Standard Operating Procedure (SOP) #9

Establishing and Marking Vegetation Monitoring Plots

Version 3.0 (April 29, 2021)

Change History

New Version #	Revision Date	Author	Changes Made	Reason for Change	Previous Version #
2.0	1/12/2017	Alison Ainsworth, Kathy Akamine	Included details from the first cycle of monitoring.	Inaccurate as written.	1.0
3.0	04/29/2021	Kathryn Akamine, Jacob Gross, Lindsay Moore	Added additional markers and tree flagging methods for fixed plot boundaries.	To increase the precision in recreating fixed plot boundary.	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 describes how to establish rotational and fixed plots for Pacific Island Network (PACN) focal terrestrial plant communities monitoring in the wet forest, subalpine shrubland, limestone forest, mangrove forest, and coastal strand community types. For the forest and shrubland communities, vegetation is sampled in large (20 x 50 m) plots. In coastal communities, vegetation is sampled in small plots (10 x 20 m) because these communities are smaller in size and linearly constrained. All plots are established using the same methodology with measuring tapes, but only the fixed plots are permanently marked for future sampling.

A master equipment list for this protocol is in SOP #1 Before the Field Season. The equipment list should be updated as needed if this SOP is revised. Prior to navigating to a plot, sanitation procedures outlined in SOP #4 Sanitation Protocol must be followed. Methods for generating plot locations and navigating are detailed in SOP #5 Generating Sampling Point Locations with GIS, and SOP #6 Using Garmin® GPS Units. Data forms for recording field observations are in Appendix E: Forms for Recording Field Data. Once a plot is established, procedures for field data collection are in SOP #10 Conducting Community Vegetation Surveys.

Locating and Accessing Plots

For each monitoring cycle, the project lead will ensure that the correct previously established start, center, and end points for fixed plots are available and new proposed random center point locations

for rotational plots are generated. Prior to each field season, the project lead and field leader(s) will work with local park staff during the permitting process to ensure that access routes are safe (i.e., do not cross risky steep areas with >70% slopes) and efficient to minimize disturbance impacts. In some instances, field crews may travel along steep slopes if using an existing park route (e.g., trails, fence lines, park transects). All field crew members must evaluate the risks and hazards of their daily travels and are encouraged to speak up if they feel a route is unsafe. If transit is deemed unsafe, the crew may find an alternate route or may choose to reject the plot.

Access will typically be through a combination of transport in vehicles, helicopter use, and hiking. A GPS (Global Positioning System) unit is used to navigate to the selected plots, but when satellite coverage is poor compasses and maps that offer topography and imagery are used. To the greatest extent possible, plot locations are pre-screened using a GIS to eliminate steep or dangerous sites beforehand; however, in some instances field crew members may encounter unforeseen conditions that make a potential plot location unsafe to access.

The field crew navigates to the proposed center point for new fixed or rotational plots or to the start/center/end of a previously established fixed plot. When navigating to an established fixed plot, the crew will have start, center, and end points available for navigation. Crews may choose to focus on the point closest to them (e.g. if the TR2 end point is closest to trail that is used to reach plot, it would be most efficient to navigate to the end point).

Plot Rejection Criteria and Relocation Procedures

When the site for a new plot is reached, the field lead determines if the plot location is acceptable. Examples of unacceptable plot locations include: unsafe area, vegetation covers less than 10% of the plot, vegetation in plot is influenced by human development (roads, powerlines, etc.). All monitoring plots must be buffered from streams (wider than 1 m), developed areas (e.g., roads, runways, houses, parking lots), trails, fence lines, archeological features, high tide lines, cliff faces, and park boundaries by at least 5 m for coastal plots and 20 m for forest/shrubland plots. **If a pre-selected plot location is rejected for any of these reasons, the field crew attempts to establish an acceptable new plot location by**: 1) selecting a new random azimuth, 2) moving the plot up to 50 m in a random direction and selecting a random azimuth if necessary, 3) moving the plot 100 m in a random direction and selecting a random azimuth if necessary, 4) If limited safe options are available, adjusting the transect to fit within the safe area is acceptable, but randomization as described previously should be employed to the greatest extent possible, 5) rejecting the proposed site all together and selecting a new alternate plot location from the preseason generated list. **It is critical to include comments on the data form describing what actions were taken when a plot is moved or has an adjusted azimuth**. If an alternate is used, details explaining why the proposed plot was rejected are required on the Plot location data form. When an alternate plot is used (e.g., A2) it is renamed as a rotational plot (e.g. if R39 is the rejected rotation plot, A2 would be renamed as R39), all data forms must be labeled with the rotational plot number that the alternate is replacing. Data forms, photos, and GPS waypoints should be labeled as the rotational plot, as opposed to the alternate plot label.

