Protocol for Detection of Invasive Plants in Palau's Terrestrial Protected Areas

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Palau Forest with Rock Islands Protected Area in the Background

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Survey Design and Methodology

The primary goal of this protocol is to locate potentially invasive plant populations at early stages of invasion to inform protected-area managers so that appropriate action (e.g., eradication, containment, additional surveying) may be taken. This protocol will also enable protected area managers to establish a baseline of invasive plants in their respective sites, which will serve as a basis for monitoring changes. The main objective is to determine whether any of the 20 species listed in Appendix 1 are present and to map their distribution if they are located. These are the "target" invasive species. Aside from target species, species of interest also includes plants that the crew cannot identify in the field, species not previously documented in the area, and rare native species.

Choosing Target Species

The target species list in Appendix 1 was developed by Dr. Joel Miles and is divided into two priority groups. There are 12 species in the highest priority group and eight in the second priority group. These plants were selected based on Dr. Miles' over thirty years of experience in Palau, taking into account potential invasiveness and impacts; there were no set selection criteria. Weed risk assessments from Hawai'i and Australia were also considered.

The target species list should be supplemented by the findings of previous invasive plant survey efforts, expert interviews, and new information that comes to light. The list should be updated as appropriate to keep all partners informed and species should be prioritized based on the environmental conditions of the area (i.e., will an invasive plant thrive in a given protected area). Background maps should also be regularly updated and provided to each protected area.

Definitions

A **survey** requires an observer to move along a path and collect relevant data, such as the presence and number of target plants, evidence of disease, impacts of fire, etc., noting the location with a global positioning system (GPS) unit and on a written data sheet.

A **corridor** is a pathway through a natural area. Corridors are often made by people (e.g., roads, trails, fence lines, power lines) but may also include streams. Buildings, parking lots, and places where fires or natural disasters have recently occurred will also be considered corridors in this protocol.

A **sweep** occurs when multiple observers line up side-by-side, close enough together to see each other through the vegetation and effectively identify plants between observers, but far enough apart to cover as much area as possible. Distance apart will vary by vegetation type, density and terrain. The observers walk through an area in a line, all moving forward or stopping at the same time. Frequent communication within the sweep line is critical to maintain thorough coverage.

Detection and Identification of Plant Species

Corridors are important areas for invasive species transport; these areas should be surveyed first. Corridors occur in places humans frequent and therefore are where weeds often first become established. They also offer relatively permanent repeatable paths that can be used to show change in target species abundance or distribution over time. If a protected area is small enough, thorough sweeps of the area may be deemed more appropriate than corridor surveys. Gaps in areas surveyed will be identified as maps are produced; any identified gap areas should be swept to complete a protected-area baseline survey. Data for all surveys should be collected as described in this protocol and in Appendix 2 and 3.

Corridor Surveys

Observers walk and survey opposite sides of a corridor. Alternatively, a single observer may be able to survey a narrow corridor, or walk down and back covering each side of the corridor if the corridor is too wide for one pass to be effective. Observer(s) walking the edges of parking lots, near buildings, burned areas, or other disturbed area should survey in the same manner. Observers may also survey small islands and/or coastlines by driving a boat along the coastline.

If it is decided that there is not enough time to survey all roads, the roads may be driven as slowly as possible, scanning both sides. This approach must be done with at least two observers for safety reasons. Driving both directions along the road or coastline will also increase detectability. Driving surveys should be noted on the data sheet. On paved roads, where target species are commonly found, the road may be broken into segments, each segment should be about 150 m and presence or absence of target species should be noted (Appendix 3). Cones are helpful for marking the start and end of segments. The start/end of each of each segment should be recorded. A large group of people may be broken into teams and assigned segments. A continuous GPS track should be used to show the area surveyed and start and end points should be recorded.

Sweep and Perpendicular Surveys

One of the short-comings of corridor surveys is the inability to find all plant locations, especially plants in remote or hard to access places. Two approaches may address these limitations.

Sweep Surveys: Sweeps cover large swaths of land with the exception of places that are inaccessible. Inaccessible places may be surveyed with binoculars, by air, by boat (rocky or steep coastlines), or through review of high resolution imagery.

