

Standard Operating Procedure (SOP) #5

Generating Sampling Point Locations with GIS

Version 3.0 (June 5, 2025)

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2.0	8/2/2019	Mark Wasser	Removal of outdated materials, software updates, update to randomization process in GIS.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
3.0	6/5/2025	Mark Wasser	Update to reflect software change to ArcGIS Pro, updated workspaces, remove outdated procedure.	Reflect migration to ArcGIS Pro, change from local file server to SharePoint, and more efficient methodology. Making SOP consistent with EIPS SOP updates.	2.0

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 Inventory and Monitoring Network (PACN I&M) Focal Terrestrial Plant Communities (FTPC) Monitoring Protocol using ArcGIS® Desktop (ArcGIS Pro 3.3.1 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.

Generating FTPC Sampling Locations

Fixed sampling points were originally generated using ArcMap® 9.3 and Hawth's Tools. No new fixed sites need to be generated, so those procedures are no longer outlined in this SOP.

Random sampling points are currently generated in ArcGIS Pro 3.3.1 using the Create Random Points geoprocessing tool. While all fixed plot locations were generated prior to the first monitoring cycle, 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 PACN GIS staff has the ArcGIS Pro projects, base layers (park boundaries, streams, roads, etc.), and additional resources necessary 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. 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 ArcGIS Pro and load the park specific map project and necessary layers including park boundaries, roads, trails, field camps, sampling frames, sampling point generation areas, and any other applicable features (helispots, etc.). Archived FTPC ArcGIS Projects and spatial data are located in the FTPC “[Spatial Info](#)” folder in the PACN Monitoring Archive¹, under the year in which sampling last occurred at the respective unit. If utilizing an existing ArcGIS Pro Project (.arpx) from the PACN Monitoring Archive, save a new copy of the project in a temp local directory with the naming convention “FTPC_EIPS_[YYYY]²_[PARK]³.arpx”.

Alternatively, if building a Pro Project from scratch is necessary, Project, Layout (.pagx), and Map (.mapx) Templates are all available in the “[ArcGIS Pro Templates](#)” folder in the PACN I&M SharePoint site⁴. Master FTPC data layers such as Sampling Frames, Sampled Points, and Exclusion Areas are stored in the FTPC Master Geodatabase (PACN_FTPC_MASTER.gdb), which is located in the FTPC programmatic spatial “[Data](#)” folder in the PACN Monitoring Archive. A local copy of the master geodatabase will also need to be downloaded (direct functionality with data housed on the SharePoint is not supported in ArcGIS Pro at this time).

2. Create a new file geodatabase (.gdb) to be used temporarily for annual rotational/alternate plot point generation. Suggested naming convention is “FTPC_[YYYY].gdb”. Save to the same local directory as the Pro Project working copy from Step 1.
3. Generate random points within the sampling area (Figure SOP 5.1).

¹ PACN Monitoring Archive, https://doimspp.sharepoint.com/sites/nps-PWR-PACNIM/monitoring_archive/ (accessed 5 June 2025).

² [YYYY] = 4-digit sampling year (e.g., 2022, 2023, etc.)

³ [PARK] = 4-letter park code (e.g., AMME, HALE, HAVO, KAHO, KALA, NPSA, WAPA)

⁴ PACN I&M SharePoint site, <https://doimspp.sharepoint.com/sites/nps-PWR-PACNIM> (accessed 5 June 2025).

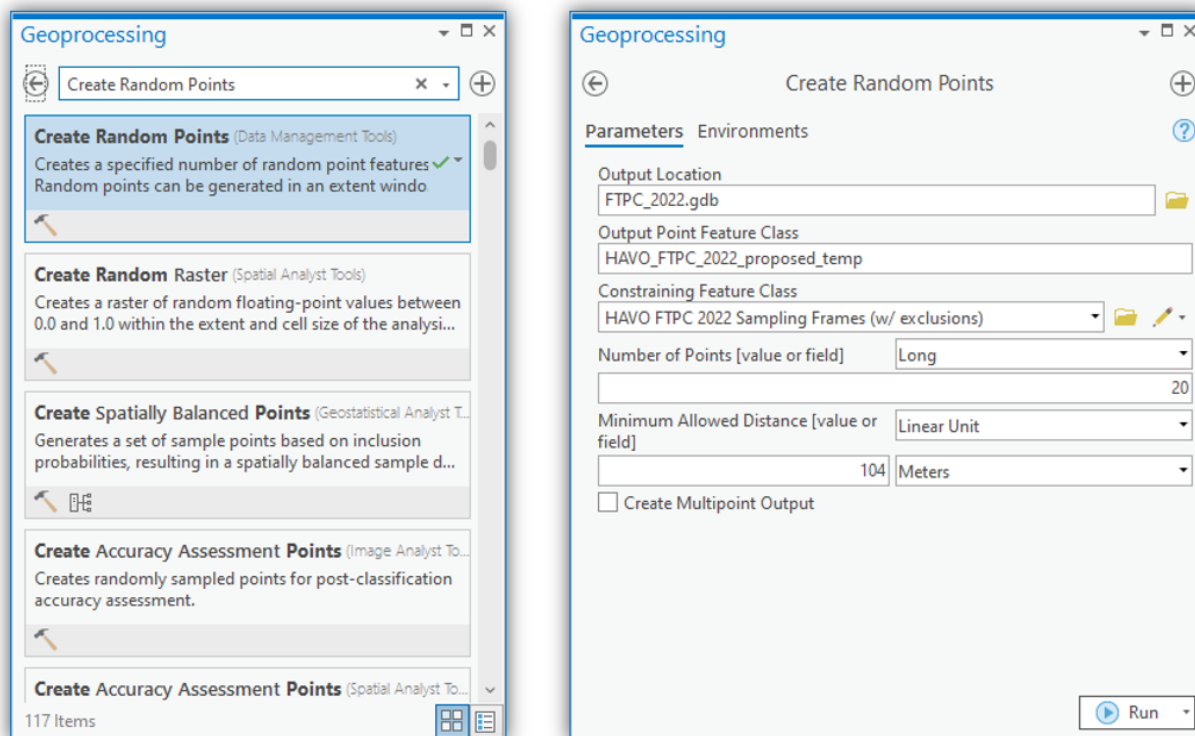


Figure SOP 5.1. Dialog box for the “Create Random Points” geoprocessing tool in ArcGIS Pro. Note relevant options constraining points to within a selected polygon, determining the number of points to generate, and to enforcing minimum distances between points.