Establishing Monitoring Plots

Field crews consisting of three (coastal) or four (forest/shrubland) members are recommended to establish and monitor plots. All field crew members must have compasses with correct declination. Three long transect tapes (TR 1, TR 2, and TR 3) and three shorter transect tapes (TR 4, TR 5, and TR 6) are necessary to install a plot in all communities. It is important to walk to the side of long transect tapes (TR 1, TR 2, and TR 3) while establishing the plot to minimize trampling because vegetation cover data are collected along the plot's centerline (TR 2) and each of the plot's long edges (TR 1 and TR 3). It is necessary to affix the start and end of each tape in order to keep the tapes in place and prevent them from moving or shifting and subsequent inaccuracies in data collection. Permanent post offset distance is recorded in the "problems" section of the plot data form when the permanent post site along TR 2 is unavailable. For example, the marker (PVC/steel rod) may be installed beyond 50 m or, if necessary, less than 50 m in a fixed forest plot if an obstacle (e.g., fallen tree, large rock, etc.) blocks the correct marker spot. **Importantly, the offset can only be in distance and not in direction, the marker must be installed along the correct plot azimuth.** The plot tapes measure slope distance rather than horizontal distance when the plot encompasses variable slopes (e.g., ravine) because this represents the ground area of the site more accurately (NPS 2003). All tapes should be laid as close to the ground as practical (e.g. under small tree branches and large shrubs, if possible). All edges of each plot should connect to form corners and provide a distinct plot for survey.

Plot Layout

For most focal terrestrial plant communities (wet forest, subalpine shrubland, limestone forest, and mangrove forest) vegetation is measured within 20 x 50 m rectangular plots (fig. 1). Three 50 m tapes (long centerline TR 2 and long edges TR 1, TR 3) are laid parallel and 10 m apart in the same direction with their 0 m starting point on TR4. The 0 m starting point of three 20 m tapes (short centerline TR 5 and short edges TR 4, TR 6) are laid along TR 1 to the left of and perpendicular to the centerline and their 20 m end points are on TR 3. The 2 x 50 m subplot is nested within the plot, along the inside of the long edge (TR 3) does not require an additional tape because a 2 m pole is used to measure/visualize the width of this subplot during monitoring.

For the coastal communities, vegetation is measured within smaller 10 x 20 m rectangular plots (fig. 2). Three 20 m tapes (long centerline TR 2 and long edges TR 1, TR 3) are laid parallel and 5 m apart in the same direction with their 0 m starting point on TR4. The 0 m starting point of three 10 m tapes (short centerline TR 5 and short edges TR 4, TR 6) are laid along TR 1 to the left of and perpendicular to the centerline and their 20 m end points are on TR 3. The two 2 x 20 m subplots are nested within the plot, along the inside of the two long edges (TR 1, TR 3), but tapes are not laid because a 2 m pole is used to measure/visualize the width of the subplot during monitoring.

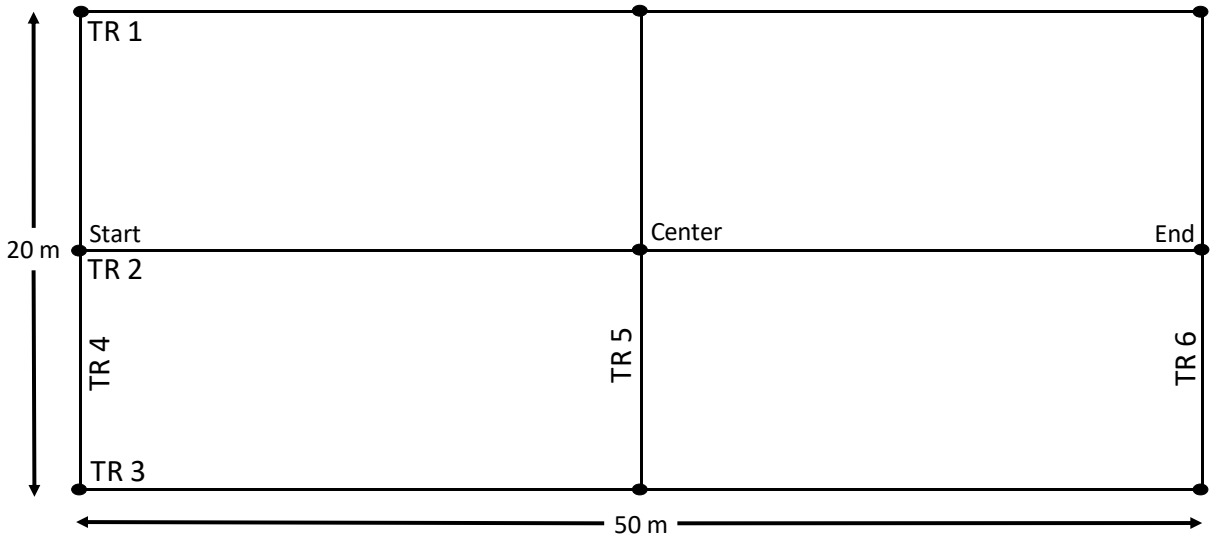

Figure SOP 9.1. Plot used to quantify vegetation composition and structure in wet forest, subalpine shrubland, limestone forest, and mangrove forest communities. Plots are installed using three 50 m tapes and three 20 m tapes to define the plot boundaries and centerlines. For all fixed plots, permanent markers are installed at the start, center, and at the end of the long centerline (TR2). Each of the transect tape connections/intersections (depicted by the solid black circles) should have flagging to assist with future plot set up. Depending on the community, witness trees and additional posts may be added to assist with plot set up. Rotational plots utilize tapes and temporary flagging only and all markers for rotational plots are removed upon completion of plot monitoring.

