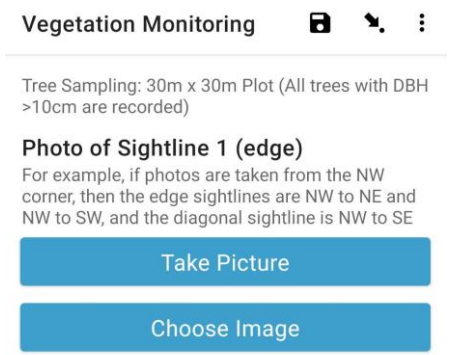




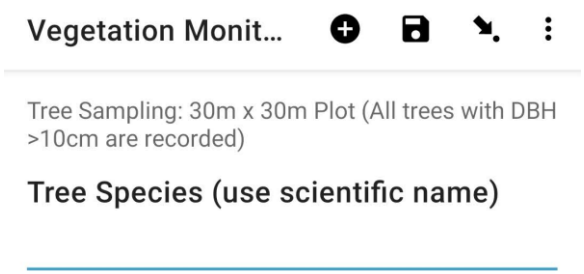


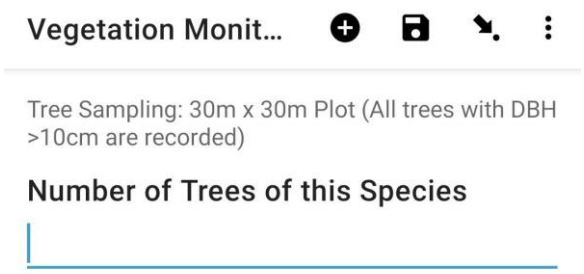
- 4 geotagged photos should be taken from each corner of the 30m x 30m plot:
  - Choose the angle that provides the best overview of the plot.
  - Take a picture on each edge of the plot in the centerline, pointing into the center of the plot.
  - NW, NE, SW, SE should be noted as in the GPS coordinates.

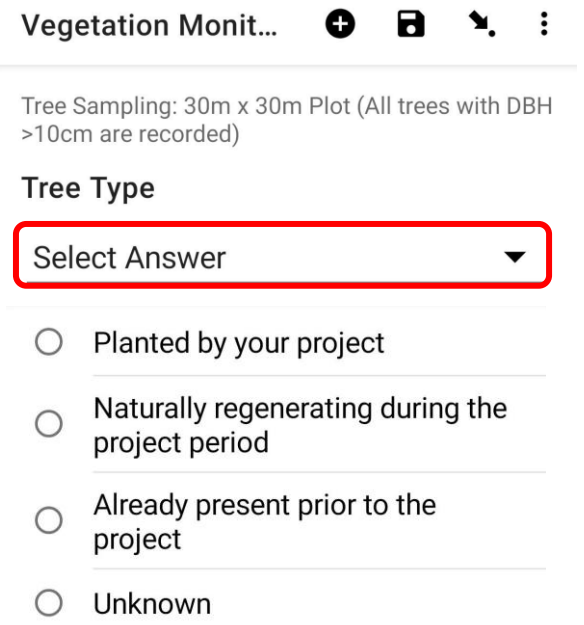
*KoboCollect Form

Step 6: Count all trees greater than 10cm DBH - record

- In the 30 m x 30 m plots all large trees (> 10cm DBH) per tree species are counted.
- DBH and height can be optionally recorded for each individual tree.
- Attention when counting the trees. Don't step on the naturally regenerant or planted trees.