- Open the Create Random Points Tool from the Geoprocessing Pane. Start typing “Create Random Points” in the search bar and the appropriate tools will display as options. Select the *Create Random Points* tool. (Alternately, the tool’s button is located within the Analysis Tab, Geoprocessing Group on the Pro ribbon)
- Set *Output Location* and *Output Point Feature Class* to the temp file geodatabase created in Step 2, and name as desired. Suggested feature class name = “[PARK]_FTPC_[YYYY]_proposed_temp”
- Select the *Constraining Feature Class*. This will be the VEG_sampling_pt_generation_areas_ply feature class from the FTPC Master Geodatabase. This point generation area feature class is based on the FTPC sampling frames, and has all buffers, exclusion areas, etc. created to meet plot centroid requirements as described in detail in [Appendix SOP 5.b](#).

Important Note: The point generation area feature class described above contains point generation areas for all the FTPC sampling frames in PACN Units. For the tool to run properly and not generate random points in all PACN Units, please apply a definition query to the feature class (before running the Create Random Points tool)

to display only the sampling frame for which random points are being generated (Figure SOP 5.2).

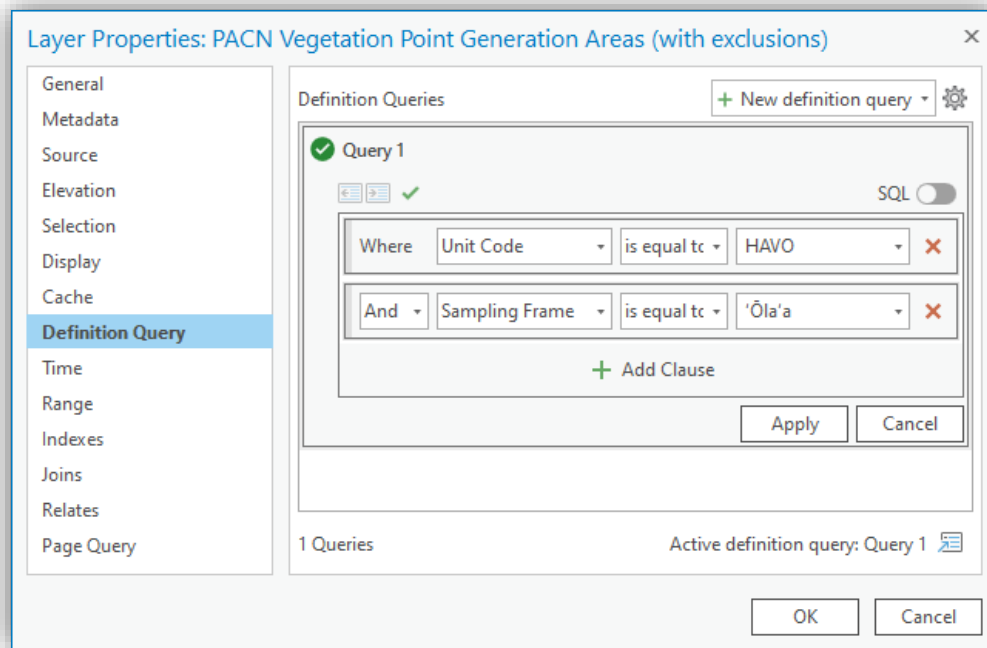


Figure SOP 5.2. Dialog box demonstrating a definition query applied to select only the relevant sampling frame from the VEG_sampling_pt_generation_areas_ply feature class from the FTPC Master Geodatabase.

- d. For *Number of Points [value or field]*, select *Long* from the dropdown. Enter the desired number of points to be generated in the box below. Refer to [Appendix SOP 5.a](#) to determine the number of points needed. Generate all rotational and alternate plots needed for the sampling frame at the same time.
 - e. For *Minimum Allowed Distance [value or field]*, select *Linear Unit* from the dropdown. Enter the desired number of points to be generated in the box below. Refer to [Appendix SOP 5.b](#) to determine the minimum distance between plot centroids. This value will be 104, 42, or 32 meters depending on plot size.
 - f. **Do not** check the box for *Create Multipoint Output*—if checked, then uncheck.
 - g. Run the tool. The output generated is the random points.
4. Populate the newly created random point feature class. 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)
 - Community (Text, 50 long); populate as appropriate

- 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”
- Random (float); populate in next step

Refer to the  [FTPC_database_labels_20210205.xlsx](#) spreadsheet for the correct values for the ‘Samp_Frame’ and ‘Zone’ fields.

5. Use the Field Calculator to generate a set of random numbers for cells in the *Random* field (Figure SOP 5.3).

- Open Field Calculator, and ensure the *Random* attribute field is selected, and the *Expression Type* is set to Python 3.
- Type the following code in the *Expression* box:

```
rand()
```

- Then type the following code in the *Code Block* box:

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

- Click OK to run the Field Calculator.