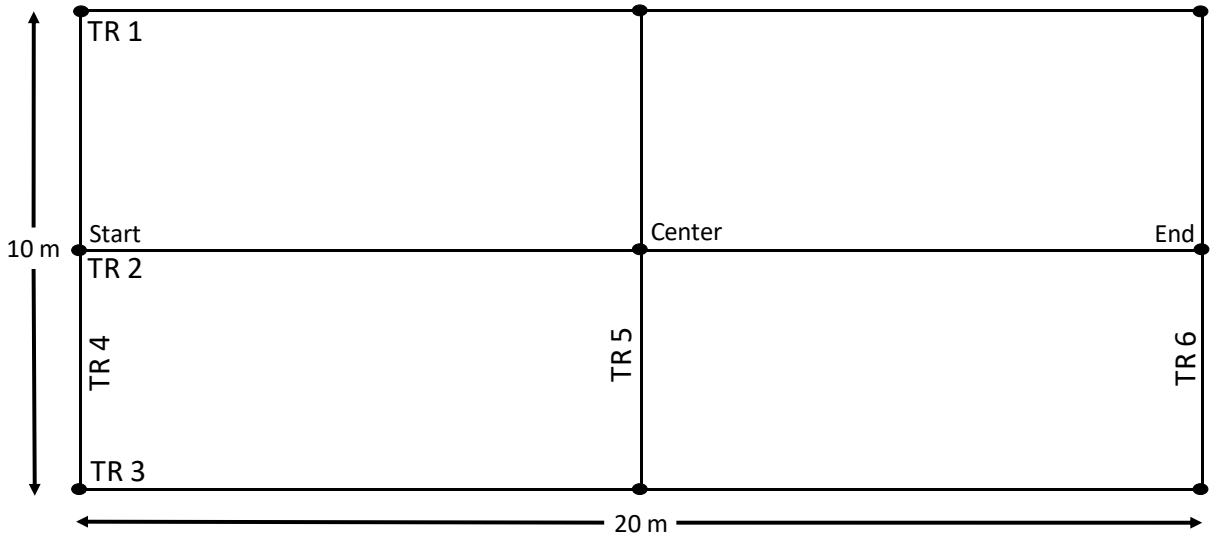

Figure SOP 9.2. Coastal community plot used to quantify vegetation composition and structure. Plots are installed using three 20 m tapes and three perpendicular 10 m tapes. For all fixed plots, permanent marker post is installed at the start, center, and at the end of the long centerline (TR2). If possible, each of the transect tape connections/intersections (depicted by the solid black circles) should have flagging to assist with future plot set up. Rotational plots utilize tapes and temporary pin flags only and all markers for rotational plots are removed upon completion of plot survey.

New Fixed or Rotational Plots

New fixed or rotational plots are plots that have never been set up or visited before. Field crews are provided the plot center point for navigation and must establish the plot using the center point and the predetermined, designated azimuth. Once the plot center is located and deemed acceptable the field crew should locate a "basecamp" for packs and gear that is outside of the plot boundaries to reduce impacts to vegetation within the plot and convenient for completing plot establishment. The easiest location for this is the distance needed to get outside of the shorter boundary (forest and shrubland: 10 m; coastal: 5m), using the plot azimuth +/- 90°. If the plot environment is difficult to navigate and having a "basecamp" within the plot can be done without impacting the vegetation the crew may do so.

The first transect to be set up is the long centerline (TR 2) (fig. 3.A). The centerline (TR 2) tape should be run in both directions (azimuth and back azimuth) from the center point. When standing at the center point, one crewmember should hold the base of a long transect tape, while another crewmember takes the 0 m end of tape and traverses half the length of the plot (forest and shrubland: 25 m; coastal: 10 m) to reach the TR 2 start by using the back azimuth (plot azimuth – 180˚) (fig 3.A). Once the 0 m end (start) of the centerline (TR 2) is in place, that crewmember will return to the center and the crewmember that was holding the base of the transect tape will take the tape and traverse the remaining length of the plot (forest and shrubland: from 25 m to 50 m; coastal: from 10 m to 20 m) using the plot azimuth (fig 3.B). As transects are being set up, crewmembers should repeatedly check on the azimuth, both moving forward and looking back, and the transect should be redone as needed. In areas of thick vegetation or difficult topography, flagging and/or additional crew members may assist to construct a line of sight. Starting from the center and running a transect tape in both directions is the preferred method because the furthest distance travelled along an azimuth from a distinct point is 10 or 25 m versus travelling the full length of 20 or 50 m and leaves less room for error.