Teams of two or more line up off corridors or protected area boundaries, space themselves at a distance where they can still see each other through the vegetation and walk on an established bearing. If the group cannot cover the entire area in one pass, observers should line up off of an "end" person. All observers line up to one side of the end person and that person leads the sweep. The person on the other terminal end of the line uses brightly colored flagging tape to mark the trail. When the line of observers reaches the end of the survey area the entire group "flips" to the right or left of the flagger. The flagger leads the sweep back the direction the group just came by following the path the flagger just took. Flagging should be taken down along the way. The rest

of the group should be covering new ground. See Appendix 4 for a visual representation. This approach works well for relatively small (less than one hectare) areas.

Perpendicular Surveys: A modified option for situations where target species are found along corridors is to survey perpendicular to (directly left or right) the corridor. The distance of the survey line should be a minimum of 200 meters. If spread out like a sweep survey, observers should be spaced so they can see each other and surveys should be repeated up and down the corridor for a minimum of 200 meters from the plant point. For example, when a plant is found along the corridor, perpendicular transects should run for 200 meters out from the corridor and be repeated up and down until a 40,000 square meter area has been covered. If more target species are found while conducting the survey, the same process may be appropriate, requiring surveying an additional 200 meters out in all directions. See Appendix 5 for a visual representation. This method can take a lot of time if additional plant detections keep extending the survey area. Depending on available resources, it may be best to document the presence of the target species and determine the extent of the infestation later.

Over time, maps showing the area surveyed and what was found will provide information to help guide next steps. Gaps in the area surveyed should be visited with the goal of eventually surveying the entire protected area, thus completing a baseline survey.

Opportunistic Surveys

Opportunistic surveys involve staff being observant while hiking, working in the field, or while conducting surveys for other projects (e.g., forest health monitoring programs, bird monitoring, etc.). Staff should record any species of interest using the protocols outlined in this document, a GPS point is particularly useful. Hiking randomly from one place to another is often a good way to stumble across target species.

Expert Interviews

Expert interviews are an integral part of the early detection process, as they help address off-corridor locations, and can help find obscure species.

The known distribution of target species and/or infrastructure maps should be shown to local botanists, land managers, and others who may have seen the target species or species of interest in the protected areas. They should be asked to add locations to the map. If asked before surveys are conducted their input should be considered when deciding where to survey first. If asked after, sites marked on the map should be surveyed. Digitized, or hand drawn information, needs to be ground-truthed and documented with a GPS unit and on a data sheet.

The interview consists of going through every target species and noting locations. Expert input is hand drawn, either on a map of the protected areas or in ArcMap. Additionally, partner GIS data or observations should be combined with the expert interview information as it becomes available. For example, if a partner finds a plant of concern and informs Protected Area Network (PAN) staff, that information should be recorded and disseminated.

Site Prioritization

If it is not feasible to survey everywhere within a protected area in the decided timeframe for the project, managers and coordinators will need to prioritize survey areas and which methods to employ. Places with the most human use should be the top priority.

Sanitation and Decontamination

All equipment, clothing, and gear should be clean and free of seeds or dirt to prevent inadvertently spreading seeds of invasive plants. Time must be set aside for decontamination of gear to remove any seeds, as well as dirt, dust, and debris which often harbors seeds that are not always visible. This is generally done with boot brushes, soap and water, and a possibly a pressure washer. It is good practice to thoroughly wash all equipment and staff clothing and shoes after every survey or treatment. In places where invasive plants are known to exist, every effort should be made to work from pristine areas towards more degraded areas.

Data Collection and Processing

When a species of interest is encountered, record GPS coordinates on the data sheet and take a GPS point. Take a GPS point for every species of interest, where species occur over a broad area record a GPS point for each species every 20 meters. Record estimated patch size (m^2 – a premeasured string may be helpful for estimating patch size), approximate number of individuals in the patch, whether the plant is mature (any fruiting or flowering parts), immature, or in an unknown reproductive stage, associated photo numbers, and any notes for each target species. An example of measuring patch size: A plant that covers a one meter wide by one meter long area has a patch size of $1m^2$.

Data sheets (Appendix 2 and 3) should be completed for every survey and opportunistic find. The following are a few considerations for observers:

Number: *Count* (if low numbers) or *estimate* the number of plants encountered. This information combined with "extent" (below) will provide an idea of the level of infestation. It does not have to be an exact count if plants are too numerous.

Extent: Extent describes what the species infestation looks like on the landscape. *Estimate* how widely spread the plant is over the area you can see (patch size). Use of a premeasured string may help with this. If the species is too widespread to estimate, circle "Unknown" on the data sheet, write down what you see in the notes column, and return later to determine the extent of the infestation.