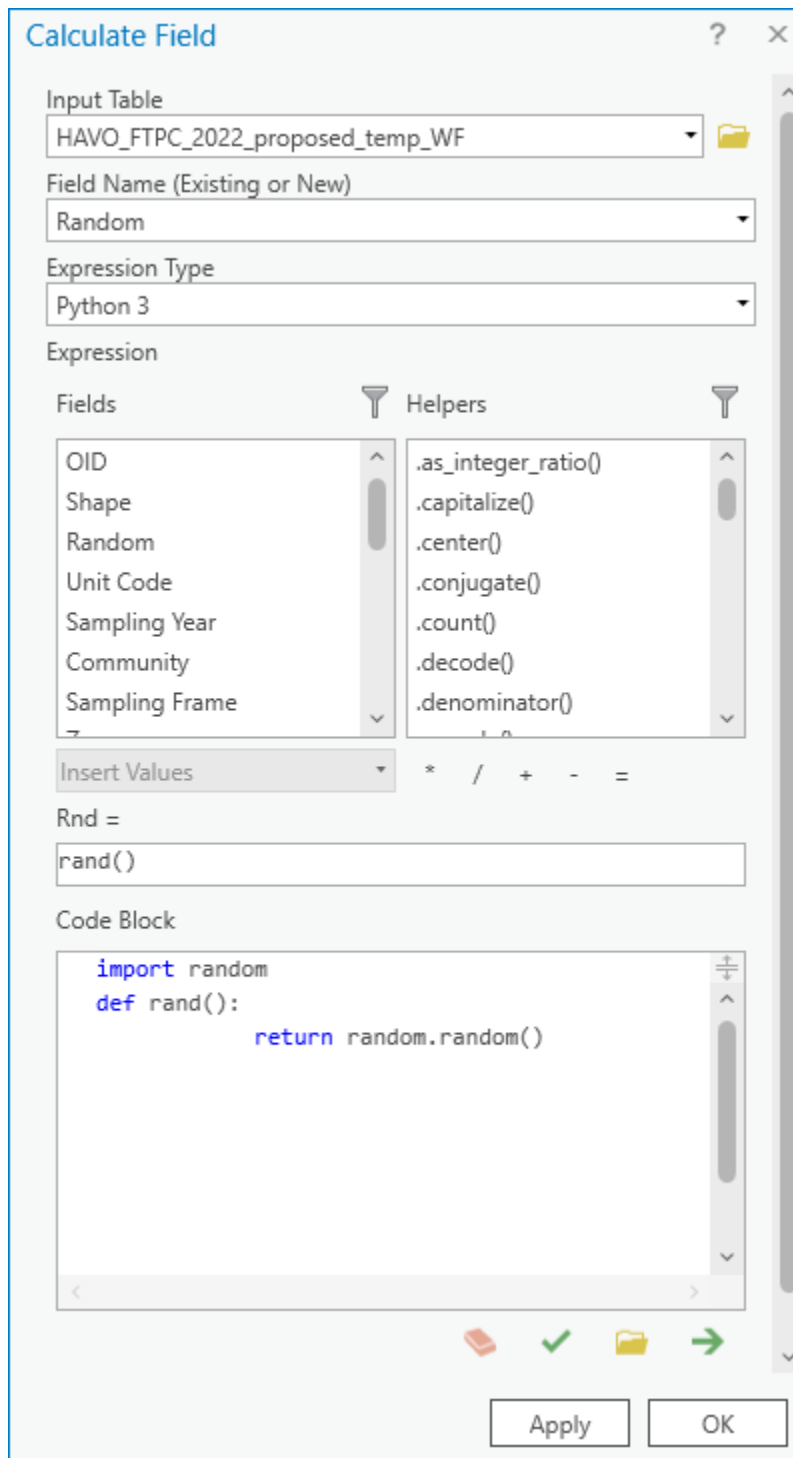


Figure SOP 5.3. Calculate Field geoprocessing tool settings and code block for generating random numbers.

6. Verify a new set of random numbers has been generated in the Random attribute field.

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.

7. Sort (ascending) the attribute table by the *Random* field. Once sorted, populate *Plot_Num* field in ascending order based on the sort, starting with rotational and then alternate plots. Rotational plots will have a two-digit number, and alternate plots will have an A prefix with a single number (starting with A1, A2, etc.). Refer to the *FTPC_sampled_plots_all_centers_pts* feature class within the FTPC Master Geodatabase 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' (Figure SOP 5.4).

	Unit Code	Sampling Year	Community	Sampling Frame	Zone	Plot Number	Plot Type	Azimuth	Latitude	Longitude
1	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	21	Rotational	335	19.692587	-156.04355
2	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	22	Rotational	53	19.679365	-156.030114
3	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	23	Rotational	144	19.693498	-156.044558
4	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	24	Rotational	60	19.671777	-156.025824
5	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	25	Rotational	47	19.691715	-156.039585
6	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	A1	Alternate	138	19.692472	-156.040303
7	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	A2	Alternate	305	19.685506	-156.033083
8	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	A3	Alternate	112	19.692103	-156.039482
9	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	A4	Alternate	107	19.686319	-156.032846
10	KAHO	2022	Coastal Strand	Kaloko-Honokohau	<Null>	A5	Alternate	324	19.684703	-156.033321

Figure SOP 5.4. Attribute Table sorted by *Random* field, with Plot Number (*Plot_Num*) and Plot Type (*Plot_Type*) fields populated appropriately.

8. Assign random azimuths to each plot (Figure SOP 5.5).
 - a. Open the attribute table and select the *Azimuth* field. Right-click on the attribute field header and select the Field Calculator.
 - b. 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 Arcade.

Type the following code in the Azimuth = box:

```
random() * (360 - 1) + 1
```

Click OK. The *Azimuth* field should be populated with random values between 1 and 360. Assuming the field type was set to short integer as specified, these will be whole numbers.