The short transects (TR 4, TR 5, and TR 6) are established along TR 2 and may be set up simultaneously. These short transects (forest and shrubland: 20 m; coastal: 10 m) are set up in the same fashion, starting at the long center transect (TR 2) and running the tape in both directions. TR 2 start is the center for TR 4, TR 2 center is the center for TR 5, and TR 2 end is the center for TR 6 (fig 3.C). The azimuth used for the short transects is perpendicular to the long center transect (TR 2) azimuth (plot azimuth + 90˚). One crewmember takes hold of the base of short transect tape, while the other crewmember takes the 0 m end of tape and traverses half the width of the plot (forest and shrubland: 10 m; coastal: 5 m) using the perpendicular back azimuth (plot azimuth – 90˚). Once the 0 m end of the short transects (TR 4, TR 5, and TR 6) is in place, that crewmember will return to the centerline and the crewmember that was holding the base of the transect tape will take the tape and traverse the remaining width of the plot (forest and shrubland: 20 m; coastal: 10 m) using the perpendicular azimuth (plot azimuth + 90˚). The perpendicular back azimuth may be calculated as perpendicular azimuth – 180° or as azimuth – 90°, either way the result will be the same.

The rectangular plot is completed by installing the two long outer edge transects (TR 1 and TR 3) parallel to the center transect (TR 2). TR 5 start is the center of TR 1 and TR 5 end is the center of

TR 3 (fig 3.D). Using the same methodology as above, the crewmember running the tape should continue to follow plot azimuth/back azimuth; however, the short transects (TR 4 and TR 6) offer some guidance on where tapes should meet to form the corners of the plot. It is helpful to add flagging over these connection points or to have a crew member there to help guide the transect runner.

All edges of each plot should connect to form corners and provide a distinct plot to survey. There is a certain amount of error that is acceptable with plot layout (because the ground is never perfectly flat). For example, if transect tapes do not connect and are less than 50 cm apart, the crew lead may move the tapes together to connect the corner. However, if the transects forming the corners are greater the 50 cm apart, the crew will need to fix the transect issue. It is best to start by identifying the problem (e.g., Is there an inconsistency in azimuth? Is there a distinct bend in the transect? Is there a large tree that the transect runs through and may make a difference if transect runs to the left or right of it?). Attempt to correct the transect with small adjustments; however, if needed, it may be necessary to be rerun the entire transect.

