Wildlife Restoration Grant Program
Final Performance Report

Detectability and Predictors of Occupancy in Nightingale Reed Warblers
F17AF00708

Submitted by

The Commonwealth of the Northern Mariana Islands
Department of Lands and Natural Resources
Division of Fish and Wildlife
Manny Pangelinan, Director

Period Covered: October 01, 2017 – September 30, 2021

FINAL PERFORMANCE REPORT FISCAL YEAR 2021
Pittman and Robertson Wildlife Restoration

Commonwealth of the Northern Mariana Islands
Division of Fish and Wildlife
Department of Lands and Natural Resources

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Date

Annual Performance Report

1. **State:** Commonwealth of the Northern Mariana Islands

   Federal Grant Identifier: F17AF00708 Amendment #3 (Final Performance Report)

   Grant Name: Detectability and Predictors of Occupancy in Nightingale Reed Warblers

   Project Name: Detectability and Predictors of Occupancy in Nightingale Reed Warblers

2. **Report Period**: October 1, 2017 through September 30, 2021

3. **Location of work**: Saipan, CNMI

4. **Costs**:

SOURCE	BUDGETED	ESTIMATED COST
Federal:	[redacted]	[redacted]
State:	0	0
Other:	0	0
Total Federal:	[redacted]	[redacted]
Total Match:	0	0
TOTAL PROJECT:	[redacted]	[redacted]

5. **Objectives and Target Activities:**

   1. Determine statistical probability of detection for both playback-absent and playback-assisted point count surveys for Nightingale Reed Warblers by Sept. 30, 2021.

   2. Develop a preliminary model of Nightingale Reed Warbler occupancy by Sept. 30, 2021.

6. **If the work in this grant was part of a larger undertaking with other components and funding, present a brief overview of the larger activity and the role of this project.**

   N/A

7. **Accounting of Accomplishments:**

   Objective 1: Determine statistical probability of detection for both playback-absent and playback-assisted point count surveys for Nightingale Reed Warblers by Sept. 30, 2021.

   DFW staff began capturing and attaching transmitters to Nightingale Reed-warblers (NIRW) in late-January 2019. A total of 30 NIRW were captured and monitored for the entire duration of the transmitter battery. Four of the birds were recaptured and a second transmitter was attached in order to collect data for an extended period of time. Five random non-playback and three random playback-assisted surveys were conducted on each captured bird to estimate difference in non-playback versus playback-assisted and seasonal detection probability. A total of 238 surveys (149 non-playback, 89 playback) were conducted at sites with a known NIRW present. We used a Pearson's chi-squared test to assess if detection rates were independent between playback and non-playback surveys. As expected, playback-assisted surveys had a higher detection rate (65% vs 44% across all months for both years) than non-playback surveys (P=0.001). Results indicate that for non-playback surveys, detectability varied slightly depending on the time of year. However, with the exception of the July-September time period, detectability did not surpass 50% (Figure 1). In contrast, detectability during playback-assisted surveys was 50% or greater across all time periods (Figure 2). The major differences between non-playback and playback-assisted surveys were observed during the April-June and October-December time periods where the detectability of NIRW was more than double for playback-assisted surveys. During April-June, the detectability was 35% for non-playback surveys compared to 72% for playback-assisted surveys (Figures 1 and 2). Similarly, the detectability during October-December was 33% for non-playback surveys compared to 78% for playback-assisted surveys (Figures 1 and 2).