A GPS unit should be used to record locations when plants of interest are encountered. As previously mentioned, these may include targeted invasive species, any new or unknown plant species, or some of the less common native plant species. One GPS point should be taken per plant unless there is a contiguous patch of plants. If a contiguous patch is encountered, estimated patch size is an essential piece of information. Try to take a GPS point in the center of the infestation. Also record survey start and end points as well as other key features (e.g., trailheads).

High resolution photographs may be taken to help with identification of individual species and to capture a record of the status of the general vegetation. Photos should also be taken at the beginning and end of trails or at fixed points to help monitor change over time. At fixed points, photos should be taken in a series. Twelve photos should be taken in a 360 degree circle. Photo one is taken on a compass bearing (starting at North); continue clockwise (roughly corresponding to each hour of the clock). Photos should be taken at a one meter height and continue until facing North again. The height and photo details should be recorded on the data sheet and on an aluminum tag left at the fixed point. Permanently placing rebar at the fixed point is helpful for relocation. A pre-cut pipe can be slid over the rebar and a camera set on top so pictures are taken from a consistent height. These steps will ensure that the height and location of the pictures is the same over time.

Good notes on placement of photo plots and tags will help ensure consistency over time. Ideally, pictures should be numbered to match the number for the corresponding GPS point. Put N/A in the plant code field on the data sheet and document that this is a photo plot in the notes.

Field maps should be created or updated regularly to ensure future teams are able to relocate sites easily and fill gaps in coverage. Both the Palau Automated Land and Resource Information System (PALARIS) and PAN offices can assist with map making.

All data (GPS files, hard data sheets, and hand drawn maps) should be copied and sent to the PAN office for processing in a timely manner. A copy should be kept at each protected area.

The following is a list of supplies needed to complete surveys and collect data:

- Compass
- GPS unit
- Extra batteries
- Digital camera
- Data sheet and pencils
- Map(s)
- Notebook
- Flagging tape and markers
- Aluminum tags and wires
- Pre-measured string
- Plant ID guide
- Zip-lock bags for keeping things dry
- One meter long PVC pipe(s)

References

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APPENDIX 1: 20 INVASIVE PLANT THREATS TO PROTECTED AREAS IN PALAU

DECEMBER 2014

Joel Miles

Scientific Name for Target Invasive Species	TAXON CODE (used on the data sheet)	PALAUAN NAME	ENGLISH NAME
Adenanthera pavonina	AdePav	Edebsungel era Ngebard	Coral bean tree, etc.
Antigonon leptopus	AntLep	Dilngau	Chain of love
Arundo donax	AruDon		Giant reed
Chromolaena odorata	ChrOdo	Ngesngesil	Chromolaena, Siam weed
Clidemia hirta	CliHir	Kui	Koster's curse
Eichornia crassipes	EicCra		Water hyacinth
Imperata cylindrica	ImpCyl	Kasoring	Imperata, Cogon grass
Mikania micrantha	MikMic	Teb el yas	Mikania, mile-a-minute
Praxelis clematidea	PraCle		Praxelis
Spathodea campanulata	SpaCam	Orsachel kui	African Tulip Tree
Sphagneticola trilobata	SphTri	Ngesil era Ngebard	Wedelia
Timonius timon	TimTim	Liberal	
Allamanda cathartica	AllCat		Allamanda
Arundina graminifolia	AruGra		Bamboo orchid
Cenchrus polystachios	CenPol	Desum	
Clerodendrum quadriloculare	CleQua	Kleuang	Bronze-leaf clerodendrum
Falcataria moluccana	FalMol	Arbasia	Albizia
Leucaena leucocephala	LeuLeu	Telengtungd	Leucaena, Haole koa
Melia azedarach	MelAze		Chinaberry
Thunbergia grandiflora	ThuGra	Bung el etui	Bengal trumpet

PINK = Top 12 species. Highest priority.

YELLOW = Next 8 species. Second priority.

APPENDIX 2: DATA SHEET FOR CORRIDOR SURVEYS, NOT ROAD SURVEYS

Protected Area Name: _____ Date: _____

Area / Trail / Building: _____ Time Start: _____ Time End: _____

Surveyors: _____ _____ Camera: _____

GPS Unit: _____ Starting Number: _____ (*if you can enter the plant code use that for point name*)

Survey Type: Sweep / Corridor (*circle one*)

Remember to "mark" a start and end point with your GPS unit and record it on your data sheet for every survey.