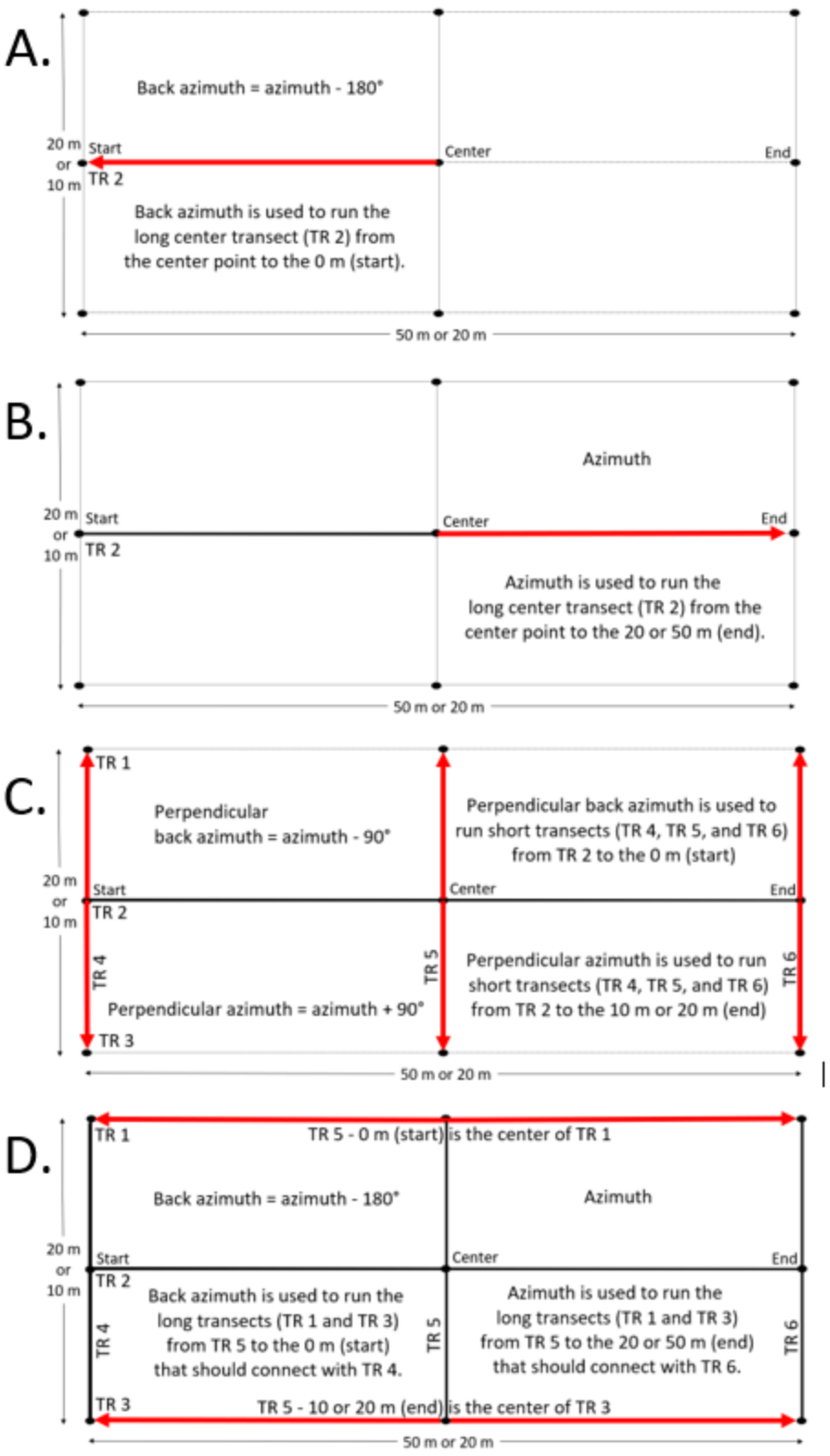

Figure SOP 9.3. Plot layout and set up: A) From the center point, use the back azimuth to run the center transect (TR 2) half the length of the plot, 10 m or 25 m, so the 0 m mark is at the “start”. B) Once the start of TR 2 is in place, use the azimuth to run the remaining length, 20 m or 50 m, to the “end”. C) The

short transects (TR 4, TR 5, and TR 6) are established along TR 2 and may be set up simultaneously. D) Finally, TR 1 and TR 3 are set up using TR 5 as its center and TR 4 and TR 6 for guidance on where to connect plot corners.

Previously Established Fixed Plots

Field crew lead(s) should review previous sample cycle plot data forms, photos, and operational review reports prior to plot visits and should upload all information to field tablet for reference while in the field. Field operational review reports and previous sample cycle data forms offer guidance on the best route to the plot and any potential obstacles or safety concerns. As the plot was previously established the field crew will have start, center, and end GPS point of the fixed plot's centerline (TR 2). The fixed plot should have blue and pink (pink and red may used interchangeably depending on the park and/or field season) flagging to help the crew locate the plot from a distance and assist in the location of permanent posts (a metal post and/or a PVC post) in the ground. The field crew should navigate to the start, center, or end point to locate the plot's permanent marker posts (all fixed plots have metal posts, some have a metal post with a PVC post and additional flagging). Prior to 2021, the only two permanent marker posts (start and end) were installed along TR 2, because of this 2021-2025 crews should navigate to the start or end.

For fixed plots that are monitored before 2026, crews will need to establish TR 2 by finding the start and/or end post and connecting the two. This is recommended over the methods for establishing a new fixed or rotational plot because the goal for subsequent field crews is to recreate the plot as it was surveyed previously. Data forms and photos may help with relocation of permanent markers and hand drawn maps may show the path of transects that may need to meander around vegetation or other obstacles. Once the centerline (TR 2) is established the rest of the plot should be done as mentioned in the previous section to minimize error. Pin flags and flagging will be in the plot for guidance. If crew cannot find one or more permanent marker posts, crew should use all resources (e.g. flagging, photos, GPS points, etc.) to best recreate plot.

For fixed plots that are monitored from 2026 and on, plots should have additional markers as stated in the section below, this should assist with location of the permanent markers from afar and allow field crews to set up the plots as shown in Figure SOP 9.3.

Marking Permanent Fixed Plots

Fixed plots will be revisited every five years during their designated sampling cycle. Permanent markers are important to locate and recreate the plot. Markers used will vary depending on park, community type, and sampling frame (Table SOP 9.1).

Table SOP 9.1. Permanent markers used for fixed plots.

Cycle Year	Park	Community	Sampling Frame	S, C, & E Metal post	PVC over TR 2 Metal post	T1 and T3 metal posts	T1 and T3 PVC Post	Brass tags (S & E)	Flagging and Witness trees
1	HAVO	Wet Forest	ʻŌlaʻa	Y	Y	Y	Y	Y	Y
1	HAVO	Wet Forest	Nāhuku / East Rift	Y	Y	Y	Y	Y	Y
2	HAVO	Wet Forest	Kahuku	Y	Y	Y	Y	Y	Y
2	HAVO	Subalpine Shrubland	Mauna Loa	Y	N	Y	N	Y	Y
2	KAHO	Coastal Strand	Kaloko-Honokōhau	Y	N	Y	N	Y	Y
3	HALE	Wet Forest	Kīpahulu District	Y	Y	Y	Y	Y	Y
3	HALE	Subalpine Shrubland	Haleakalā	Y	N	Y	N	Y	Y
3	KALA	Wet Forest	Puʻu Aliʻi	Y	Y	Y	Y	Y	Y
3	KALA	Coastal Strand	Kalawao	Y	N	Y	N	Y	Y
3	KALA	Coastal Strand	Hoʻolehua	Y	N	N	N	Y	Y
4	NPSA	Wet Forest	Tutuila	Y	Y	N	Y	Y	Y
4	NPSA	Wet Forest	Taʻū	Y	Y	Y	Y	Y	Y
5	WAPA	Limestone Forest	Guam	Y	Y	Y	Y	Y	Y
5	AMME	Mangrove Wetland	Puerto Rico	Y	Y	Y	Y	Y	Y

From 2010-2020, each fixed plot had two metal posts installed along its centerline (TR2) at the start and the end. In some sampling frames a PVC post was installed over the metal posts to increase visibility, along with pink (or red) and blue flagging. These two anchor points were not sufficient to ensure the plot boundary was replicated.