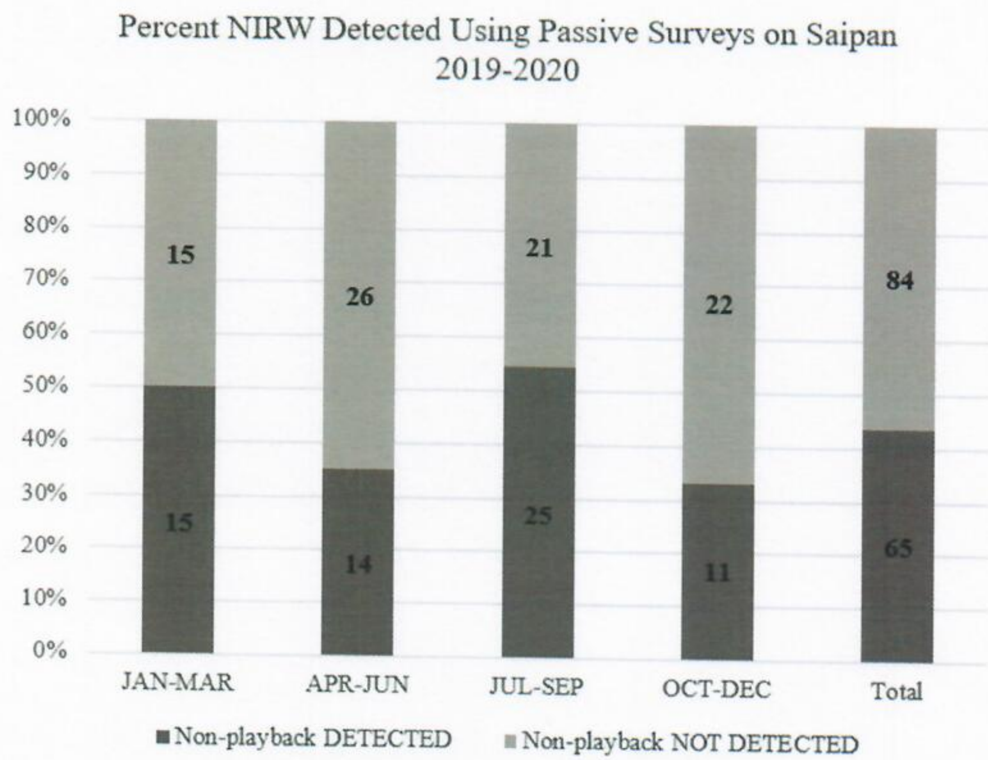

Figure 1. NIRW seasonal detectability using passive surveys on Saipan in 2019-2020. Survey sample size indicated in graph.

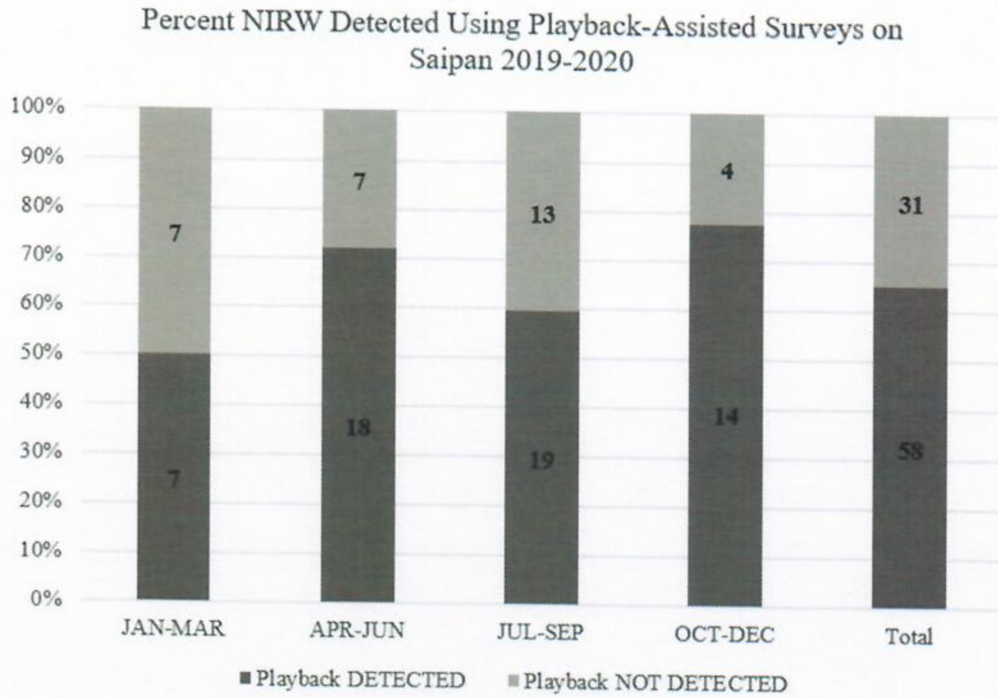

Figure 2. NIRW seasonal detectability using playback-assisted surveys on Saipan in 2019-2020. Survey sample size indicated in graph.

