Sub-protocol 2: Control Sites

Includes details for siting and establishment of landscape level control units, siting and establishment of control plots within sites, and monitoring methods for baseline and monitoring.

Provides field data for Indicator 1.1: # of trees planted per area under restoration

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Data collected by project developers and submitted to IMP. Analyses completed by the global monitoring team. Control plots are a required minimum in all projects, but inclusion of landscape level control units is optional.

Guidance for Users

This sub-protocol is intended for use by *project developers* to guide identification and selection of control units (plot or landscape-level).

Disclaimer*: It is extremely challenging to achieve a generic set of monitoring requirements that can be spread across all of the possible PPC Program sites. The following is meant as guidance for the minimum set of requirements for the PPC Program. If you would like to add more rigorous monitoring in addition to what is laid out here, you are encouraged to do so by contacting the global monitoring team.*

Timeline*: Control units and plots should be established directly prior to restoration activities. Monitoring is required to establish the baseline and in Y2.5 and Y5. Monitoring in other years varies based on how many optional monitoring activities are undertaken and which indicators are scheduled for monitoring in a given year.*

Importance of Control

Whereas the driving purpose of the PPC program is restoring tree cover, in order to understand how much of the observed tree restoration is actually due to the activities of the project, we need to have control units. Control units areas designated for no intervention (i.e. restoration). By comparing control units to restored areas, we can determine the additionality of the restoration intervention(s) used in the restoration activity, because the control units mirror the restored sites in terms of degradation intensity and the duration since both sites were last intact and represent a 'business as usual' continuation of those conditions (Marchand et al., 2021). Basically, control units are used to demonstrate the change(s) that would normally take place over the same period of time, but in absence of the restoration intervention (i.e. planting or assisted natural regeneration of trees). Since multiple different restoration interventions are used in the PPC Program, it is critical to clearly define what the restoration intervention(s) are that are being applied, and, the type(s) of intervention may also impact the selection of the control unit.

For the PPC program, control units are established for the key impact indicator of 'number of trees restored.' Control units will allow us to answer the following key question for all projects across this initiative:

How many additional trees would be present, without our restoration interventions?

With a good 'control' unit, we can also answer other questions about restoration's impacts on biodiversity, biomass/carbon accumulation, ecosystem services, microclimate, socioeconomic benefits. We can compare the restoration intervention treatments between sites or plots, among other units of analysis.

Essentially, control units allow us to avoid attributing all of the observed changes in the restored areas directly to the restoration intervention. They allow us to isolate the additionality of the restoration interventions.

Compliance with the PPC Monitoring Framework will provide the minimum level of data needed to support a very minimal Impact Evaluation under the quasi-experimental approach, with the main goal of determining the number of trees restored as discussed above.[1]

II. Theoretical Foundations: Types of Control

1. Types and Qualities of Control Units

Key Definitions:

A *plot-level contro*l is an area (designated plot) within the restoration area where the restoration method ('treatment') is not applied. We assume that any biophysical changes observed within the control plot, for instance erosion or natural regeneration, would have taken place without the restoration.

A *landscape-level control unit* is a unit of land that is separate from the restoration site, but similar enough to the restoration site (see criteria in Table 1, Annex 1) to be comparable, where the restoration method ('treatment') is not applied. We assume that the changes observed in the control, are the same changes that would have occurred in the restored area, if there was no restoration.

In an ideal situation, both plot-level and landscape-level controls would be included in the restoration design. Implementing both types of controls makes for a more robust experimental design, but may not be feasible due to cost, or land availability/access, therefore, choosing a control type should be dependent on the resources available.

One key aspect of selecting control units is that these need to be as similar as possible to the units under restoration, i.e. comparing "apples to apples" and avoid comparing "apples to oranges." In a within-plot, or plot-level control, this is almost guaranteed, because the control plot is contained within the restoration site.