Plant Code *6 letter plant ID*	Waypoint #, Long. / Lat. *Example: N/S: 07° 30′ E/W: 134° 30′*	# of Plants	Patch Size	Life Stage *circle one* <u>*Mature*</u> *= flowers or fruit*	Photo # *put none if no photo taken*	Notes (*including name of plant if no plant code*)
	Pt. #: N/S: E/W:		m^2: *-or circle-* Unknown	Mature Immature Unknown		
	Pt. #: N/S: E/W:		m^2: -or- Unknown	Mature Immature Unknown		
	Pt. #: N/S: E/W:		m^2: -or- Unknown	Mature Immature Unknown		
	Pt. #: N/S: E/W:		m^2: -or- Unknown	Mature Immature Unknown		
	Pt. #: N/S: E/W:		m^2: -or- Unknown	Mature Immature Unknown		

Date Processed: ___/___/___ Initials of Processor: _____ Submitted to PAN & PALARIS offices (circle one): Yes / No

APPENDIX 3: DATA SHEET FOR ROAD SURVEYS

Protected Area Name: _____ Date: _____

Area / Road / Mile Markers: _____ Time Start: _____ Time End: _____

Surveyors: _____ _____ Camera: _____

GPS Unit: _____ Starting Number: _____ (*if you can enter the plant code use that for point name*)

Driving Survey? Yes / No (*circle one*) SURVEY ROADS IN ~150 m SEGMENTS (10 reflector count, first reflector is 0)

The dark gray fields are to be filled out for smaller observations of plants (meaning one or two plants or small groupings vs. a large area of spread out plants - too many to log individually on the data sheet). For larger infestations just complete the light gray fields. Write segment number on the data sheet and take a point at the beginning and end of each segment.

Plants in the Segment *Use 6 letter plant codes*	Waypoint #, Long. / Lat. *Example:* *N/S: 07° 30′* *E/W: 134° 30′*	# of Plants	Patch Size	Life Stage *circle one* *Mature = flowers or fruit*	Photo # *put none if no photo taken*	Notes (*including name of plant if no plant code*)
Segment #:	Pt. #: N/S: E/W:		m^2: *-or circle-* Unknown	Mature Immature Unknown		
Segment #:	Pt. #: N/S: E/W:		m^2: *-or circle-* Unknown	Mature Immature Unknown		
Segment #:	Pt. #: N/S: E/W:		m^2: *-or circle-* Unknown	Mature Immature Unknown		

Date Processed: ___/___/___ Initials of Processor: _____ Submitted to PAN & PALARIS offices (circle one): Yes / No

APPENDIX 4: SWEEP SURVEYS

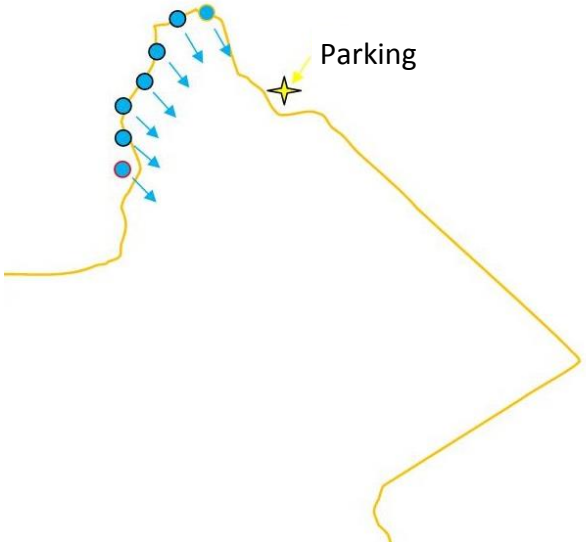

Figure 1. Observers park near a protected area boundary (orange line) and space themselves so they can see each other, see plants between, but cover as much ground as possible.