*KoboCollect Form

Step 6: Count all trees greater than 10cm DBH - record

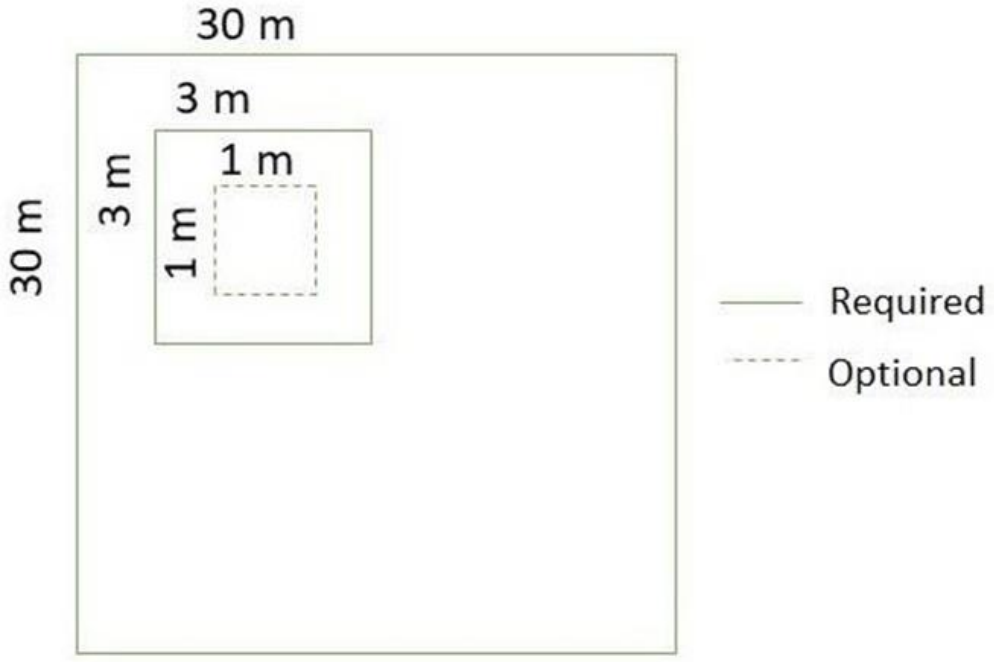
- How to distinguish a Naturally Regenerating Tree from a Planted/Seeded Tree

  - The historical knowledge of the planting patterns used (i.e., if it was a grid, what was the spacing of the grid, and/or what was the orientation (N/S/E/W) and spacing of the rows) will be essential to help in this task of distinguishing between a planted/seeded tree and a naturally regenerating tree.

  - In general, a tree is probably a regenerant (i.e., not planted) when any of the three following conditions apply:

    1) it is located outside a known planting row or grid position
    2) it is an obviously different size (either bigger or smaller suggesting more than one year's difference in age) than the observed range of sizes of the planted/seeded trees or
    3) it is not included in the species list of planted/seeded trees.

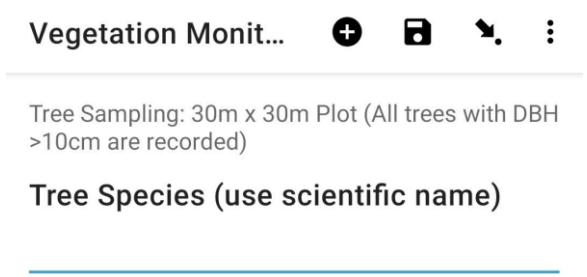
Step 7: Lay out your 3m x 3m plot – record trees greater then 1cm DBH

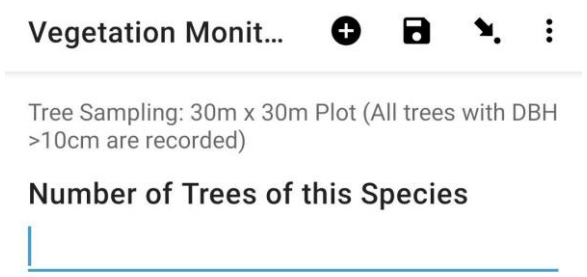


- All medium size trees/saplings (diameter s 1 – 9.9 cm DBH) per tree species are recorded – disaggregated by species and type (planted, naturally regenerated, etc).
    - Example: Species A, count of 2, and naturally regenerating.
- GPS coordinates of centroid.