While the use of playback-assisted surveys to determine the presence or absence of NIRW at a site has been demonstrated in this study to be an effective technique during the time periods of April-June and October-December, there is no clear evidence that playback surveys increase the chance of detection during January-March and July-September (Figures 1 and 2). Although a greater sample size would benefit the inferences derived from the data, there appears to be no difference in detectability between playback and passive surveys in January-March (both 50%) and only a slight increase in detectability using playback in July-September (59% vs 54%).

Data suggests that male territoriality was more pronounced (greater playback incited response) during the late-dry periods (April-June) and late-wet periods (October-December) possibly due to males attempting to ward off competing males during courtship of females. Mosher (2006) detected many more active nests during early-dry (January-March) and early-wet periods (July-September) compared to other periods, indicating that prior to these nesting bouts there would be a greater degree of courtship/nest building behaviors occurring. We would expect that during the early-wet and early-dry periods, females would be less likely to abandon an active nest for a competing male in the area and therefore less aggressive behavior by the paired male would be required.

Care needs to be taken when surveying project development sites for NIRW. If sites are assessed for threatened and endangered species during the late-dry and late-wet and playback-assisted surveys for NIRW are not employed, there is a greater likelihood that the surveys will result in a false negative detection which could result in "take' of the species.

Objective 2: Develop a preliminary model of Nightingale Reed Warbler occupancy by Sept. 30, 2021.

Birds with affixed transmitters were tracked using telemetry for an average of 43.3 days (range: 21-71 days). The length of monitoring generally was determined by battery life (transmitter manufacture's expected battery life was 48 days) of the attached transmitters, however, battery life decreased with time so that transmitters attached to birds several months after being purchased would have a shorter duration than those used immediately after being received. On two occasions, the transmitter harness failed resulting in shorter periods of tracking data. Additionally, four birds were recaptured so that a second transmitter could be attached to allow for a longer tracking period. The software package LOAS (Ecological Software Solutions LLC, USA) was used to determine bird locations from daily telemetry data. For each bird, we estimated the home range using 95% kernel density estimators with both least squares cross validation (LSCV) and H-plugin smoothing parameters using the adehabitat package in R version 3.3.0 (Figure 3).

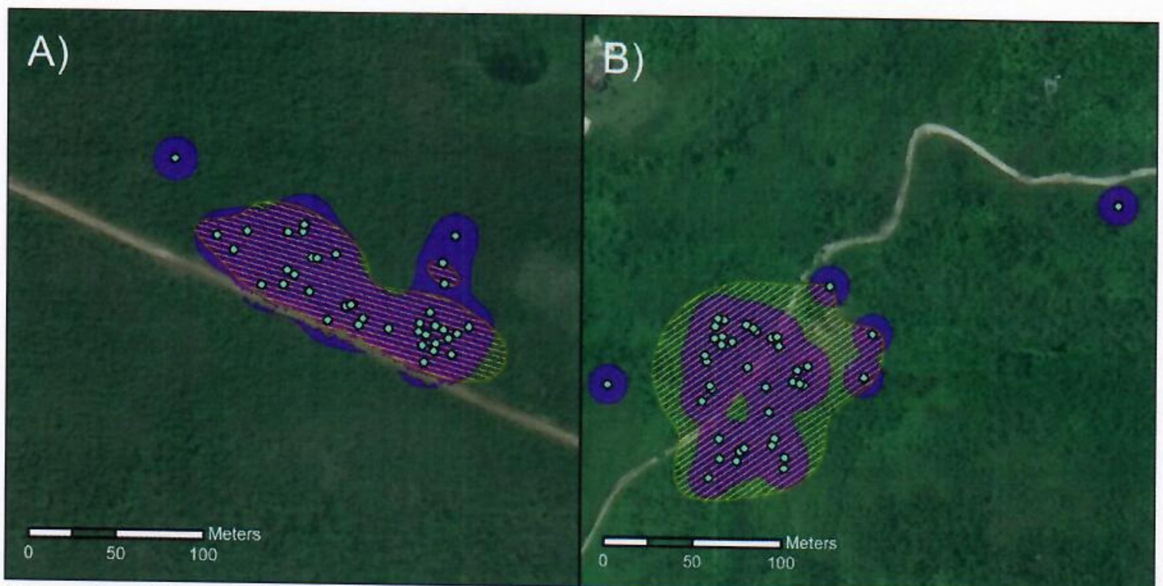

Figure 3. Telemetry-derived points locations (cyan) and estimated home ranges for two Nightingale Reed-warblers on Saipan, Northern Mariana Islands, using 95% kernel density estimators (KDE) with least squares cross validation (LSCV) (purple) and H-plugin (hatched yellow) smoothing parameters.

