Standard Operating Procedure (SOP) #5

Generating Sampling Point Locations with GIS

Version 2.0 (August 2, 2019)

Change History

New Version #	Revision Date	Author	Changes Made	Reason for Change	Previous Version #
1.01	5/6/2017	Scott Kichman	Updates to procedures		1.0
2.0	8/2/2019	Mark Wasser	Removal of outdated materials, software updates, update to randomization process in GIS	Currency with actual PACN procedures, clarity & consistency, ease of use	1.01

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision, changes made, and reason for the change along with the new version number.

Purpose

This SOP explains how to generate random sampling points for Pacific Island Network (PACN) Terrestrial Plant Community Monitoring Protocol using ArcGIS® Desktop (ArcMap® version 10.6.1 as of this update). Once sampling points have been generated, SOP #9 Establishing and Marking Vegetation Monitoring Plots describes how to install rectangular plots around each sampling point.

Procedures

Sampling points are currently generated in ArcMap® 10.6.1 using the Create Random Points tool within the Data Management Toolset. All fixed and rotational plots (including alternates) were generated for the first monitoring cycle (ArcMap® 9.3 and Hawth's Tools were used to generate these initial points). Additional rotational plots need to be generated on a continual basis for subsequent monitoring cycles (except for the mangrove forest frame, which has only fixed plots). Alternate points are generated simultaneously in the event any of the initial locations are unsafe, unrepresentative, or infeasible to sample. For the remainder of this SOP, it is implied that alternate plots will be generated whenever rotational plots are generated. The I&M GIS staff has the necessary ArcMap® documents and base layers (park boundaries, streams, roads, etc.) to generate the required rotational plots for subsequent sampling cycles, as described below.

Rotational Plot Point Generation

This method for generating random plots within a sampling frame applies to the five FTPC plant communities: Subalpine Shrubland, Coastal Strand, Limestone Forest, Mangrove Forest, and Wet Forest. However, no additional plots need to be generated for the Mangrove Forest, only the initial fixed plots are sampled in this community. Within these plant communities, sampling plots are generated randomly using a simple random sampling strategy outlined below.

1. Open ArcMap®, and load the park specific map document and associated layers including park boundaries, coastlines, roads, trails, elevation grids and slope grids.

2. The criteria for generating random points are listed below.

Plot Centroid (point) Requirements: All 20 x 50 m plots

- Within the sampling frame.
- Greater than 47 m from sampling frame boundaries, roads, trails, streams, coastlines, cultural features or other unrepresentative features, ensuring that plot edges are at least 20 m away from these features (Figure SOP 5.1).
- Greater than 104 m from fixed plot centroids and other sampling points, ensuring a 50 m buffer between the adjacent plots.
- Location with slope less than 100% (45°).