Crews visiting fixed plots in the third cycle (2021-2025) will install additional permanent markers to add redundancy therefore creating a faster and more accurate plot set. All additional markers, or a lack of them, should be noted on the Plot Location form (APP. E). Notes should be clear and concise and written with the purpose of assisting future crews to recreate the plot, further directions can be found in FTPC SOP #10 Conducting Community Vegetation Surveys.

From 2026 and on, all fixed plots should have adequate permanent markers installed and field crews will need to replace any missing markers as needed.

Metal Posts

Prior to 2020

A fixed plot's centerline (TR 2) was permanently marked with metal posts (e.g., stainless-steel threaded rods, rebar, or something similar.) (figs. 1 and 2). The 0.01 m x 0.5 m metal posts were installed at the start and end point of the centerline (TR 2), **sometimes noted with an offset** (see below) on plot location data forms if obstacles were present. The metal posts should be inserted into the ground at these points so that they stand vertical with at least 0.3 m of the post above ground. In rocky substrates, setting the post may require a tool (i.e., a 5 lb sledgehammer or a rubber mallet) to keep the marker vertical. Many of the rocky substrates (e.g., subalpine shrubland at HAVO and HALE and coastal strand at KALA Kalawao) have metal posts that were not buried in the ground to protect sensitive resources and ensure compliance with the National Historic Preservation Act. These sites have metal posts that were laid on the ground in relatively secure sites (i.e., should not roll away) with the post marking the appropriate TR 2 start and end point.

During the sampling period of 2021-2025

- All metal post should be labeled with brass tags which should include: I&M, Transect number (1, 2, or 3), and Location (S = Start, C = Center, and E = End). If a PVC post is used over a metal post, the metal post does not need a label as the PVC post will be labeled.

- Fixed plots in all sampling frames, *except KALA coastal strand Ho'olehua sampling frame (see below)*, should have an additional third metal post installed at TR 2 center. The addition of new metal posts should also be noted on the Plot Location form (APP. E).

- Installation of seven additional permanent posts. This includes the TR 2 center, along with installing metal posts at the start, center, and end points on TR 1 and TR 3. The addition of new metal posts should also be noted along with specific notes if one or more posts were not installed for any reason.

    - In the subalpine shrubland and coastal strand communities additional metal posts may be installed if the vegetation is thick. Prior to monitoring fixed plots crew lead should review plot photos from previous cycles to assess need for additional metal posts. For a plot that may have thick vegetation on one side (i.e. TR 1 has thick vegetation and TR 3 has very little vegetation) additional metal posts may be added to the area of thick vegetation and not necessarily to the entire plot. Additionally, over time, as vegetation grows and/or changes there may be a need to add additional markers.

    - In the forest communities, all seven additional posts should be installed. PVC posts will be used over the metal posts.

    - *KALA coastal strand Ho'olehua sampling frame* fixed plots were originally established, as mentioned above, with a TR 2 start and TR 2 end metal post. The sampling frame has a predominantly sandy substrate. Metal posts were installed vertically, with 0.3 m of post above ground. During the second monitoring (2017)

cycle most of the metal posts were not found. I&M and KALA NPS staff attribute the missing posts to shifting sands, high tides, and possibly beach clean-up crews that frequent the area. Although most metal posts were not found, high accuracy GPS points and previous cycle photos were extremely helpful, and plots were recreated. *It is advised that additional or replacement metal posts be installed only if the area has become vegetated.*

- If any metal posts from a previous cycle is missing, replace the metal post and note this on the Plot Location form (APP. E).

- **All permanent posts should be drawn on map on Plot Location form**.

    - Post should ideally be installed at the start, center, and end of TR 1, TR 2, and TR 3 (see fig. 4A).

    - If there is an obstruction (e.g., tree trunk, fallen tree, etc.) at the target point (i.e., the start, center, or end points), the crew should offset the post. **When a post is offset, it should be drawn on the plot map and its location information is recorded** (i.e., Notes should state post (TR 1 S, TR 1 C, TR 1 E, TR 2 S, TR 2 C, TR 2 E, TR 3 S, TR 3 C, or TR 3 E) and where it exists in the plot (on which TR it's on and the meter mark of the transect) or out of the plot (which transect's azimuth it extends from and approximate distance from target point). **Posts may be offset up to 2 meters away from target point. Posts should be offset using option 1 below, if option 1 is not possible, proceed to option 2, then 3, then 4. If all options have been exhausted, do not install the post and note the omission.**

        1. Offset the post along the <u>short transect</u>, (TR 4, TR 5, or TR 6) with post <u>inside</u> the plot (fig. 4 B1). Example: fig. 4 B1 should be recorded as "TR 1 End offset on TR 6 @ 1.2 m."

        2. Offset the post along the <u>short transect</u> (TR 4, TR 5, or TR 6) with post located <u>outside</u> the plot (azimuth extending beyond the plot) (fig. 4 B2). Example: fig. 4 B2 should be recorded as "TR 3 Center extending ~1.4 along the TR 5 azimuth."

        3. Offset the post along the <u>long transect</u> (TR 1, TR 2, or TR 3) with post <u>inside</u> the plot (fig. 4 B3). Example: fig. 4 B3 should be recorded as "TR 2 End offset on TR 2 @ 48.7 m."