Average home range estimates were similar when using LSCV (4.38 +/- 1.74 ha, n=30, SD=4.87) and H-plugin (4.07 +/- 1.30 ha, n=30, SD=3.63) smoothing parameters. While the majority (70%) of the home range estimates were below 4.00 ha, there were two greater than 15.00 ha. Both of these male birds were in highly disturbed and fragmented areas and both moved greater distances than other birds. Additionally, neither bird seemed to be paired with a female. While it was possible that neither bird had a strong affinity to the site that they were currently occupying and were at the same time searching out better options, it is equally possible that the condition of the habitat caused the bird to require a larger home range due to food or other limitations. While we do not want to discount the data collected from these two individuals, we want to point out that we may have overestimated the average home range by including them in the analysis. When removed, the estimates were still similar for LSCV (3.36 +/- 1.08 ha, n=28, SD=2.93) and H-plugin (3.49 +/- 1.10 ha, n=28, SD=2.97) smoothing parameters, however, they were approximately 1.00 ha less than when included.

Core usage areas for each individually tagged bird were determined using 50% or 70% kernel density estimates with LSCV smoothing parameters in order to determine the areas where random vegetation surveys would be conducted. If the core usage area was not large enough using 50% fixed kernels to fit 10 vegetation plots, 70% fixed kernel estimates were used. Habitat data were collected at ten randomly-chosen plots within each of the 30 core usage areas for a total of 300 vegetation plots.

Species composition and structure in addition to substrate cover were measured within 10-m x 10-m plots (100 m^2) for forest/woodland vegetation and 5-m x 5-m (25 m^2) for grassland communities. Vegetation plots were centered on randomly selected points within the 50% or 70% fixed kernel areas (Nightingale Reed-warbler core habitat). Substrate cover within each plot was estimated by eye for rocks, coarse woody debris, leaf litter, or bare soil. Herbaceous vegetation cover was estimated by eye for grass, herbs, vines, and other (i.e., ferns, mosses, etc.) to the nearest 5 percent. Approximate height and cover for each vegetation strata (herbaceous (H), shrub (S), canopy (T2), and emergent canopy (T1) were also estimated by eye to the nearest meter and percent (Figure 4).

Figure 4. DFW Assistant Biologist, Lee Roy Sablan Jr., collecting site information for vegetation plots within Nightingale Reed-warbler territories (photo credit: Amanda Deleon Guerrero).

Woody vegetation ≥ 1.3 m in height within each plot were identified to species and measured for diameter-at-breast height (DBH) (Figure 5). If the measured tree's DBH was under 5.0 centimeters, it was counted/tallied as a stem with the species recorded and DBH was not recorded. Otherwise, the DBH was measured and recorded for each individual tree. Data was collected for all trees with a portion of the stem/trunk base (above the roots) within the plot boundaries. Dead standing stems ≥ 1.3 m tall were labeled as "snags". If a trunk split below 1.3 m, then all portions of the split were treated as separate stems.

Figure 5. DFW Assistant Biologist, Amanda Deleon Guerrero, measuring the diameter-at-breast-height (DBH) of a tree in a vegetation plot within Nightingale Reed-warbler territories (photo credit: Lee Roy Sablan Jr.).

Relative density (RD) for each woody species was calculated by dividing the species' abundance over the sum of stems for all species within a plot. Relative basal area (RBA) was calculated for tree and shrub species by dividing a species basal area by the sum of all species' basal area within a plot. Importance values (IV) were calculated for woody plant species to summarize the dominance of each species within the respective plots. IV were calculated for each species within a plot by summing the RBA and RD and dividing by 2 (IV = (RBA+RD)/2)) to get an index of species dominance per plot that ranges from 0.0 to 1.0. Binning woody species by DBH class suggests that the vegetation plots were noticeably dominated by a high mean abundance of smaller diameter (0.0-5.0 cm) stems of tångantångan (*Leucaena leucocephala*) compared to all other woody species (Figure 6). Smaller diameter (0.0-5.0 cm) stems of hibiscus/pago (*Talipariti tiliaceum*), snags, and bamboo (*Bambusa vulgaris*) were also abundant but to a much lesser degree than tångantångan.