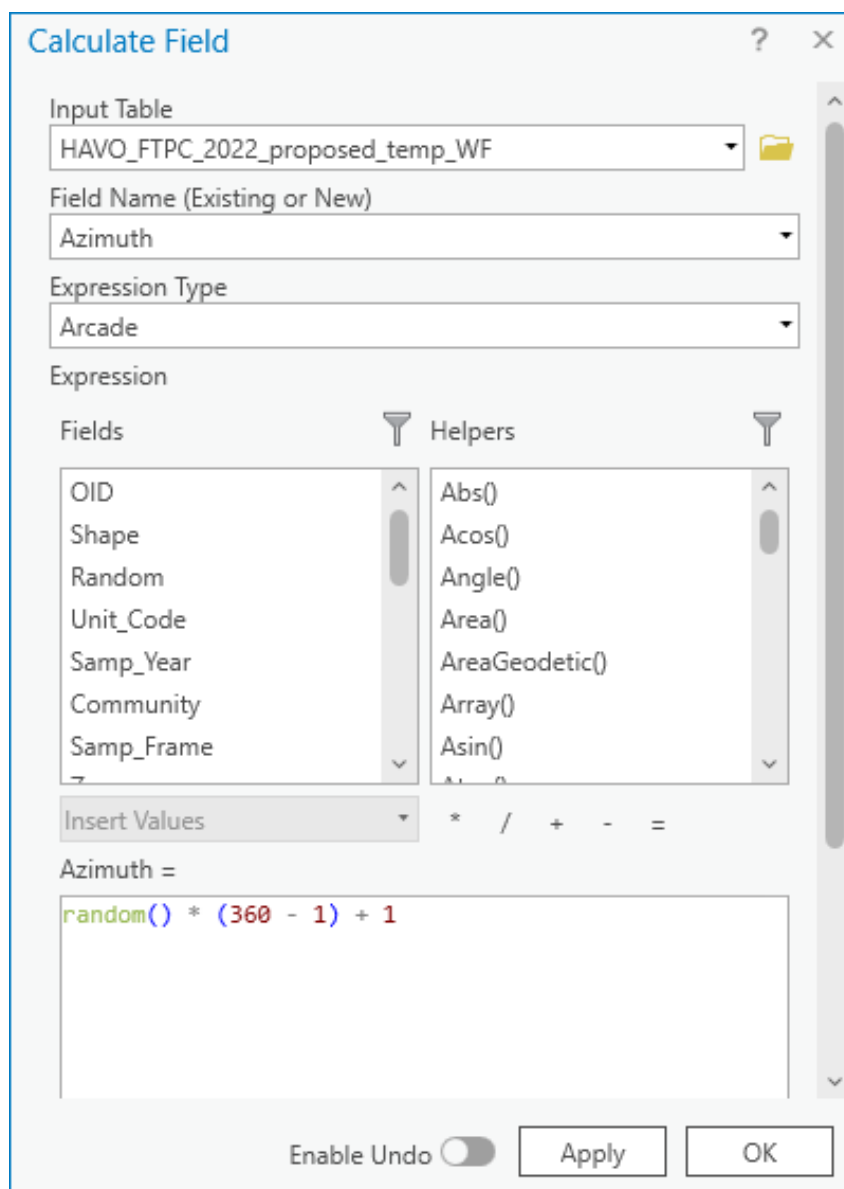


Figure SOP 5.5. Calculate Field geoprocessing tool settings and code block for generating random numbers between 0 and 359 for plot azimuths.

9. Run the *Sort* Geoprocessing Tool (Figure SOP 5.6).
 - c. Select the feature class containing the random points created in the previous steps for *Input Dataset*.
 - d. Select 'Random' for the *Sort Field* drop down menu and 'Ascending' for *Sort Method*.
 - e. Specify your *Output Dataset* to the temp file geodatabase created in Step 2 and name the output feature class as desired. Suggested feature class name = "[PARK]_FTPC_[YYYY]_proposed_temp"

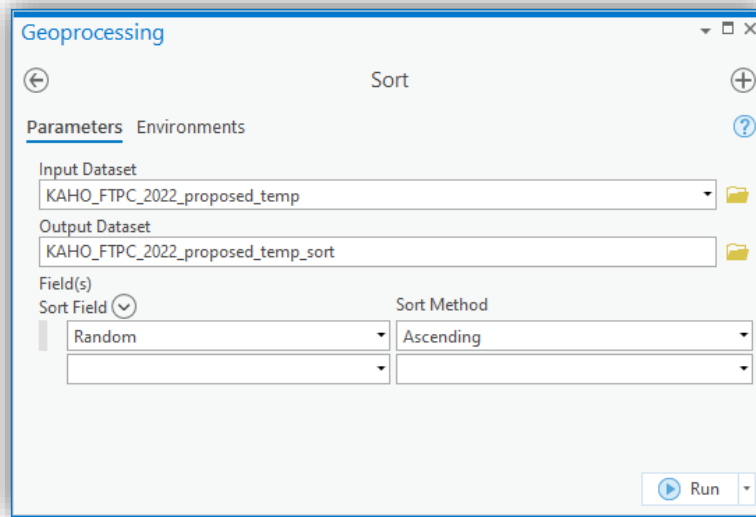


Figure SOP 5.6. The Sort geoprocessing tool in ArcGIS Pro.

10. Once the previous steps are complete, consult the PACN Botanist to verify rotational and alternate plot locations do not inhabit any previously unknown hazards, new exclusion zones, or any otherwise areas that are otherwise known to be unavailable for sampling. Once the Botanist has approved plot locations, rotational plot generation is complete.

Data Management Following Rotational Plot Point Generation

After the generation of random plot point locations for Rotational and Alternate plots, there are several data management steps that must be completed before the field season.

1. Append the feature class of random points for Rotational and Alternate plots generated in the previous section to the *FTPC_proposed_plots_pts* feature class within the FTPC Master Geodatabase.
 - a. If the local copy of the FTPC Master Geodatabase (PACN_FTPC_MASTER.gdb) has not already been added to your Pro Project, navigate and add it via the Catalog Pane.
 - b. From the Catalog Pane, right-click on the *FTPC_proposed_plots_pts* feature class within the local FTPC Master Geodatabase copy and select *Load Data*. This will open the *Append* geoprocessing tool and automatically populate the *FTPC_proposed_plots_pts* feature class as the *Target Dataset*.
 - c. Select the feature class of random points generated in the previous section as the *Input Dataset*.
 - d. *Target Dataset* should already be populated to *FTPC_proposed_plots_pts*.

- e. For *Field Matching Type*, select ‘Use the field map to reconcile field differences’ from the drop-down menu. The Output Fields schema should match very closely, make any changes as needed.
 - f. Run the *Append* tool. Once complete, verify the year’s Rotational and Alternate points have been added successfully to the *FTPC_proposed_plots_pts* feature class.
2. Replace the FTPC Master Geodatabase in the FTPC programmatic spatial “[Data](#)” folder of the PACN Monitoring Archive with the updated local copy which includes the newly generated random points. The old geodatabase version can have the date added to the end of the name and be moved to the *Archive_versions* folder within that root directory.
3. Create a new feature class containing all the monitoring plots for the current field season (Fixed, Rotational, and Alternate) (Figure SOP 5.7).
 - a. If not done already, add the *FTPC_sampled_plots_all_centers_pts* feature class within the FTPC Master Geodatabase to the local Pro Project.
 - b. Apply a definition query to the *FTPC_sampled_plots_all_centers_pts* feature class to display only the fixed plots for the current sampling year.
 - c. Use the *Merge* geoprocessing tool to create a new feature class that combines the fixed plots from the *FTPC_sampled_plots_all_centers_pts* feature class with the rotational and alternate plots feature class created in the previous section.