        4. Offset the post along the <u>long transect</u> (TR 1, TR 2, TR3) with post <u>outside</u> the plot (azimuth extending beyond the plot) (fig. 4 B4). Example: fig. 4 B4 should be recorded as "TR 3 End extending ~1.8 m along the TR 3 azimuth".

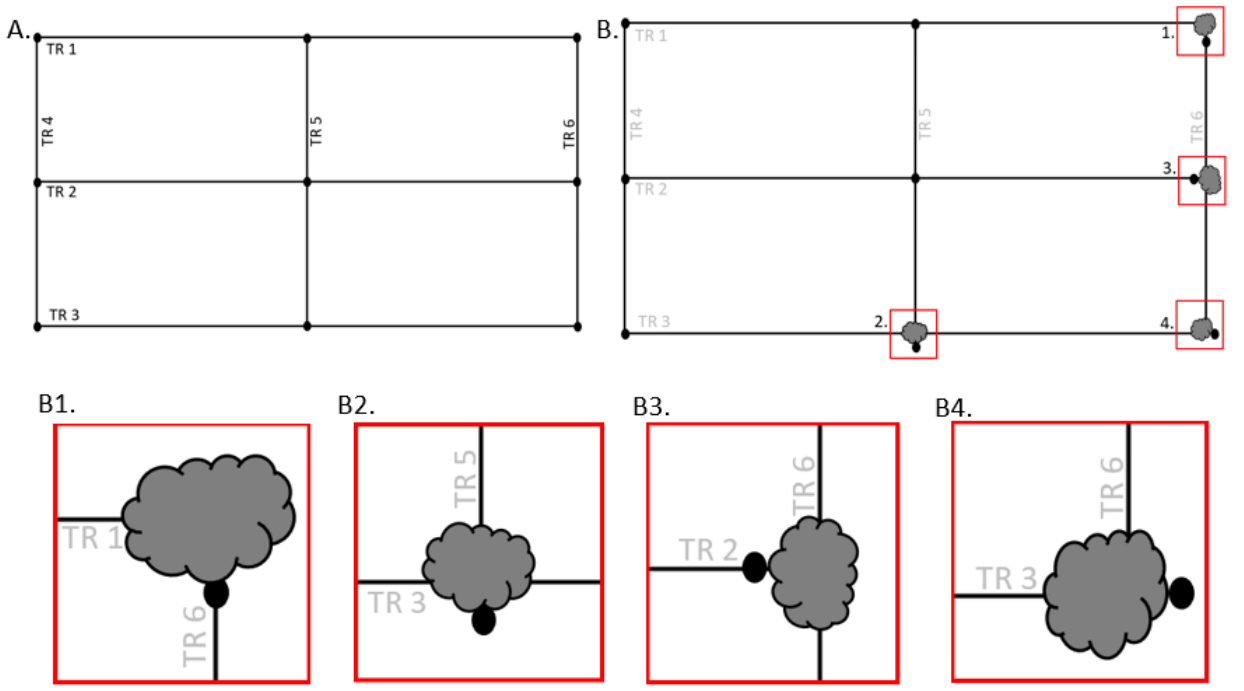

Figure SOP 9.4. Black dots represent permanent posts. A) Ideally, posts are installed at start, center, and end of TR 1, TR 2, and TR 3. Plot with no offset posts. B) Post offset options. B1) Offset on a short transect. B2) Offset extending from a short transect. B3) Offset on a long transect. B4) Offset extending from a long transect.

PVC Posts

Prior to 2020

A white PVC post is used to increase visibility of permanent posts in thick vegetation. A PVC post with the inner diameter of 1 cm perfectly fits over the metal post and is used in some forest communities to increase marker visibility.

During the sampling period of 2021-2025

- All PVC posts should be labeled with brass tags which should include: I&M, Transect number (1, 2, or 3), and Location (S = Start, C = Center, and E = End). If a PVC post is used over a metal post, the metal post does not need a label as the PVC post will be labeled.

- Fixed plots in all sampling frames should have an additional third metal post installed at TR 2 center. The addition of a PVC post over that post should occur in all forest communities (wet forest, limestone forest, and mangrove forest).

- Installation of 7 additional permanent posts. This includes the TR 2 center, along with installing PVC posts at the start, center, and end points on TR 1 and TR 3. The addition of new PVC posts should also be noted along with specific notes if one or more posts were not installed for any reason.

- In the wet forest, limestone forest, and mangrove forest, all 7 additional PVC posts should be installed. The crew should have an adequate amount of PVC posts (7).
- In the subalpine shrubland and coastal strand communities additional PVC posts are **NOT** used.

Permanent Tags

Prior to 2020

At the time of plot installation permanent posts were labeled with "hard tags". They were attached to the posts with I&M, FTPC, plot number, year and month of plot installation, appropriate transect and meter mark (e.g., 0 m, 20 m, 50 m), and plot azimuth. In locations that permitted it, aluminum (soft) tags were be labelled with the same information and were attached to the permanent posts and pin flags at corners of plot; therefore, each long transect should have a tag on each start and end marker.