Selecting a landscape-level control is challenging. Variables that could be considered to assess similarity between control and interventions units include similar elevation, have similar slope, have similar precipitation levels, are located at similar distances to major towns, etc. (See Table 1 in Annex 1). Control units and treated sites need not be directly adjacent to each other. For example, a control that complies with the comparability principle could be located kilometers apart from a treated (restored)

[1] In some restoration sites, teams will conduct more detailed analysis under a much more detailed experimental approach. If you are interested in collaborating at the level, please write to email X

unit and that would be acceptable, if that is where a similar site can be accessed. The most important thing is to maximize similarity/comparability between the control units and restored sites.

1.a. Plot-level control (minimum standard): setting aside a part of the potential restored area as a 'control plot' is a typical experimental approach, and it helps to guarantee that many of the environmental factors/site conditions are identical (Table 1). This approach is often used for plantation style restoration methods where a part of the plot might be left with 'no planting.'

However, control plots within restored sites may still benefit from and be impacted by the restoration interventions. Specifically, they will probably be less likely to be subject to certain disturbances (grazing, fire), due to the protections established in the restored areas. In this way they are only a partial control and should be analyzed as such. This is where having a similar, but separate, entire unit designated as landscape-level control, could allow for an improved counterfactual control.

1.b. Landscape-level control (preferred) 'units' should be as comparable as possible to the restored sites. The landscape-level control is outside the boundaries of the restored area, but still in close proximity. It is important to note that landscape-level control units can be on land that was never intended for the restoration intervention. Therefore, they do not diminish the amount of land available for restoration. There are several factors to consider when establishing a control unit (Table 1).

If landscape-level control units are feasible in your situation, please refer to Sub-protocol 2, Annex 1, which will guide you in choosing landscape-level control units. Please note that control plots within landscape-level control units are still needed, and will be established using the same method described below.

Methodology 1: Control Plot Selection and Demarcation

1. Size of Control Plots:

Control plots, either inside restored areas or within landscape-level control areas, are the same size as regular monitoring plots (30m x 30m) and should be mapped, marked, and monitored in the same manner as the restoration monitoring plots (Sub-protocol 4). If a site is between ½ and 1 hectares in size, then the control plot can be 10m x 10m instead of 30m x 30m. If a site is less than ½ a hectare in size, no control plot is required.

2. Number of controls per number of restoration sites:

(Minimum) Ideally there should be at least one control plot per restoration site. However, if there is significant variation in the restoration site, then multiple control plots may be needed to encompass that variation. Types of variation include topography (steeply sloped vs. flat), land cover and ecotype, land use history, and disturbances. If a site is less than ½ a hectare in size, then no control plot is required.

(Complex Situation Guidance) Different situations may require modifications to the number of needed controls. For instance, in situations where more than one treatment is being implemented in the same

space, then it is ideal to also have a "0/no" treatment plot and two individual treatment plots (1 for each type of treatment). For instance, if tree planting is being done with monthly grass cutting, the would be one control with no tree planting or grass cutting (0/no treatment control), one control with only tree planting and no grass cutting (1st treatment control) and one control with no tree planting and only grass cutting (2nd treatment control). This is what is considered a "full factorial" design, and more guidance can be found here.

If in doubt about the proper number of control plots, please contact the global monitoring team. WRI/CI welcomes conversations around proper control unit design and is available to help determine the right specifications for any given site.

3. Location of plots: The location of control plots should be randomized[2] within the restoration site, in order to better ensure that they represent the conditions in the site. Tools such as the Create Random Points Tool in ArcGIS can be used to identify locations of the plots, but the use of GIS is not required. Simple field methods can be used with random number generation determining the number of steps from the edges of the site where the corner of the control plot should be placed.