Step 8: Record planted trees in 30m x 30m that haven't already been counted

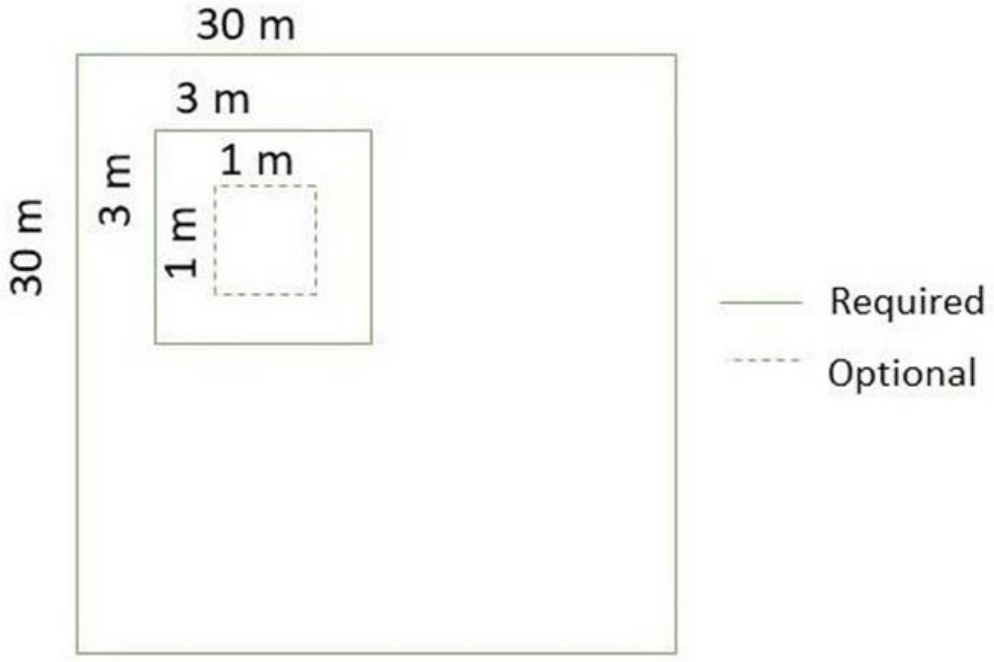
- Any trees PLANTED during this project that have not yet reached 10cm DBH should also be recorded.
  - This allows us to calculate survival of planted trees at Y5.
  - All tree species are recorded – disaggregated by species.
  - Example: Species A, count of 2.





*KoboCollect Form

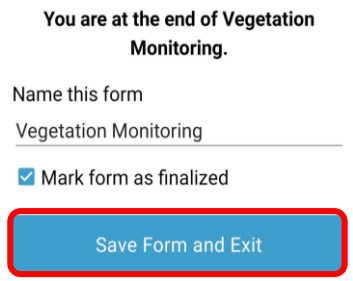
Step 9 (optional): Lay out 1m x 1m plot and count all trees of all sizes - record



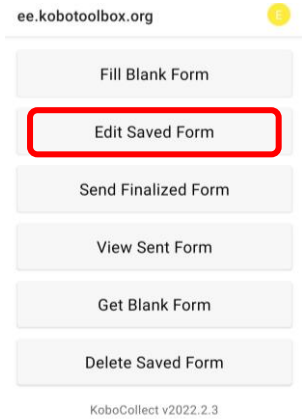
- Indication of the emerging, very young trees on the site.
- All tree saplings (<1 cm DBH) will be counted and identified to species or species type as much as is possible.
    - Example: Species A, count of 3, planted by your project.

Step 10: Check over all data in KoboCollect survey - submit

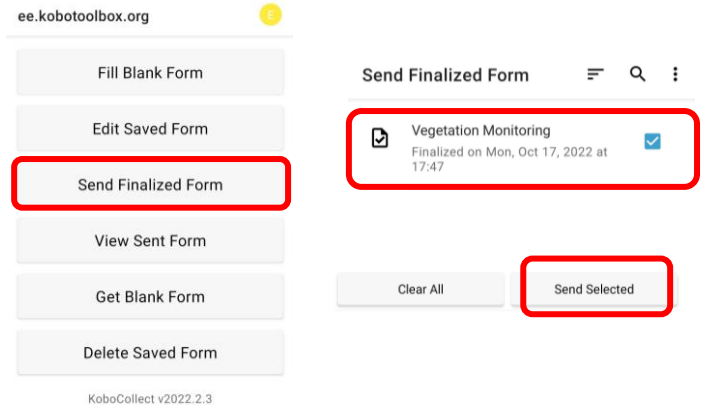
1) Save your data when all form is filled.



2) In the main menu, Edit Saved Form, if needed. This is the step to correct any possible mistakes.



3) Send Finalized Form when returning to Wi-Fi/cellphone service.