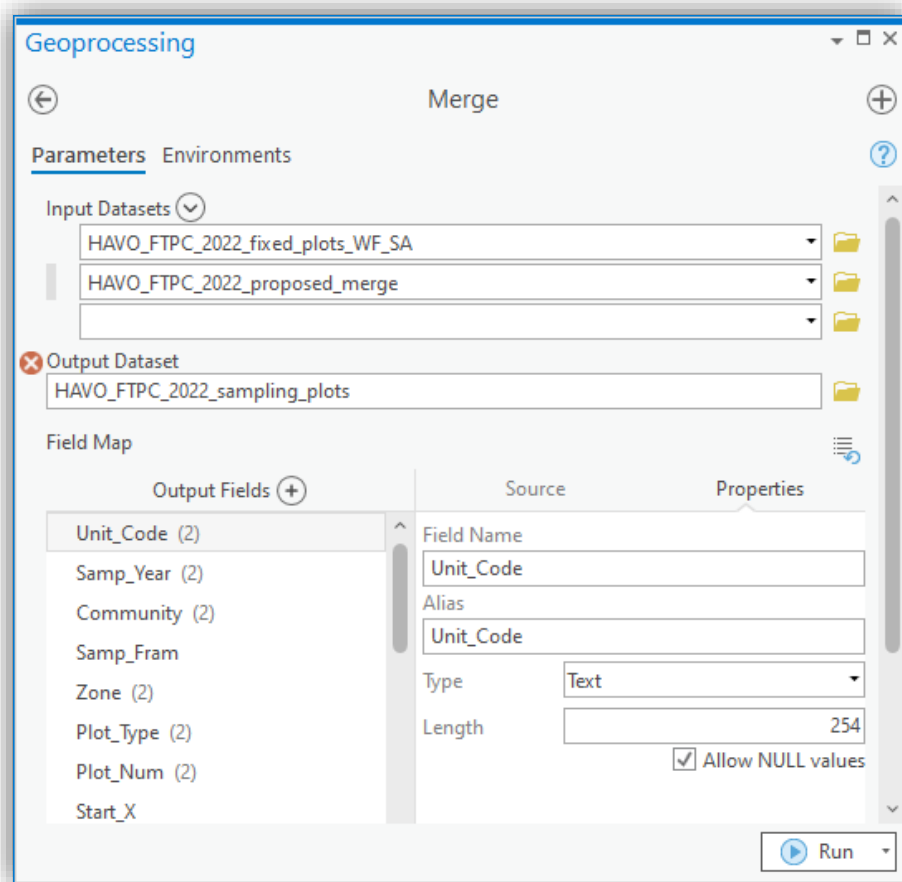


Figure SOP 5.7. Merge geoprocessing tool used to combine existing fixed plots and newly created rotational and alternate plots into a single feature class.

4. Export the newly created feature class with all sampling plots for the current year as a shapefile to the local temp directory (Figure SOP 5.8). To export, right-click on the feature class in the Contents Pane, then select Data → Export Features. Naming convention = *[PARK]_FTPC_[YYYY]_plots.shp*

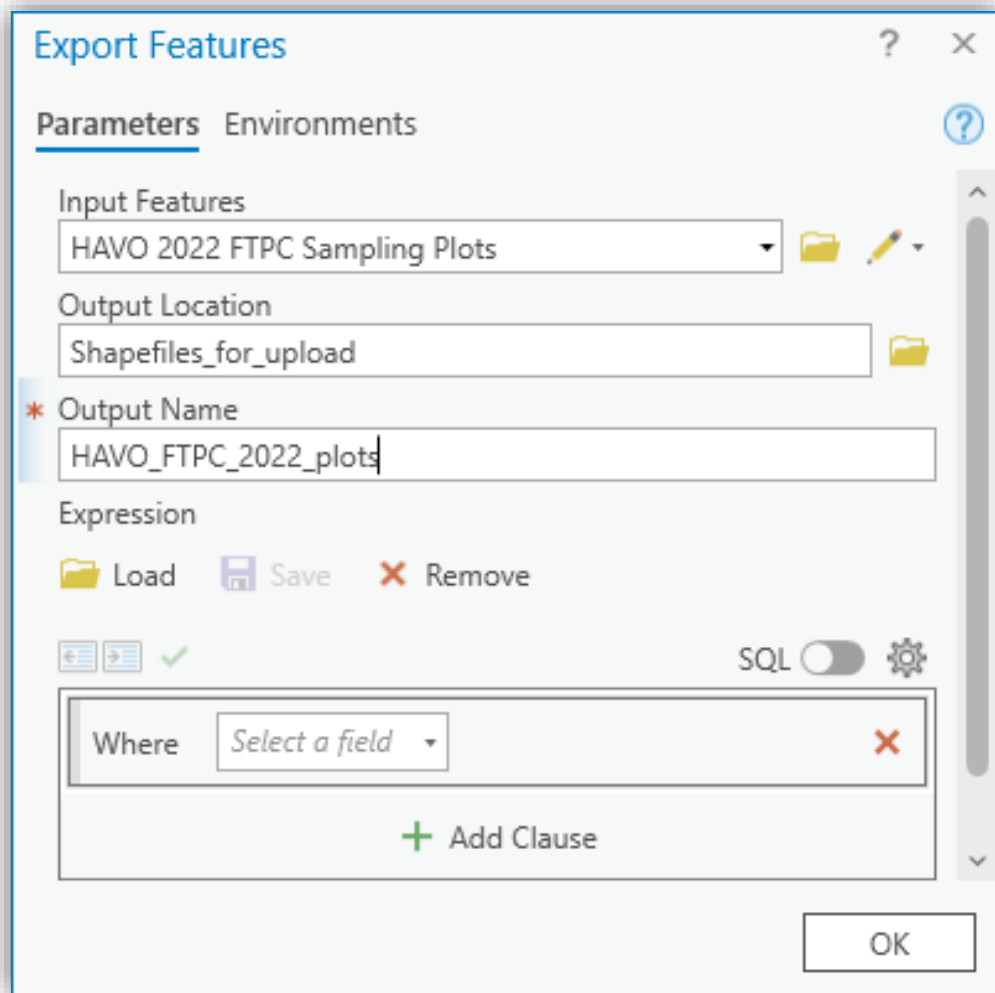
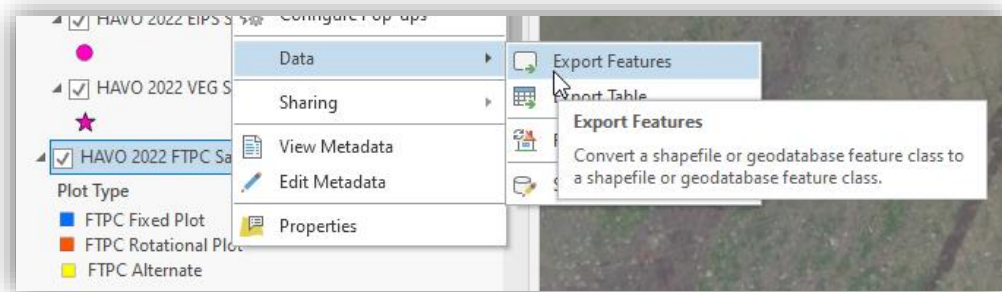


Figure SOP 5.8. Exporting feature class containing sampling plots to a shapefile.