- **Submission of Site Plan including Control Plots:** The mapping of the planned restoration intervention should include the proposed location of the control plot(s) and a description of the rationale for their location, if not completely randomized. This applies for both plot-level and landscape-level control units.
- *If in doubt about the proper location of control plots, please contact the global monitoring team We welcome conversations around proper control unit design and is available to help determine the right specifications for any given site.*

1. Sampling within Control Plots

a. **Dimensions of Control Plots:** The control plots will be the same size as the regular vegetation monitoring plots, 30 m x 30 m (s). If there are more than one control plot per restored site, at least one of the control plots must have smaller nested plots for monitoring of smaller vegetation (details below, and see Figure 1). If there is only one control plot per site, it will be a nested plot.

[2] Some restoration methodologies may make it unrealistic to randomize the locations of the control plots (I.e. applied nucleation). Please contact X email if seeking an exception to the randomization requirement

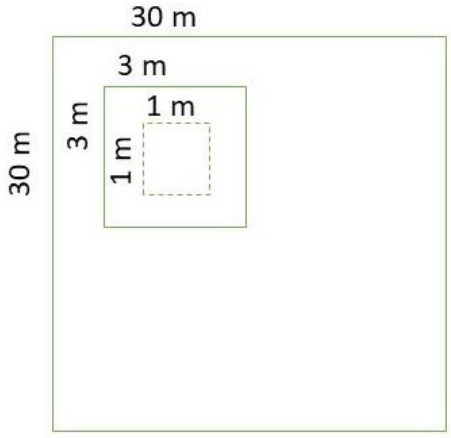

Figure 1: Nested Monitoring Plot arrangements of 30m x 30m (900 m^2), 3m x 3m ($9m^2$), and optional 1m x 1m ($1m^2$) plots

b. Control plot marking: Control plots are permanent, and should therefore be mapped and marked to facilitate ease of monitoring the same plot through the project cycle (up to Y5). The corner points should be recorded in the data collection form (integrated monitoring platform) along with the device margin of error. Each corner must be georeferenced with landmarks in the ground (wood staking, iron pipes or PvE tubing) at 1.2 m in height (PACTO, 2013).

c. **Measurements in Control Plots:** In each monitoring sampling plot, counts of the trees/saplings per tree species must be recorded by size class, following the same protocol as in the vegetation monitoring (Sub Protocol 4, summarized in next paragraphs). Three (3) photos should also be taken from one corner of the plot, one each with the edge of the plot in the centerline, looking at the opposite corner, and one looking across the diagonal. The corner from which the photos are taken should be the corner that provides the best overview of the plot (accounting for slope, existing vegetation, etc) and should be noted (NW, NE, SW, SE as noted in the GPS coordinates). For example, if the photos are being taken from the northwest corner in the plot diagram below, one photo would have line NW to NE (one side), one with line NW to SW (other side), and one with line from NW to SE (the diagonal).

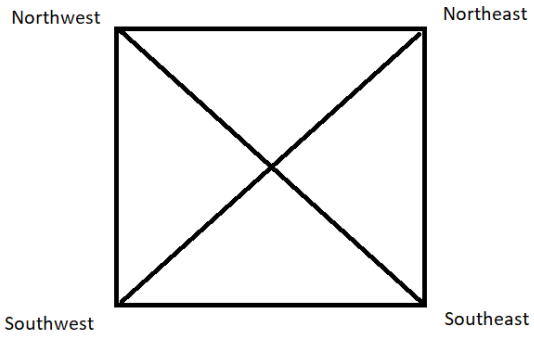

Figure 4. Sightlines for photos taken as part of control plot monitoring

In each control plot, the trees and species must be recorded. Tree diameter (DBH) and height can also be recorded, but this is optional. In the 30 m x 30 m plots all large trees and their species are recorded. DBH (>10cm) and height are optionally recorded. In the nested 3 m x 3m (9 m^2) all medium sized trees (diameters 1 – 9.9 cm DBH) and species are recorded. DBH and height are optionally recorded. Sampling in the smallest nested plots is optional. In the smallest nested plot, 1m x 1m (1 m^2) all tree sapling or trees (<1 cm DBH) will be counted and identified to species or species type as much as is possible (no height or DBH measurements for this small category, adapted from Celentano et al., 2020)

Measuring protocols:

1. (Optional) Diameter at Breast Height (DBH): Use a forestry-grade DBH measuring tape at diameter at breast height (1.3 m) around the stem or trunk of the tree. Record in metric units.
    a. If stems have bifuricated below 1.3m, DBH should be taken from all stems above 1.3m (PACTO, 2013)
2. (Optional) Height: Use a clinometer, or for Saplings or regenerants too small for the use of a clinometer, use a measuring stick.