*KoboCollect Form

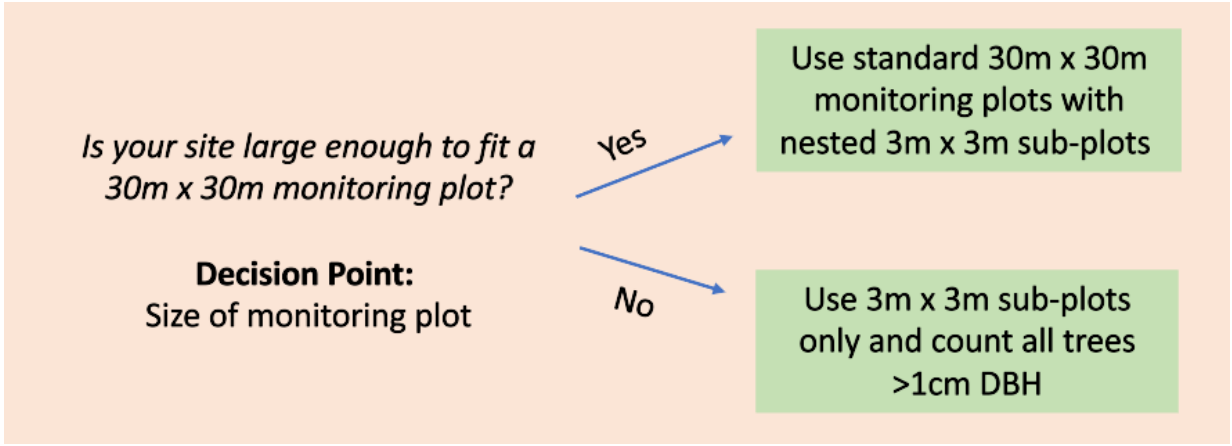
Exceptions

Exceptions for control and tree monitoring plots

- Multiple strata in a small restored area and the number of vegetative strata exceeds the number of hectares being restored:
    - You will need to exceed the 1/ha minimum monitoring requirement, to ensure some monitoring coverage in each strata (i.e. 2 plots would be needed in a 1 ha plot with 2 vegetative strata).

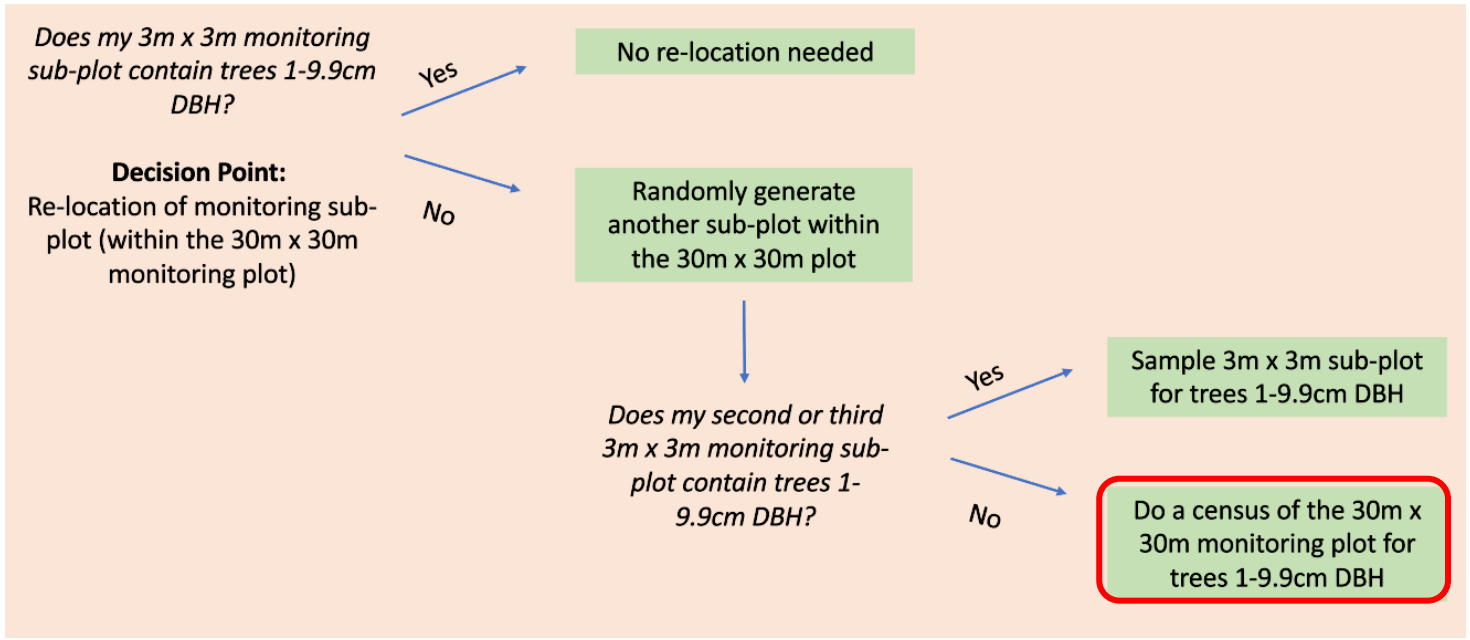
Exceptions for control and tree monitoring plots