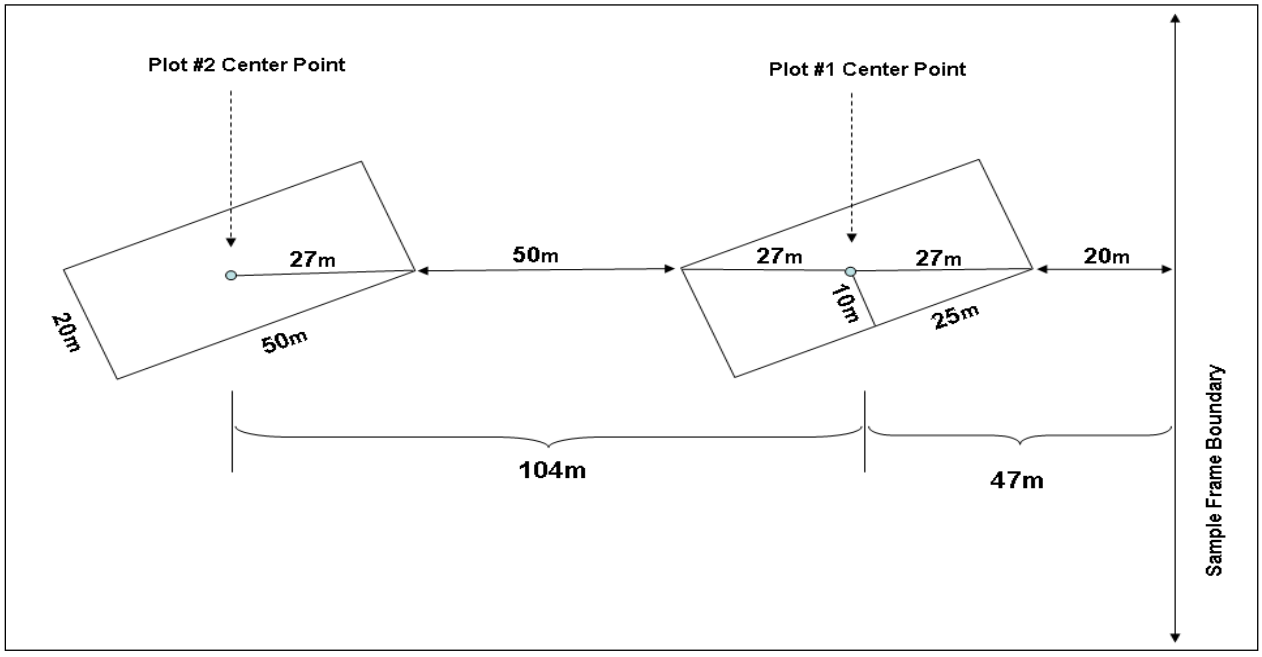


Figure SOP 5.1. The minimum distance between plot center points and either frame boundaries or unrepresentative features (47 m), as well as adjacent plot center points (104 m) for 20 x 50 m plots. Note

that these distances ensure plot edges greater than 20 m from frame boundaries or unrepresentative features and greater than 50 m from other plots. These values apply to all 20 x 50 m plots.