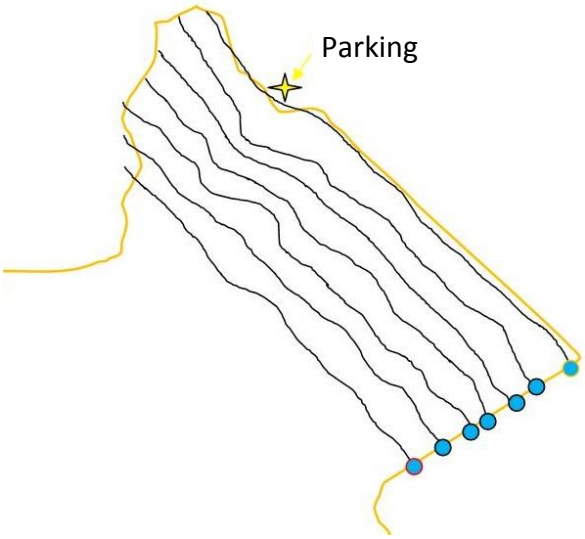

Figure 2. Observers complete their first "sweep." The person nearest the parking leads the sweep, so everyone follows them. The person furthest from the parking flags their trail as they go.

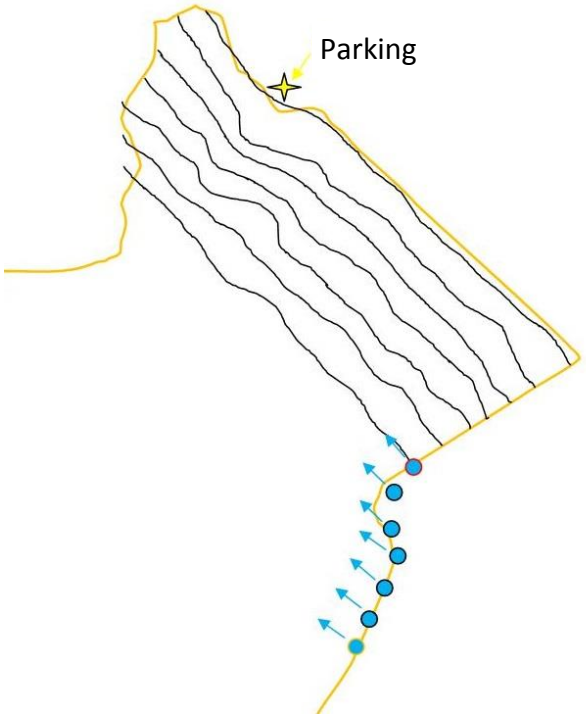

Figure 3. Observers "flip" the line. The "flagger," now leads the sweep and follows the flagged path they just walked taking their flags down as they go. The original leader is now the flagger.

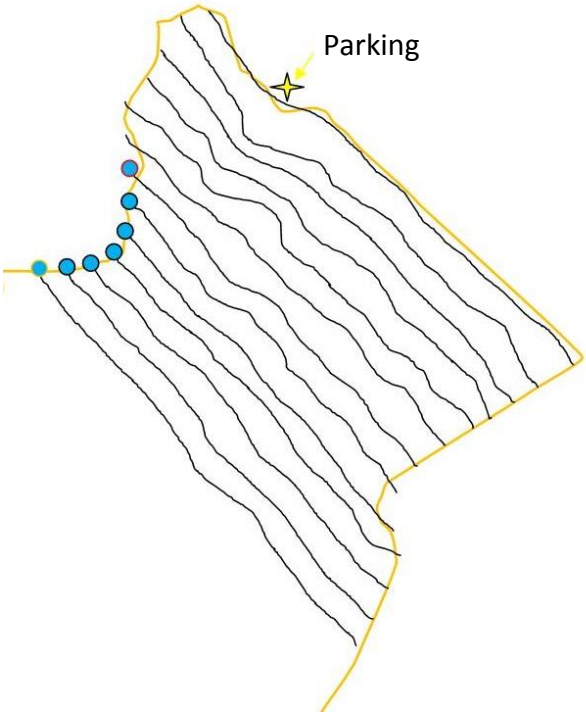

Figure 4. Observers continue flipping the line until the entire protected area is surveyed. Flaggers and leaders continue to alternate as the line flips.