- Sites smaller than 30m wide:
  - Denoted in the data sheet.
  - Use a 3m x 3m sub-plot.
  - All trees >1cm DBH should be recorded – disaggregated by species and type (planted, n aturally regenerated, etc).
  - GPS coordinates of centroid.
  - Description of location within 30m x 30m plot.



Exceptions for control and tree monitoring plots

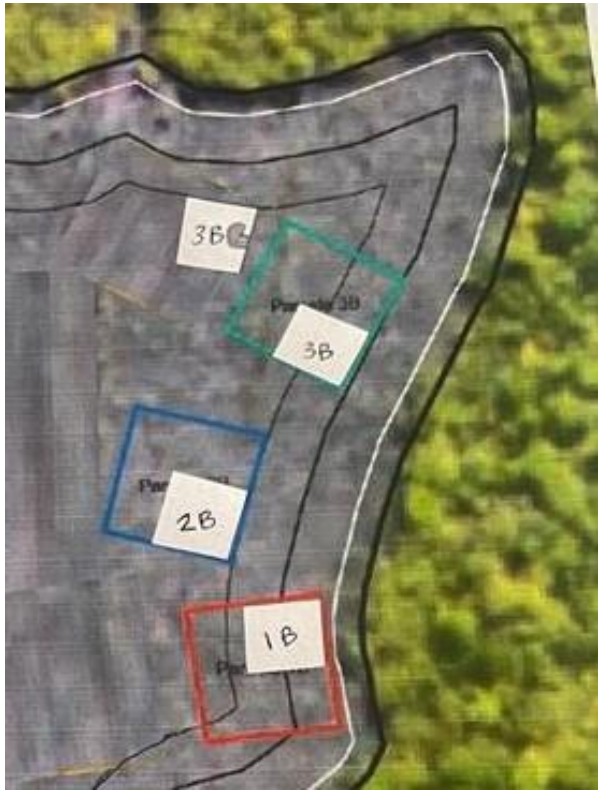
- Census:
  - If my second or third 3m x 3m monitoring sub-plots have no trees 1-9.9cm DBH, a full census count of the 1-9.9 cm size class should be done in the entire 30x30 m plot.



Special Considerations by Restoration Strategy

Applied Nucleation

- This restoration method integrates tree planting and natural succession to restore and regrow forests.
- Trees are planted in groups (called nucleii or islands), rather than over the whole site, and natural regeneration is promoted around them.
- It is unrealistic to randomize the locations of monitoring or control plots when this restoration technique is used. Instead, the plots must be placed relative to tree islands (see example at right).
- The global monitoring team can assist with planning.



Tree island planting locations inside grey restoration area are outlined in green, blue, red