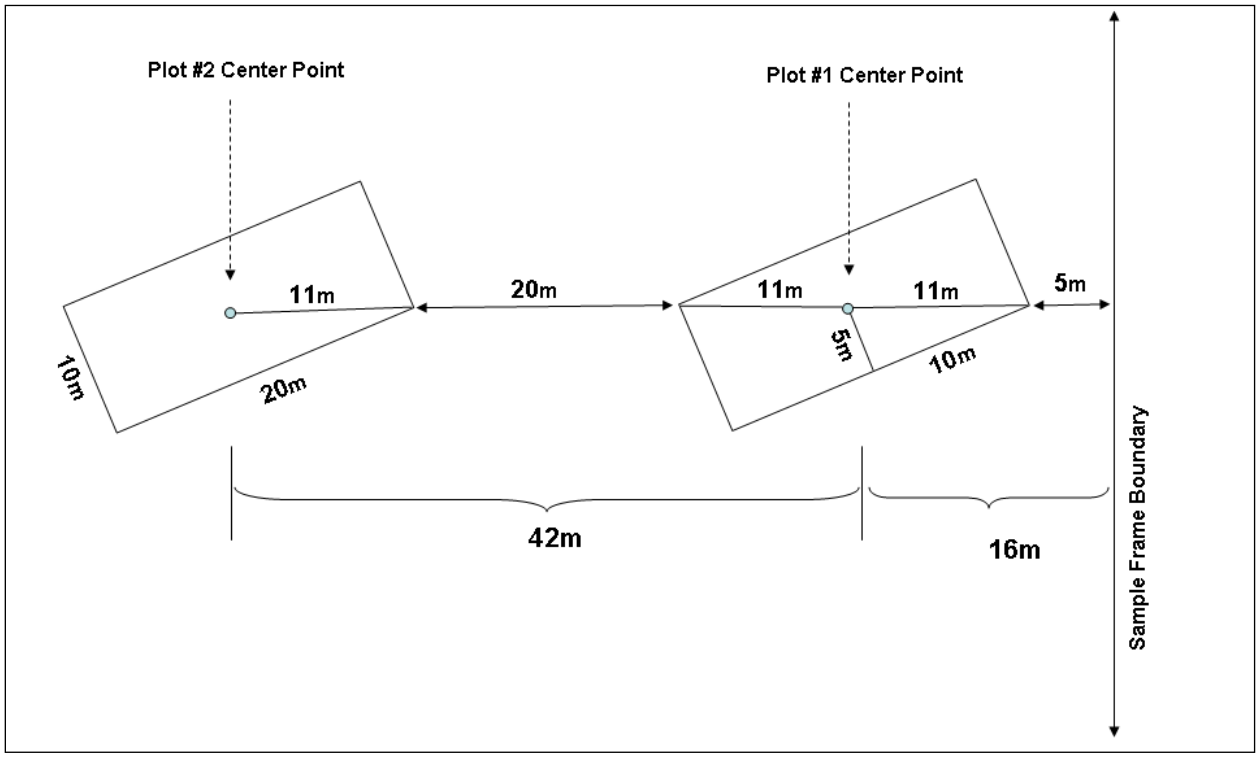


Figure SOP 5.2. The minimum distance between plot center points and either frame boundaries or unrepresentative features (16 m), as well as between adjacent plot center points (42 m) for 10 x 20 m plots. Note that these distances ensure plot edges greater than 5 m from frame boundaries or unrepresentative features, and greater than 20 m from other plots. For the 10 x 20 m plots at KAHO, these buffer requirements are slightly more lenient (see text).

Plot Centroid (point) Requirements: 10 x 20 m coastal plots (KALA)

- Within the sampling frame.
- Greater than 16 m from sampling frame boundaries, roads, trails, streams, coastlines, cultural features or other unrepresentative features, ensuring that plot edges are ≥5 m from these features (Figure SOP 5.2).
- Greater than 42 m from fixed plot centroids and other sampling points, ensuring a 20 m buffer between adjacent plots.
- Location with slope less than 100% (45°).

Plot Centroid (point) Requirements: 10 x 20 m coastal plots (KAHO only)

- Within the sampling frame.

- Greater than 11 m from sampling frame boundaries, roads, trails, streams, coastlines, cultural features or other unrepresentative features, ensuring that plot edges do not touch any of these features.
- Greater than 32 m from fixed plot centroids and other sampling points, ensuring a 10 m buffer between adjacent plots.
- Location with slope less than 100% (45°).

1. Generate buffers around all unrepresentative features. These buffer zones represent areas that cannot contain plot center points; otherwise portions of the plot may lie too close to unrepresentative features, beyond sampling frame boundaries, or in an unsafe area. Combine all these buffers into a single layer that can be used as the constraining feature class for point generation. Buffer size will depend on plot size – see plot requirements and Figures SOP 5.1 & 5.2).
    - Buffer (11, 16, or 47m) all roads, boundaries, trails, etc.
    - Buffer (11, 16, or 47m) any areas with slopes greater than 100% (45º), or areas with potential safety hazards. (In general, only the wet forests of KALA, NPSA and HALE have large areas with slopes greater than 100%.) Slope rasters can generally be found on the GIS Share Drive.
    - Buffer (32, 42, or 104m) around all existing fixed plots.