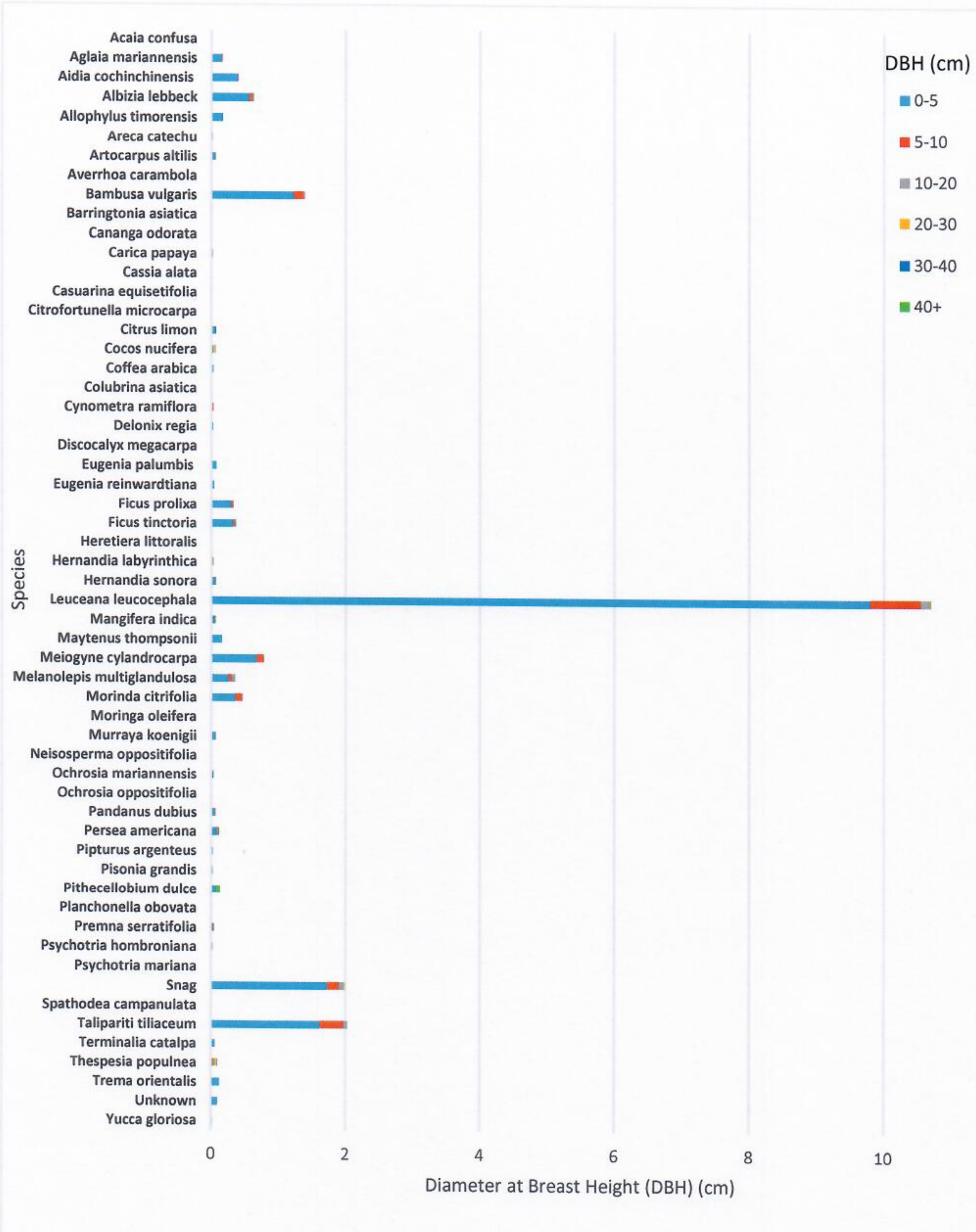

Figure 6. Mean abundance of woody species per DBH class for vegetation plots measured within Nightingale reed-warbler home ranges.