1. **Data Recording:** Data should be recorded following the template of Form 1 in Sub-protocol 2, Annex 2, which will be done using the integrated monitoring platform data collection app.

IV. Expected costs of control plots and technical assistance available

Control plots are not expected to create significant costs because they have no interventions. For landscape-level control units, the units only need to be accessed for the monitoring. This access should be negotiated with the lowest possible cost (if any) and may also be a consideration in the control site selection. Estimation of the time required for monitoring is an area of work in development, and details will be updated as that work proceeds.

V. Data Analysis

The data is analyzed in the control plots in the same way as it is in the vegetation monitoring plots (please see Sub-Protocol 4).

The control plot represents the state that we would expect the restored area to be in, in the absence of the restoration intervention- a 'coutnterfactual.' It is different than a baseline measurement, because the control area may change over time just as the restored areas change over time. There might especially be some natural regeneration in the control plot.

Comparing the changes in the restored areas to their controls for any of the vegetation indicators (trees restored, tree cover) gives an estimation of the amount of observed change that is additional- that would not have happened without the restoration intervention. Fine-scale differences in microclimate and soil properties can also be quantified by additional measurements in control and 'restored' areas.

VI. References

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Sub-protocol 2, Annex 1: Landscape-level control units

Going beyond control 'plots' that primarily show changes in vegetation, landscape-level 'control' units allow quantification of restoration's impacts on biodiversity, ecosystem services, socioeconomic benefits, and more accurate quantification of changes in biomass/carbon accumulation (following the additional/optional sub-protocols).

Size of Control Units

Following the logic of "apples to apples" we still seek to compare similar units for the restoration treatment and control. Hence, ideally the restoration sites and control units would be of similar size. In practice, for small restoration sites (< 5 ha), landscape-level control units can be the same size as the restored site they are controlling for. However, if the restored area is very large, it may not be feasible for the control unit to be the same size. In this case, the control unit can be smaller. Generally, the control unit should not be more than 50% smaller than the area restored, but not smaller than 0.5 ha or larger than 25 ha.

Number of Control Units per Number of Restoration Sites

If a project has multiple areas restored in the same year, it is not necessary to have a landscape-level control for each area restored. We should strive to have at least 1 control site per group of 5 very similar restored sites.

If all of the restored sites have similar characteristics in terms of size, and the environmental and socioeconomic factors listed in Table 1, then you would only need one control site per 5 similar sites. However, if the sites vary significantly in terms of the factors listed in Table 1, then, each group of sites with similar characteristics should have a control site.

> *For example: If the sites vary by size, and you have 3 sites that are >5 ha and 3 sites that are <1 ha, you should have 1 control unit > 5 ha and 1 control unit <1 ha. If the sites vary by previous land use, and you have 15 sites in abandoned pastures and 5 sites in agricultural land, you should have 3 control units in abandoned pastures and 1 in agricultural land. Also, if you have sites that are in different geographical regions, for example separated by more than 10 km, you should have a control unit in each region. These are only a few examples, please adapt the logic to your situation.*

Factors to consider in control selection

When establishing control units at the landscape scale, it is important to prioritize ecological and socioeconomic factors that will help determine the needed properties of, and therefore the location of, the control. Table 1 below details several factors to consider when choosing the control unit. Proper selection of the control will lead to a more accurate experimental design.

Table 1. Prioritization of ecological and socioeconomic factors to indicate a suitable control unit.