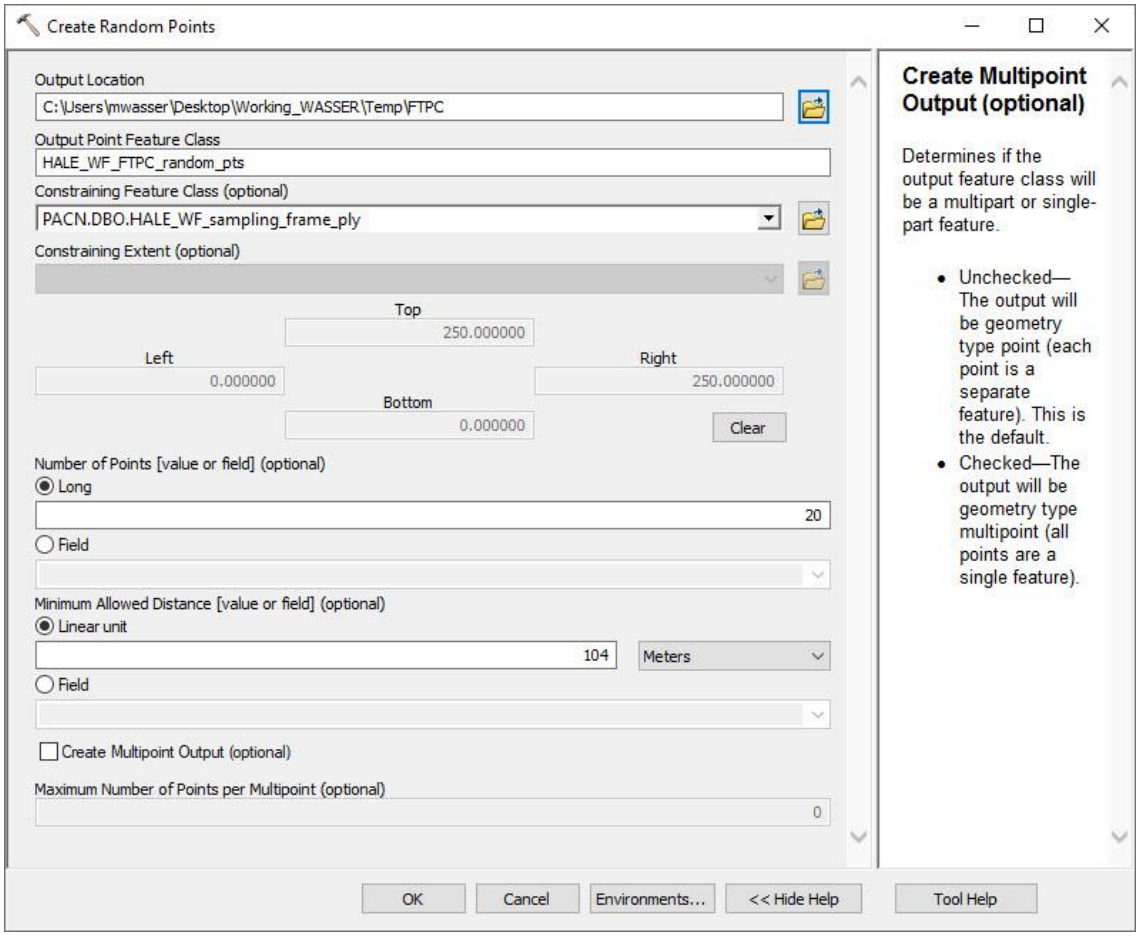


Figure SOP 5.3. Dialog box for the "Create Random Point " tool in ArcToolbox Note relevant options constraining points to within a selected polygon [sampling frame], determining the number of points to generate, and to enforcing minimum distances between points.

2. Generate points for plot centroids and plot azimuths using the following procedures:

   - Open the "Create Random Points" Tool from either ArcToolbox (Data Management Tools → Sampling → Create Random Points) or the Search function.

   - Set Output Location and Output Point Feature Class to appropriate directories / names.

   - Select the Constraining Feature Class. This will most likely be a polygon created from the sampling frame with buffer areas excluded, located in the FTPC SDE feature dataset (PACN.DBO.FTPC). If buffer areas have not been created, select the sampling frame polygon as the Constraining Feature Class (see steps 3 about creating the necessary buffer areas).

   - Enter the desired number of points to be generated in the Long field under Number of Points [value or field]. See Appendix SOP 5.a. for recommended number of rotational and alternate plots to be generated for each sampling frame.