5. Copy the newly created shapefile to the directory listed below in the [FTPC Monitoring project workspace](#) in SharePoint (Figure SOP 5.9). This will be used by field staff to upload sampling points to Garmin GPS units. Within the [FTPC Monitoring project workspace](#), copy

new shapefiles to – [Spatial Info](#)/[YYYY]/[PARK]/GIS_Data/Shapefiles_for_upload/

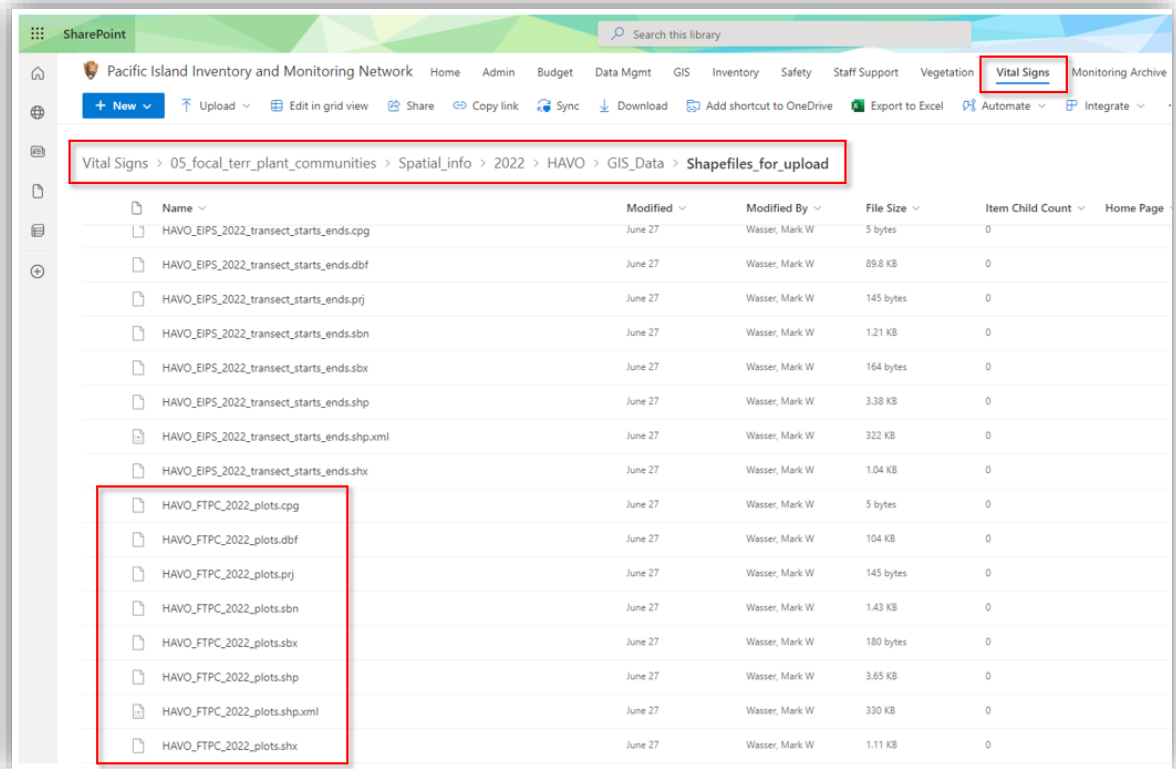


Figure SOP 5.9. Example of exported shapefile location for a particular year and park in SharePoint.

6. Publish the feature class of all sampling points for the current year created in Step 3 of this section to ArcGIS Online (AGOL) for use in electronic data collection with the Field Maps App. (Publishing privileges in AGOL are required to complete this step).
 - a. From the Contents pane, right-click on the feature class and select *Sharing* → *Share as Web Layer*.
 - b. Populate item details as appropriate (see Figure SOP 5.10.) and select appropriate publishing location based on publishers AGOL folder structure and organization. Also specify the following parameters.
 - i. Layer Type = Feature
 - ii. Share with *PACN_Vegetation* Group
 - iii. Enable Editing
 - iv. Enable Sync
 - v. Enable Export Data
 - vi. Preserver Editor Tracking Info
 - vii. Set time zone to UTC-10:00 Hawaii

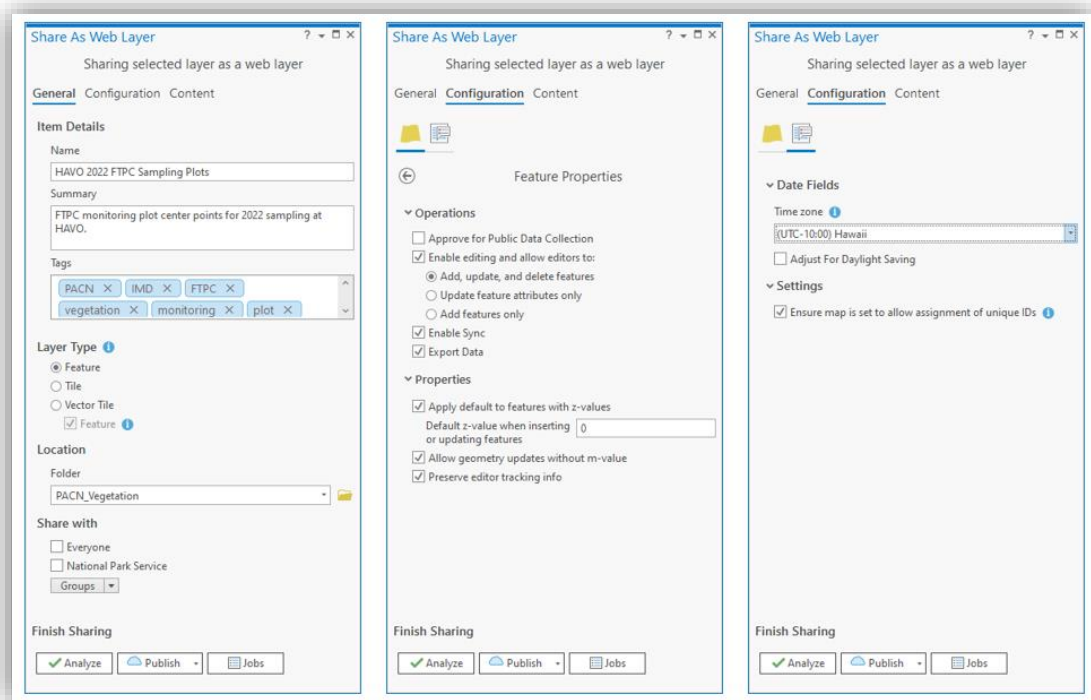


Figure SOP 5.10. Example of publication settings for sampling points feature class published to ArcGIS Online (AGOL).