Starting in 2017, new factory stamped permanent numbered brass tags were installed on the permanent posts at the TR 2 start and TR 2 end for all fixed plots. The original hard tags were hand-dremmeled and many are illegible after five years. These new tags will have an I&M identifier and a stamped number, but no information regarding which plot or post is labeled. It is critical that the Plot Location data form (Appendix E) includes the brass tag number per post and that this information is transferred to the plot location database. Because tags may be used out of numerical order (e.g., F14 TR 2 start post #03, F14 TR 2 end post #12), careful record keeping is critical.

During the sampling period of 2021-2025

- All fixed plots should have a brass tag attached to the TR 2 start and TR 2 end post (see above)
- All previous "hard tags" and "soft tags" can be removed from plots.

Permanent Flagging

Flagging is used on any "long standing" vegetation to help assist in future location on the plot. "Long standing" vegetation should be thought of as vegetation that will likely be there 6 years or more (e.g. a tree). A tree trunk is more likely to be long standing compared to a branch; similarly, a tree fern caudex is more likely to be long standing compared to a frond. In areas without "long standing" vegetation (e.g. a grassland, a fernland, etc.) the crew should not use flagging, as the flagging will not survive the five years between cycles. Crews may get creative and flag anything that is "long standing" (e.g. rocks, CWD that is sound, etc).

- Blue flagging is used as trail markers
- Blue and pink flagging (red flagging may be used interchangeably with pink) together to mark TR 2 start, center, and end posts and their witness trees.
- Pink flagging is used on TR 1 and TR 3 start, center, and end posts and their witness trees.
- Lime green flagging is used to mark transect trees.

- Although not used by I&M, orange flagging is used by NPS to identify snares/traps and may be seen in the field. Crews should use caution when approaching orange flagging.

<u>During the sampling period of 2021-2025</u>

- Guidelines for flagging in different communities.
    - Subalpine shrubland and coastal strand communities are often less vegetated and, in some sampling frames (e.g. Subalpine shrubland Haleakalā and Coastal strand Kaloko-Honokōhau), they may be visible to the public. Crews should flag as instructed and as needed, but the length of the flagging used should be minimal. Enough flagging should be used to tie around object (e.g. tree, post, etc.) with a little (i.e. ~5-10 cm) excess flagging to add to visibility. When excessive flagging was used in subalpine shrublands, the flagging often deteriorated to the point of disintegrating in the harsh environment. The lack of long-standing vegetation/objects may also affect amount of flagging in these communities. Some plots within the KALA coastal strand have no flagging at all because of these limitations.
    - Wet forest, limestone forest, and mangrove forest communities typically have thick vegetation. These forest communities may require an excessive (i.e. >50 cm) amount of flagging. In these environments, the flagging typically survived the 5 years between cycles and the excess flagging helped visibility.
- At the time of monitoring, old flagging should be removed and replaced with new flagging to ensure relocation in the next monitoring cycle.

Witness Trees

Witness trees are a reference for the location of a fixed plot's permanent posts (start, center, and end on TR 1, TR 2, and TR 3). Witness trees are trees or other "long standing" vegetation or a suitable substitute (e.g., a rock, sound CWD, etc.) and may be in or out of the plot. Crews should flag and record at least three witness trees per plot with TR 2 witness trees prioritized. In plots where posts are not easily visible, it may be essential for crews to take the time to flag and record as many witness trees as possible. Depending on the plot's vegetation and/or time constraints, crew lead may instruct to minimize or maximize amount of witness trees. Witness trees along TR 2 should be marked with blue and pink (or red) flagging and witness trees along TR1 and TR 3 should be marked with pink (or red) flagging only. If available, crews should flag a long-standing tree branch, or a suitable substitute, directly above the permanent marker. If vegetation does not permit this, then a witness tree should be chosen by the proximity to permanent posts. All witness trees should be recorded on Plot Location data form (APP E). Witness trees should be drawn on the plot map with the following notes: Species, DBH, and an approximate distance and bearing from the witness tree to the post; if directly over post note branch (tree, rock, etc.) flagged and 0 m @ 0 °. Witness tree location and status should be checked every visit. If the witness tree has died, a new witness tree should be chosen, flagged, and notes on changes should be recorded.

Transect Trees

Transect trees are large trees (>10 cm DBH) that touch transect lines along the borders of the plot (TR 1, TR 3, TR 4, and TR 6). These trees are problematic as they could be in or out of the plot depending on how the transect is set up. All transect trees should be recorded on the map, but **only transect trees within the plot are flagged with lime green flagging**. In plots with thick vegetation it may be essential for crews to take the time to flag and record as many transect trees as possible. Depending on the plot's vegetation and/or time constraints, crew lead may instruct to minimize or maximize amount of transect trees.

Pin Flags

Pin flags were installed at the start, center, and end of TR 1 and TR 3 as noninvasive permanent marker. These pin flags often deteriorated and/or were moved. Remove all pin flags from plots.

Literature Cited

National Park Service (NPS). 2003. Fire Monitoring Handbook. Fire Management Program Center, National Interagency Fire Center, Boise, ID. Available at https://www.nps.gov/orgs/1965/upload/fire-effects-monitoring-handbook.pdf