- Set the Linear Unit field under Minimum Allowed Distance [value or field] to the minimum distance between plots (104 meters for 20 x 50 m plots, and 42 m for 10 x 20 m plots)

- Do *not* check the box for Create Multipoint Output.

- Run the tool. The output generated is the random points

3. Populate the newly created random point shapefile. Create, name and populate the following fields in the attribute table as follows:

   - Unit_Code (Text, 5 characters long); fill in as appropriate
   - Samp_Year (Short integer); fill in as appropriate (YYYY format)
   - Samp_Frame (Text, 25 long); populate as appropriate
   - Zone (Text, 25 long); populate as appropriate
   - Plot_Num (Text, 5 long); populate in future steps
   - Plot_Type (Text, 15 long); populate in future steps
   - Azimuth (Short integer); populate in future steps
   - Longitude (Double); calculate geometry in GCS: WGS 1984
   - Latitude (Double); calculate geometry in GCS: WGS 1984
   - GCS (Text, 50); All cells populated with value "World Geodetic System 1984"
   - GCS_Datum (Text, 15); All cells populated with value "D_WGS_1984"
   - Random (float); populate in next step

   Refer to the FTPC proposed plot points feature class (PACN.DBO.FTPC_proposed_plot_pts) for the correct values for the 'Samp_Frame' and 'Zone' fields.

4. Use the Field Calculator to generate a set of random numbers for cells in the *Random* field. Within the Field Calculator, change the Parser type to Python and check the Show Codeblock box.

   Type the following code in the Pre-Logic Script Code box:

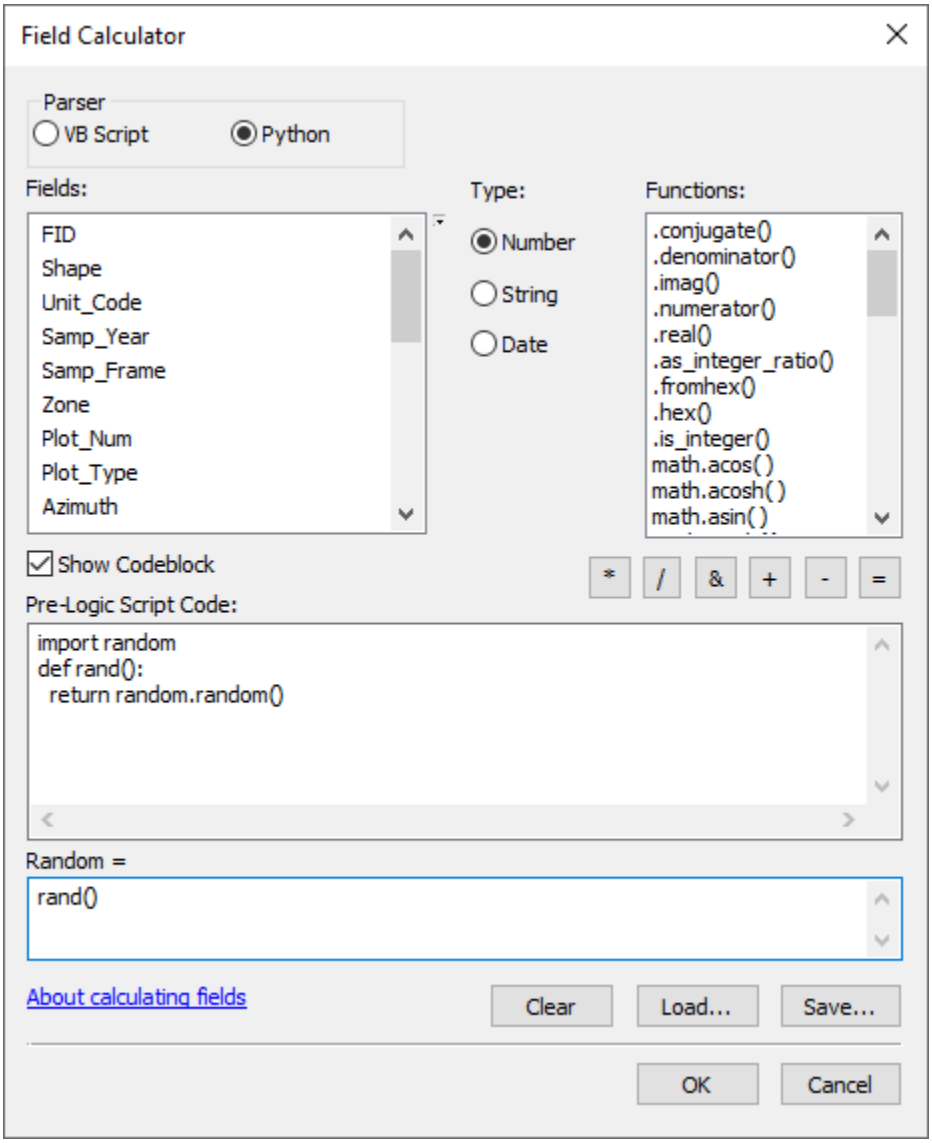
   ```
   import random
   def rand():
    return random.random()
   ```