- c. Analyze and then Publish. Once published to AGOL, the PACN GIS Specialist will use this published layer as part of the web map deployed for electronic data collection via the Field Maps App.
7. Save copies of the ArcGIS Pro Project, Map Template, temporary File Geodatabase, and Layout Template (optional) used for point generation to the [FTPC Monitoring project workspace](#) in SharePoint as follows (Figure SOP 5.11). All will be published to – [Spatial Info/\[YYYY\]/\[PARK\]](#), and then subdirectories as specified:
 - a. File Geodatabase (.gdb) - /GIS_Data/Data/
 - b. ArcGIS Pro Project (.arpx) - /GIS_Data/Projects/
 - c. ArcGIS Pro Map Template (.mapx) - /GIS_Data/Projects/
 - d. ArcGIS Pro Layout Template (.pagx) - /GIS_Data/Projects/

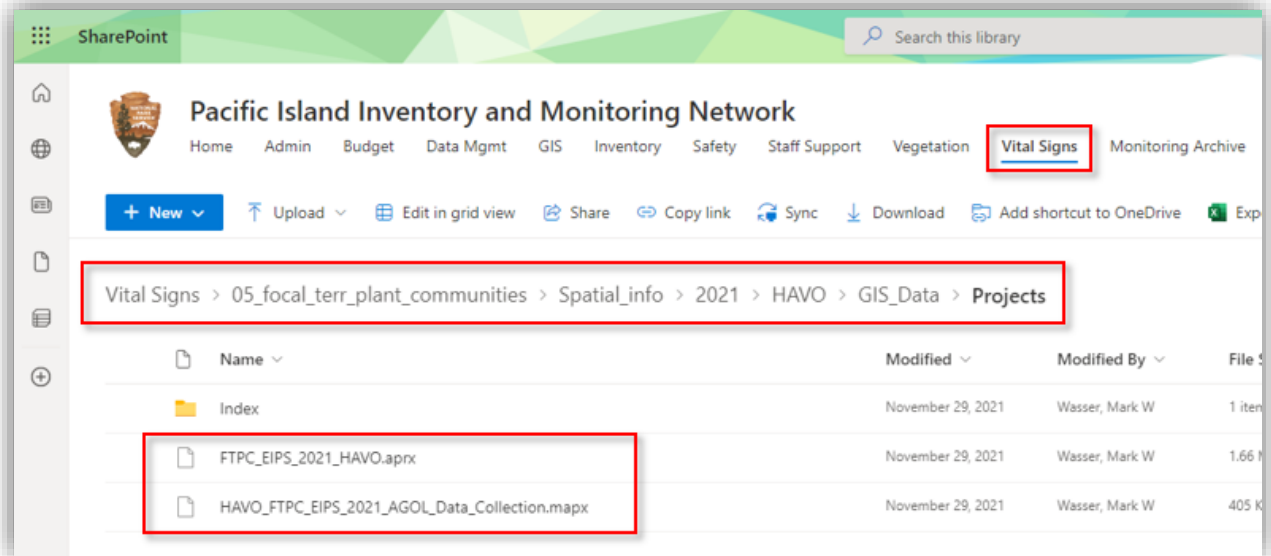
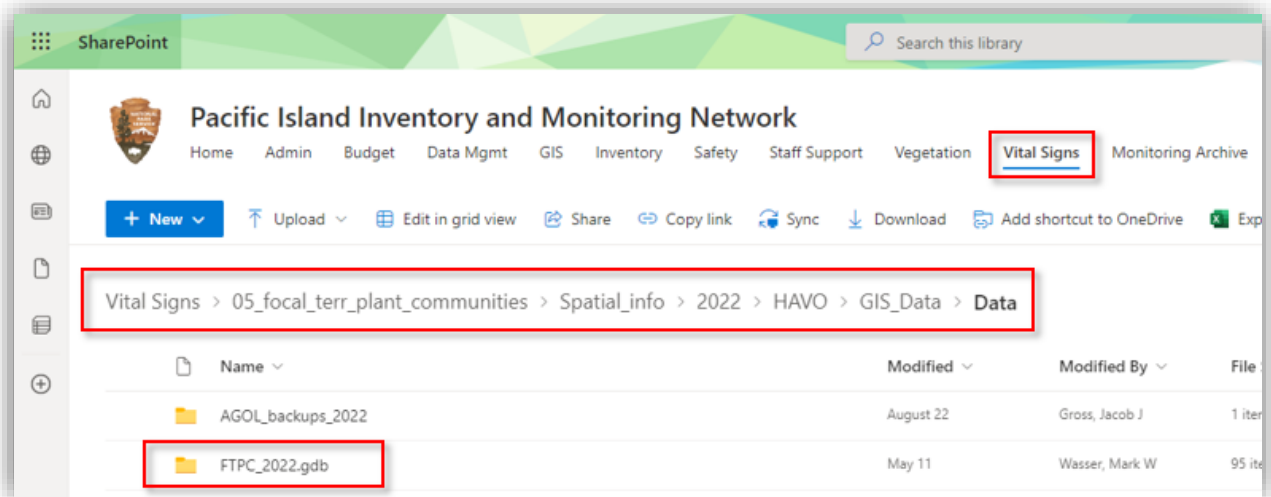


Figure SOP 5.11. Example of exported geodatabase, project, and map template locations for a particular year and park in SharePoint.

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	5
HAVO	Wet Forest	‘Ōla‘a	30	15	15	5
HAVO	Wet Forest	Kahuku	30	15	15	5
HAVO	Subalpine Shrubland	Subalpine Shrubland	30	15	15	5
KAHO ²	Coastal	Coastal	15	10	5	5
HALE	Wet Forest	Wet Forest	30	15	15	5
HALE	Subalpine Shrubland	Subalpine Shrubland	30	15	15	5
KALA	Wet Forest	Wet Forest	30	15	15	5
KALA	Coastal	Rocky Substrate	15	10	5	5
KALA	Coastal	Calcareous Substrate	15	10	5	5
NPSA	Wet Forest	Tutuila	30	15	15	5
NPSA	Wet Forest	Tau	30	15	15	5
WAPA	Limestone Forest	Limestone Forest	15	10	5	5
AMME	Mangrove Wetland	Mangrove Forest	10	10	0	-

Appendix SOP 5.b. Plot Centroid Requirements

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.b.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°).