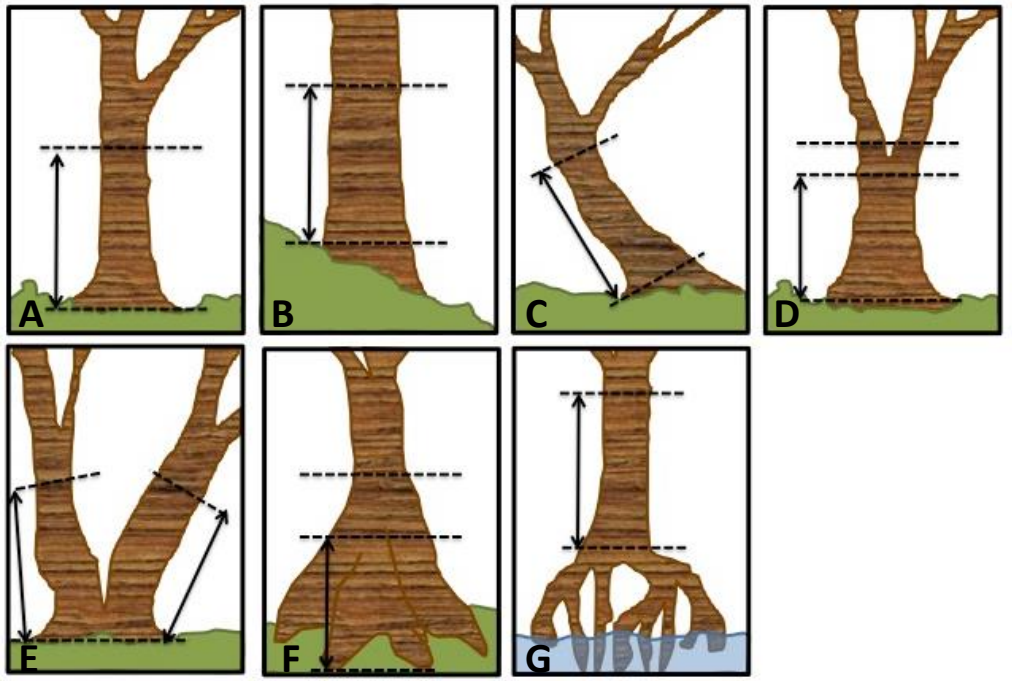
Monitoring plots inside islands (1B, 2B, 3B)

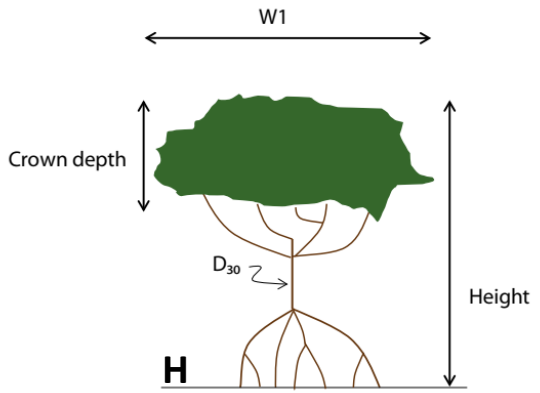
Control plot location 3BC (top left)

Source: Applied nucleation restoration guide for tropical forests. Conservation International, 2021. https://www.conservation.org/research/applied-nucleation-guide

Mangrove Restoration

- Data collection is the same in mangrove habitats, with the main stem determining which size class the tree is included in.
  - A tree is included in the survey if at least 50% of the main stem is rooted inside the plot or subplot perimeter.
  - To determine which size class a mangrove tree is placed in:
    - A) If the tree is fairly straight with a tall trunk the dbh can be measured from the ground parallel to the trunk.
    - B) If the tree is on a slope, always measure on the uphill side.
    - C) If the tree is leaning, dbh is taken according to the trees natural height parallel to the trunk.
    - D) If the tree is forked at or below 1.3 m then measure just below the fork
    - E) If the fork is very close to the ground measure as two trees.
    - F) For trees with tall buttresses exceeding 1.3 m above ground level, stem diameter is usually measured directly above the buttress.
    - G) For stilt rooted species (e.g., Rhizophora spp.), stem diameter is often measured starting above the highest stilt.
    - H) For shrubs and dwarf mangroves, the measurements consider steam diameter at 30 cm aboveground level (D30).





Source: Coastal Blue Carbon, CI, IOC-Unesco, IUCN.
https://www.thebluecarboninitiative.org/manual

Assisted Natural Regeneration (ANR)

- Data collection is the same in sites with assisted natural regeneration as a restoration strategy.
- In ANR contexts, it is especially important to be able to correctly identify tree species – special consideration to species identification resources should be made prior to monitoring.
- The use of 1x1m small monitoring plots is also highly recommended for ANR, in order to detect the younger, smaller regenerants.

Tree Monitoring

- What's done with all the data?
  - Calculation of indicators for PPC.
  - Share back of results with project developers on IMP, CI and WRI.
    - Y2.5 monitoring can inform management decisions. I.e. if more planting is needed
  - Used to strengthen the global body of research for restoration.
  - Generate learnings about restoration on a global scale.
  - Improve design of future restoration projects.