   Then type the following code in the Random = box:

   ```
   rand()
   ```

   Click OK.

The rotational / alternate plot list will be sorted in the following step by the random numbers just generated – this is done to randomize the plot order.



5. Run the *Sort* Tool (ArcToolbox → Data Management Tools → General → Sort). Specify your output dataset for the following location with the following naming convention

   - Location = \\inphavoim01\vital_signs\05_focal_terr_plant_communities\
   - \Spatial_info\[YYYY]\[Park_Name]\GIS_Data\
   - Shapefile Name = [Park_Name]_FTPC_proposed_[YYYY]
   - Example name = WAPA_FTPC_proposed_2019.shp

6. Open the newly created (sorted) shapefile in ArcMap®. Select the *Plot_Num* field and populate as appropriate. Rotational plots will have a two digit number, and alternate plots will have and A prefix with a single number (starting with A1, A2, etc). Refer to the FTPC samples sites SDE feature class to determine the numbers to assign rotational plots (start with the next number in the sequence for that sampling frame). Also populate the *Plot_Type* field with 'Rotational' or 'Alternate'.

7. Assign random azimuths to each plot. Open the attribute table and select the *Azimuth* field.

   Use the Field Calculator to generate a set of random numbers between 1 and 360 for cells in the *Azimuth* field. Within the Field Calculator, change the Parser type to Python and check the Show Codeblock box.