Factor	**Reason**
• Land Cover and Ecotype	Consistency in the type of vegetation (especially forest cover), topography, biotic and abiotic conditions
• Land Tenure and Ownership	Ownership or type of property should be considered to reduce necessary number of agreements. This includes protected areas and private verse public land.
• Land use history	Previous land use, especially those causing degradation, could have impacts on the future viability or success of the restoration activities (Crouzeilles et al., 2017). Degradation intensity in the control matches that in the treatment location (Marchand et al., 2021b) in practice. For example, if a restoration site has cattle excluded with fencing, the control unit should have cattle grazing. It is not enough to simply not have fencing.
• Distance to restored site	Proximity will keep environmental variables similar (slope, elevation, ecotype etc.)
• Disturbances	Natural or human disturbances such as fire, hurricane etc.
• Distance to community/housing (settlements)	Control units inside protected areas may not have households impacted which would produce a bias impact evaluation (Ferraro, 2009)

• Household survey opportunities	Household surveys are needed for socioeconomic analyses, so control unit locations should allow for surveying that meets the criteria specified in sub-protocol 18

How To Select a Control Unit:

Step 1: Determine the scale of your restoration project and the appropriate number, type, and size of control units.

Do you have budget and land access to create both a landscape-level control unit and plot-level control?

If yes, then proceed with steps 2-4 for siting landscape level controls.

If no, please focus on following the plot-level control described in the main sub-protocol 3 text.

Step 2: Identify the types of data necessary to create your control.

Use the prioritized factors in Table 1 to find the appropriate data layers to establish your control locations.

Table 2: Factors for siting landscape control sites

Suggestions of data sources for factors	
Factor	**Data source**
Land cover/ecotype	See Restoration Siting Guide Data Library*
Land tenure	See Restoration Siting Guide Data Library*
Land use history	See Restoration Siting Guide Data Library*
Distance to restored site	Use shapefiles for restored sites and calculate distance to proposed control locations
Disturbances	See Restoration Siting Guide Data Library*
Distance to community/housing	Refer to the households identified in the socioeconomic subprotocol to calculate the distance to proposed control locations. (Subprotocol 10)
Household survey opportunities	Refer to the socioeconomic subprotocol (10)

**The Restoration Siting Guide can be provided upon request by emailing the Global Monitoring Team*

Step 3: Define geographic range of the search for the control site

How far from the restored sites could you select your control? This determines the area of the mapping exercise.

Step 4: Prioritization and Weighting of Layers

A 'weighted overlay' in which different data layers are assigned different weights (for example, if variable a (I.e. land cover/ecotype) is x (I.e 2) times more important than variable y (I.e. land tenure), then variable a has a weight of 2), and then these are mapped and overlaid. More details on this

process can be found in the Restoration Siting Guide, which can be provided upon request by emailing the global monitoring team.

Step 5: Create a map of the potential, optimal control units

Use the data layers to create a map of the potential, optimal control units in the landscape.

Step 6: Feasibility and selection of control sites

Considering all of the potential optimal control units, investigate the feasibility of being able to access each one. Will there be added costs to access the units? Can any be accessed through a no-cost agreement? Please document the reasoning behind the final decision with regards to the control units.

Step 7: Submission of Site Plans including Locations of Landscape level controls relative to restored areas and locations of control plots within the landscape level controls

The mapping of the planned restoration intervention should include the proposed location of the landscape-level control sites and control plot(s), and a description of the rationale for their location.

Landscape Control Unit Monitoring

Within the control unit, the same monitoring protocols are followed as in the restored sites. For instance, the same baseline site information should be entered into the information system, especially including the site GIS shapefile, which will enable remote sensing analysis of tree cover and other site properties. Moreover, in terms of field work, a 'control' vegetation monitoring plot must be established following the similar procedures as described in the main text of this sub-protocol.