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.b.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°).

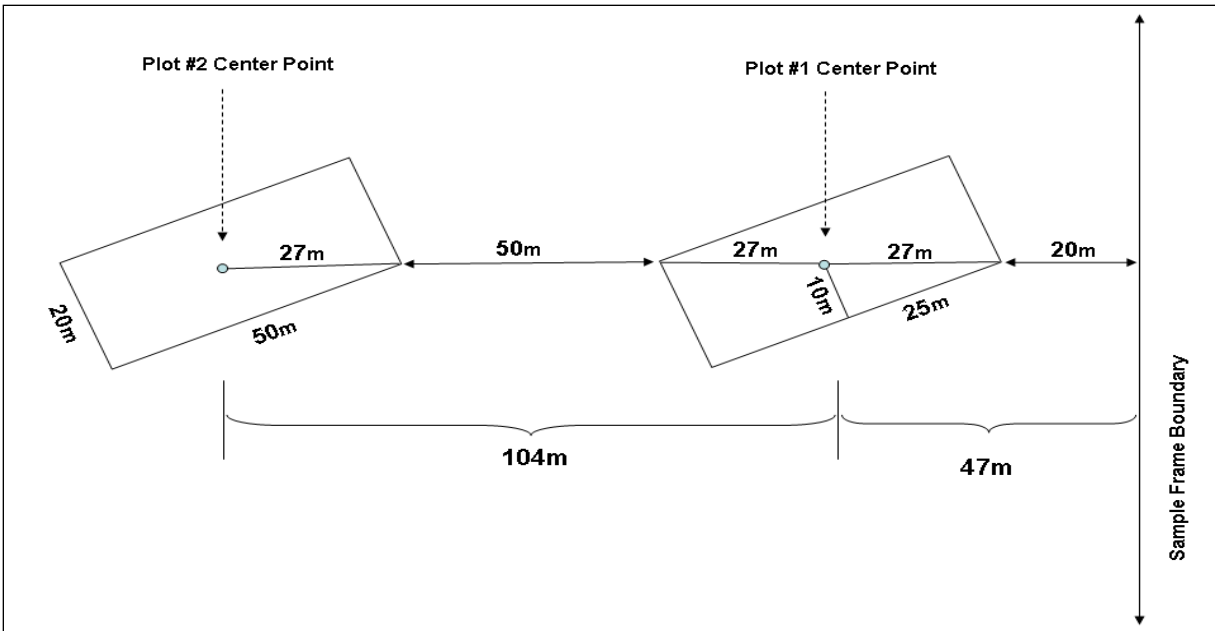


Figure SOP 5.b.1. The minimum distance between plot center points and either frame boundaries or unrepresentative features (47 m), as well as adjacent plot center points (104 m) for 20 x 50 m plots. Note that these distances ensure plot edges greater than 20 m from frame boundaries or unrepresentative features and greater than 50 m from other plots. These values apply to all 20 x 50 m plots.

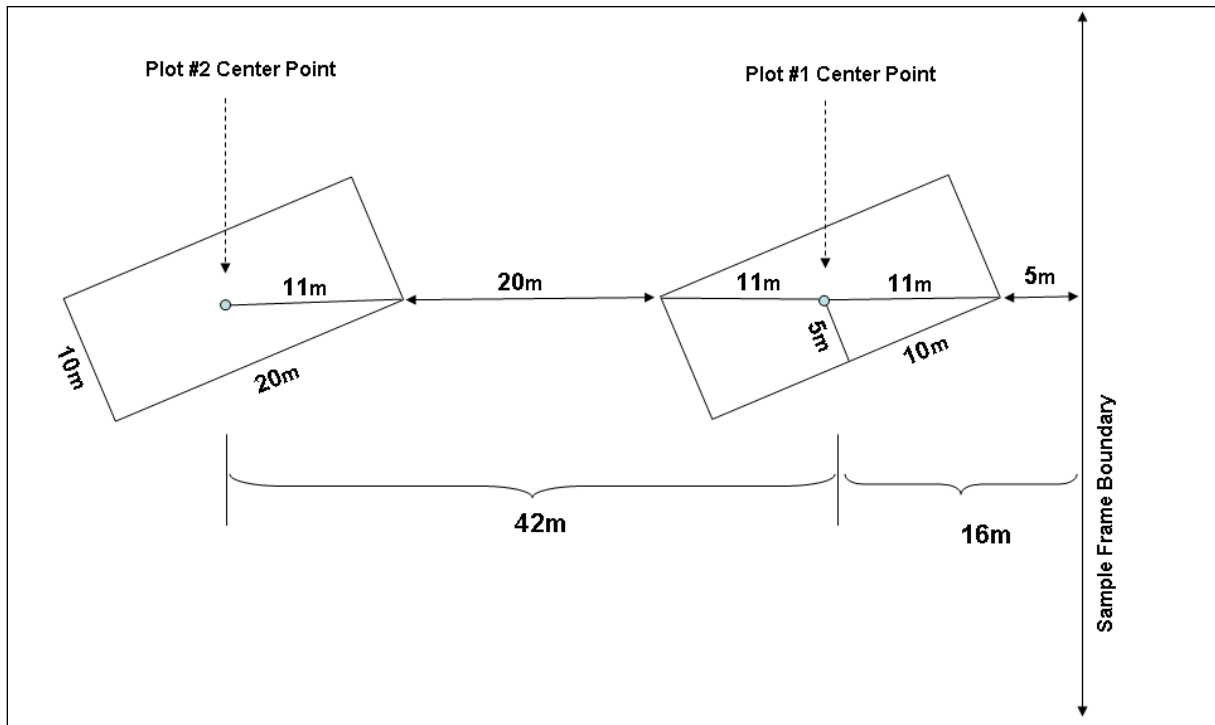


Figure SOP 5.b.2. The minimum distance between plot center points and either frame boundaries or unrepresentative features (16 m), as well as between adjacent plot center points (42 m) for 10 x 20 m plots. Note that these distances ensure plot edges greater than 5 m from frame boundaries or unrepresentative 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).