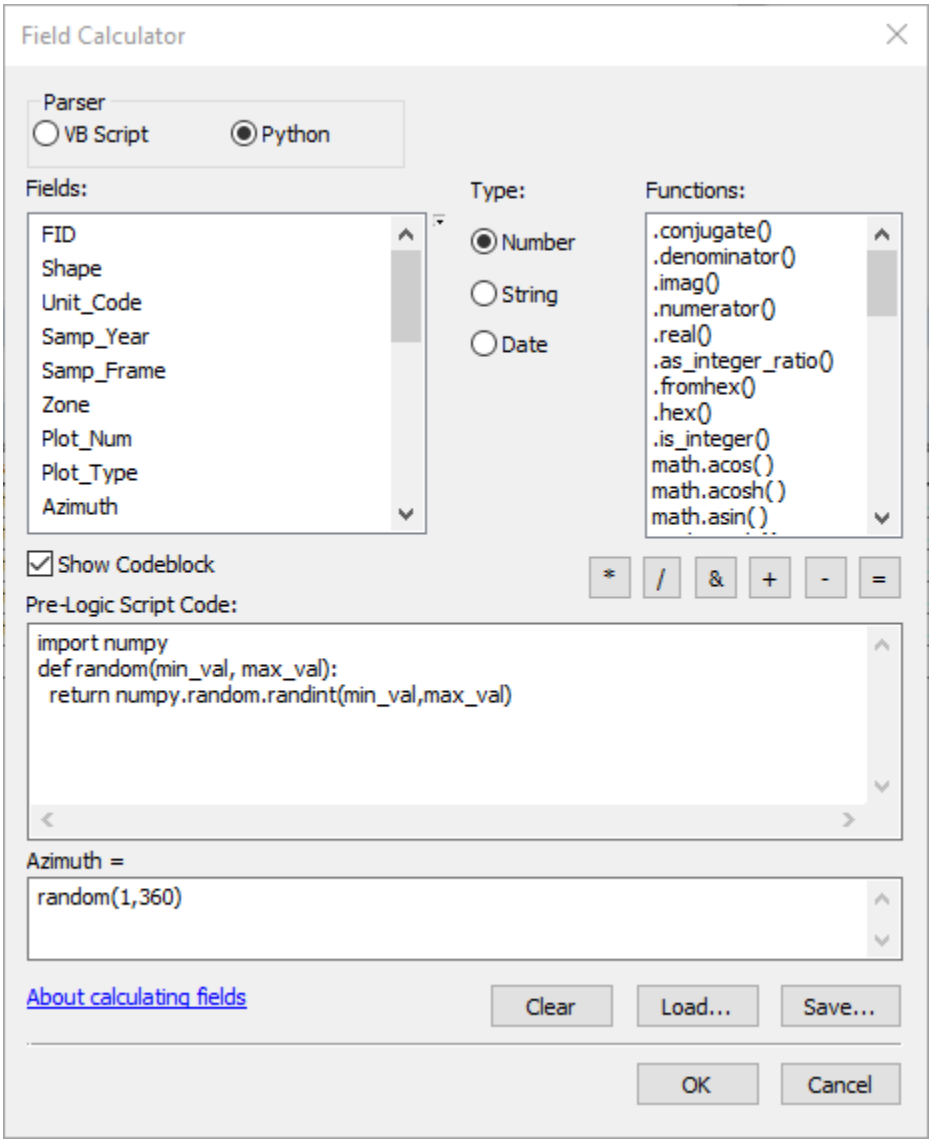
   Type the following code in the Pre-Logic Script Code box:

```
import numpy
def random(min_val, max_val):
 return numpy.random.randint(min_val,max_val)
```

   Then type the following code in the Azimuth = box:

```
random(1,360)
```

   Click OK. If there are issues running the Python code there is a good ESRI thread here.



Point Generation Along Transects in ArcGIS®

This method applies only to the Wet Forest sampling frame, where logistics dictate that sampling *may need to* occur along established transects. Before generating plot locations, consult the PACN Botanist to determine if this will be the case for the monitoring period in question. Fixed plot locations are randomly located along fixed transects and rotational plots are randomly located along rotational transects. The fixed plots have been generated (see Appendix A "Target Populations and Sampling Frames") and should not need to be modified again. Rotational plots were generated for the first cycle of sampling (Appendix A), but additional plots need to be generated prior to each subsequent sampling cycle. This process involves generating new rotational transects and selecting a random set of points along these rotational transects. To the greatest extent possible this protocol will share rotational transects with the Landbirds Protocol (Camp et al. 2011). Table SOP 5.a.1 lists

the required number of rotational plots for each frame. The following steps describe in detail the procedure to generate rotational transects and rotational plots.

1. Generate a series of random transects. The criteria for transect establishment is identical to the Landbirds Protocol enabling the I&M GIS staff to create one set of transects for both protocols where applicable. The procedure to create rotational transects is as follows:

    - Using the Select Query tool in ArcMap® select 20 random points from within the sampling frame for use as potential transect starting points.

    - Beginning with the first random point, assign a random azimuth (either by computer or using the random number table in SOP #9 Establishing and Marking Vegetation Monitoring Plots). Draw a 1500 m transect (or shorter if the transect reaches a park boundary, coastline, or impassable section) in the direction of that azimuth. If the transect is less than 600 m long (i.e., the equivalent of five landbirds monitoring stations spaced 150 m apart), then discard the transect since it is not practical to access and sample isolated plots. Rotational transects and legacy transects may cross one another.