APPENDIX 5: PERPENDICULAR SURVEYS

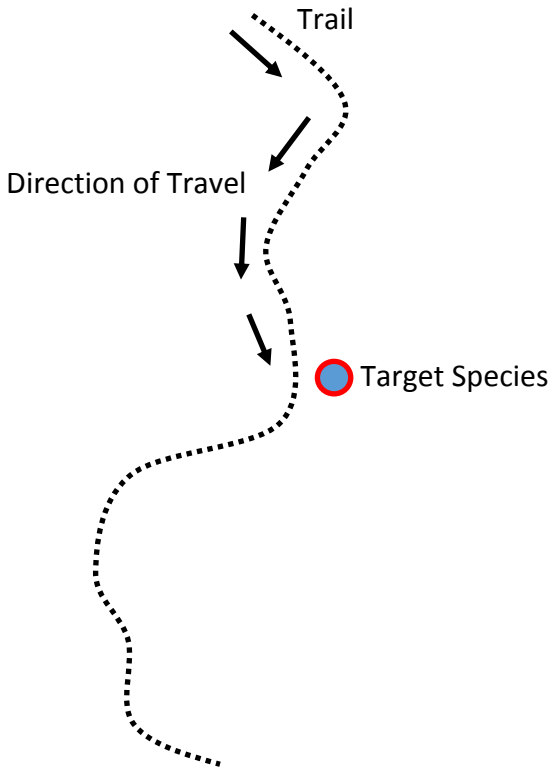

Figure 1. Observers walking down the trail find a target species on their left-hand side (blue dot with red circle).

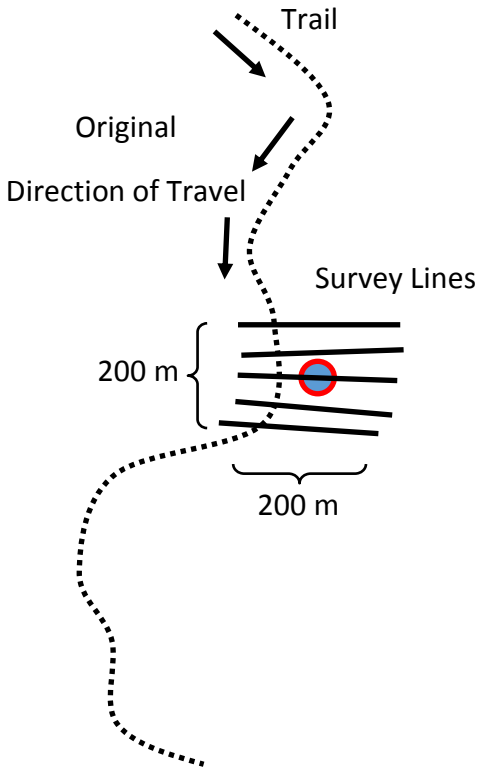

Figure 2. Observers want to know how widespread the plant is so they survey 100 m out from either direction of their find, 200 m total. They extend their searches 100 m up and 100 m down the trail from the find, so 200 m total along the trail.

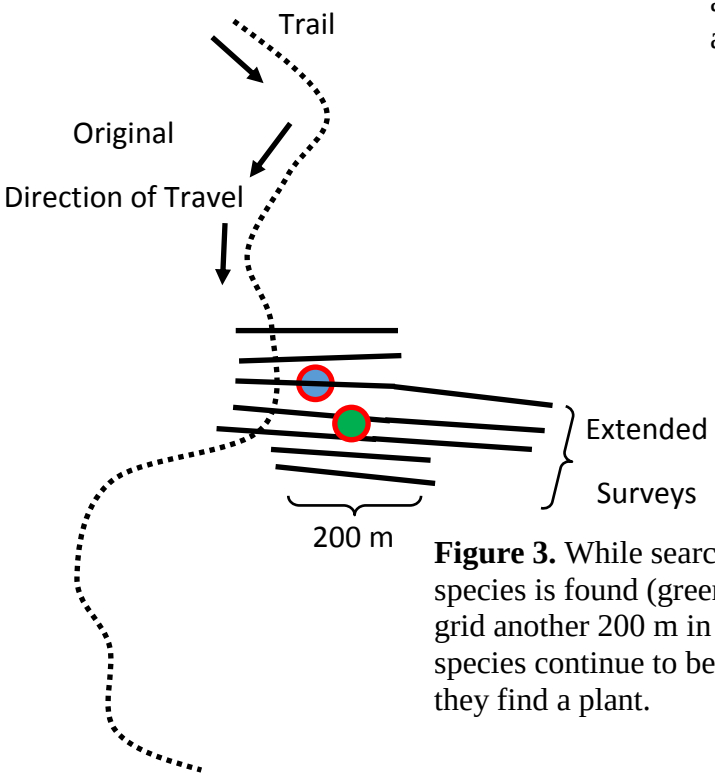

Figure 3. While searching as shown in Figure 2, another plant of the same target species is found (green dot with red circle). The observers extend their survey grid another 200 m in an effort to find more of the target species. If more target species continue to be found they would extend another 200 meters each time they find a plant.