Expected Costs:

Control units are expected to be slightly more expensive than control plots due to the potential additional cost of accessing land that may not be under the same ownership as the restored sites. Estimation of costs by activity is an area of work in development, and details will be updated as that work proceeds

Sub-protocol 2, Annex 2: Data collection sheet

Table detailing the information collected during vegetation monitoring. Items highlighted in grey are optional. Data is collected using KoboToolbox, which can be accessed on the IMP.

Data Collected	Options	Data Type	Notes
General Information			
Date		Date	
Organization Name		Select one from list	
Site ID		Select one from list	
Sampling Timeframe	Y0 (baseline), Y2.5, Y5, Other	Select one from list	

Site Type	Control, Restoration	Select one from list	
Start time of data collection		Time	
End time of data collection		Time	
Plot Information			
Plot ID		Text	
Plot Type	Control, restoration	Select one from list	All restoration should be looking for natural regen
Strata		Text	NA if only 1 stratum, if multiple in restored area then match answer with strata identified in site establishment form
Coordinate System Used		Text	
Northeast corner of plot (30x30)		GPS coordinate	
Device margin of error (NE corner)			Automatically included in KoboToolbox
Northwest corner of plot (30x30)		GPS coordinate	
Device margin of error (NW corner)			Automatically included in KoboToolbox
Southeast corner of plot (30x30)		GPS coordinate	
Device margin of error (SE corner)			Automatically included in KoboToolbox
Southwest corner of plot (30x30)		GPS coordinate	
Device margin of error (SW corner)			Automatically included in KoboToolbox
Trees in 30m X 30m Plot All trees > 10cm DBH by species and type should be recorded. ** Note that DBH and height measurements are not required, only a count by size class, disaggregated by species and type*			
Count of trees (>10 cm DBH)	Disaggregated by species and type (naturally regenerating, planted by your project, already present prior to project, don't know)	Integer + species + select one from list (type)	If using this sheet for data collection, repeat this line for each species and type. Ex: species A, count of 2, and naturally regenerating Species A, count of 3, planted by your project

Notes		Text	
3 geotagged photos of AB, AC, and AD sightlines (in vegetation monitoring protocol)- specify corner		Picture upload + text (corner chosen)	Photos should be taken from the corner that provides the best overview of the plot (accounting for slope, existing trees, etc)
Trees in 3m X 3m Plots In the nested 3m x 3m sub-plots all trees with a diameter between 1 – 9.9 cm DBH are recorded ** Note that DBH and height measurements are not required, only a count by size class, disaggregated by species and type*			
Number of resamplings needed for 3m x 3m sub-plot	0, 1, 2	Select one from list	A resampling (relocation of the sub-plot within the 30m x 30m plot) occurs if there are no trees 1 - 9.9 cm DBH in the sub-plot
Count of trees (1-9.9 cm DBH)	Disaggregated by species and type (naturally regenerating, planted by your project, already present prior to project, don't know)	Integer + species + select one from list (type)	If using this sheet for data collection, repeat this line for each species and type. Ex: species A, count of 2, and naturally regenerating Species A, count of 3, planted by your project
Notes		Text	
Centroid		GPS coordinate	
Description of location within 30m x 30m plot		Text	
(Optional) Additional Photos			
Saplings in 1m X 1m Plots In the smallest nested plot, 1m x 1m (1 m2) all saplings (regenerants) (<1 cm DBH) will be recorded. At this size, it is important to distinguish between trees and shrubs			
(Optional) Count of saplings (<1cm DBH)	Disaggregate by species and types (naturally regenerating, planted, don't know)	Integer + species + select one from list (type)	
(Optional) Centroid		GPS coordinate	
(Optional) Description of location within 3m x 3m plot		Text	

Additional Information			
(Optional) File Upload		File upload	

Special Circumstance: Restoration Site is between ½ HA and 1 HA In this scenario, a 10m x 10m monitoring plot with a 3m x 3m sub-plot is sampled.
All data collection is the same as above. The only difference is the size of the monitoring plot