    - Continue generating transects from each random starting point until the combined length of new transects equals the total length of rotational transects from year 1. The I&M GIS staff has this transect information in their geodatabases. In general, this length corresponds to 7500 m (7.5 km) or approximately 50 landbirds monitoring stations (located on five to eight transects). However, the total length of transects varies between frames; so the safest approach is to match the length of new rotational transects to the length of rotational transects generated in year 1. To ensure compatibility with the Landbirds Protocol, consult with the Landbirds project lead to verify that the new transects meet their protocol requirements.

2. Using the "Split Feature" tool in the ArcGIS® editor, create sampling stations at 150 meter intervals along each of the newly created rotational transects. In addition to serving as landbirds sampling stations, these stations act as a pool from which we will select our sampling points.

3. Before selecting specific points, discard any points that are potentially unsafe or that may contain features such as human structures or disturbance corridors making the plot unrepresentative of the main surrounding. Since this protocol requires the placement of 20 x 50 m plots around each sampling point, we may have to discard some points that are acceptable to the Landbirds Protocol.

4. Table A.1 lists the required number of rotational (15) and alternate plots (number varies). The required number of plots will match the number of plots generated in year 1 of sampling. Using the "Create Random Selection" tool from X Tools Pro, select and partition the appropriate number of rotational and alternate plots from the pool of acceptable plots.

5. After all the sampling points have been generated, assign plot numbers to each plot. Since fixed plots are numbered 1–15 in each wet forest frame, rotational plots will be numbered 16–30 in year 1 of sampling, 31–45 in year 2, 46–60 in year 3, and so on. Alternate plot numbering begins with "A1" and continues until each alternate plot has a number (e.g., A1–A15).

6. Since we do not anticipate any "transect" effects on rotational transects, rotational plots do not need to be shifted off transect by 50 m.

Defining Plots from Random Sampling Points

Using the random sampling points generated above, follow SOP #6 Using Garmin® GPS Units to locate these points in the field, and SOP #9 Establishing and Marking Vegetation Monitoring Plots to establish and mark rectangular plots around these points.

Appendix SOP 5.a. Overview of the sampling years, parks, focal plant communities, frames and plots.

Table SOP 5.a.1. For focal communities with only one sampling frame, the community and sampling frame have the same name. The total number of plots represents the sum of the fixed and rotational plots sampled in a given year, while the number of alternate plots represents the number of plots generated in case the field crew cannot sample one or more of the fixed or rotational plots. The number of alternate plots varies from frame to frame, based on conservative estimates of how many alternates might be required as well as how many plots could fit in particular frames given buffer constraints

Park	Focal Plant Community	Sampling Frame	Total Plots	Fixed Plots	Rotational Plots	Alternate Plots
HAVO	Wet Forest	Thurston / East Rift	30	15	15	10 /10
HAVO	Wet Forest	ʻŌlaʻa	30	15	15	10 / 10
HAVO	Wet Forest	Kahuku	30	15	15	15 / 15
HAVO	Subalpine Shrubland	Subalpine Shrubland	30	15	15	15
KAHO[2]	Coastal	Coastal	15	10	5	5
HALE	Wet Forest	Wet Forest	30	15	15	10 / 10
HALE	Subalpine Shrubland	Subalpine Shrubland	30	15	15	25
KALA	Wet Forest	Wet Forest	30	15	15	15 / 15
KALA	Coastal	Rocky Substrate	15	10	5	10
KALA	Coastal	Calcareous Substrate	15	10	5	10
NPSA	Wet Forest	Tutuila	30	15	15	10 / 10
NPSA	Wet Forest	Tau	30	15	15	8 / 8
WAPA	Limestone Forest	Limestone Forest	15	10	5	10
AMME	Mangrove Wetland	Mangrove Forest	10	10	0	3