We classified vegetation plots into plant communities to determine if NIRW had a preference for specific habitat types. Only forested plots were used for plant community analysis since plots without woody species contain null importance values and are not able to be evaluated with this method. A dissimilarity matrix was calculated using the Bray-Curtis distance measure. Cluster analyses using the Bray-Curtis distance measure was used to classify plots into groups based on IV for woody species using Ward's objective function. Silhouette width and partana ratio combinations were used as criteria for selecting the number of groups for the cluster analysis, which was determined to be five clusters since both the ratio and silhouette width were maximized at this threshold (Figures 7 and 8).

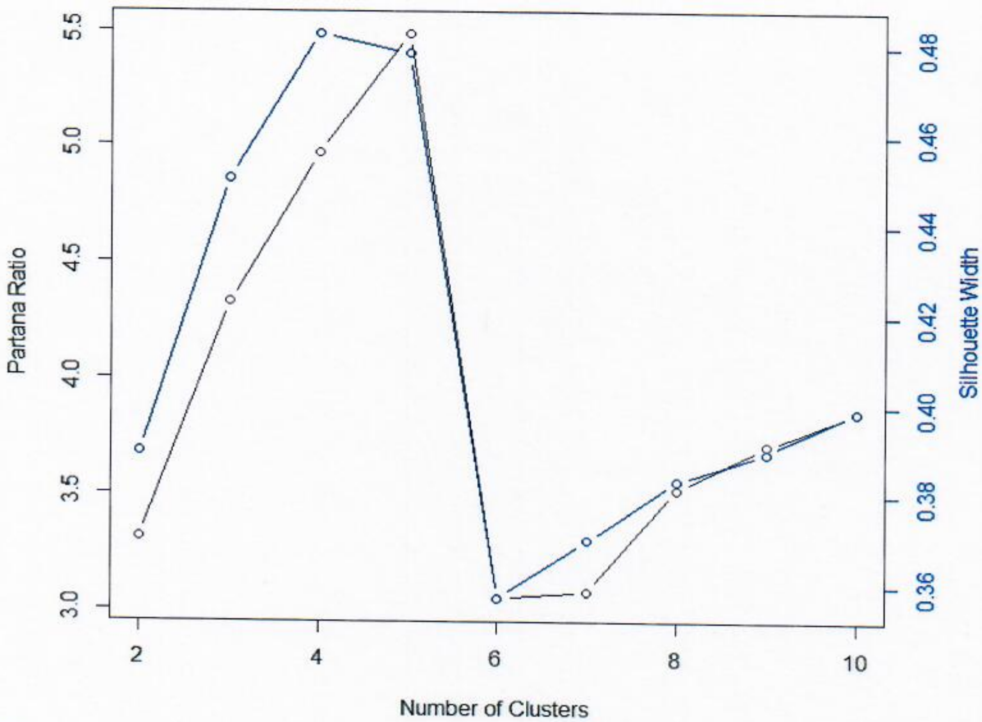

Figure 7. Plot of partana ratio and silhouette width for 2-10 hierarchical clusters based on woody species importance values measured in core Nightingale Reed-warbler habitat vegetation plots on Saipan.

Figure 8. Hierarchical cluster diagram of vegetation plots using woody species importance values and a Bray-Curtis dissimilarity matrix displaying plots grouped into five distinct clusters.

After plots were grouped into clusters, mean importance values were calculated to determine dominant species within each plant community cluster (Figure 9). Cluster 1 was dominated by hibiscus/pago (*Talipariti tiliaceum*), cluster 2 by tångantångan (*Leucaena leucocephala*), cluster 3 by siris tree (*Albizia lebbeck*) and tångantångan, cluster 4 by tångantångan, fingersop/paipai (*Meiogyne cylindrocarpa*), and noni/lada (*Morinda citrifolia*), and cluster 5 by bamboo (*Bambusa vulgaris*). Given the dominance of specific single species in clusters 1, 2, and 5; we determined the clusters to represent hibiscus thickets, tångantångan/*Leucaena* thickets, and bamboo monocultures respectively. The remaining clusters 3 and 4 were dominated by mixed species with tångantångan as a co-dominant and were therefore combined into a Mixed Introduced Forest vegetation class. Evidence suggests that NIRW have a preference for these 4 habitat types.

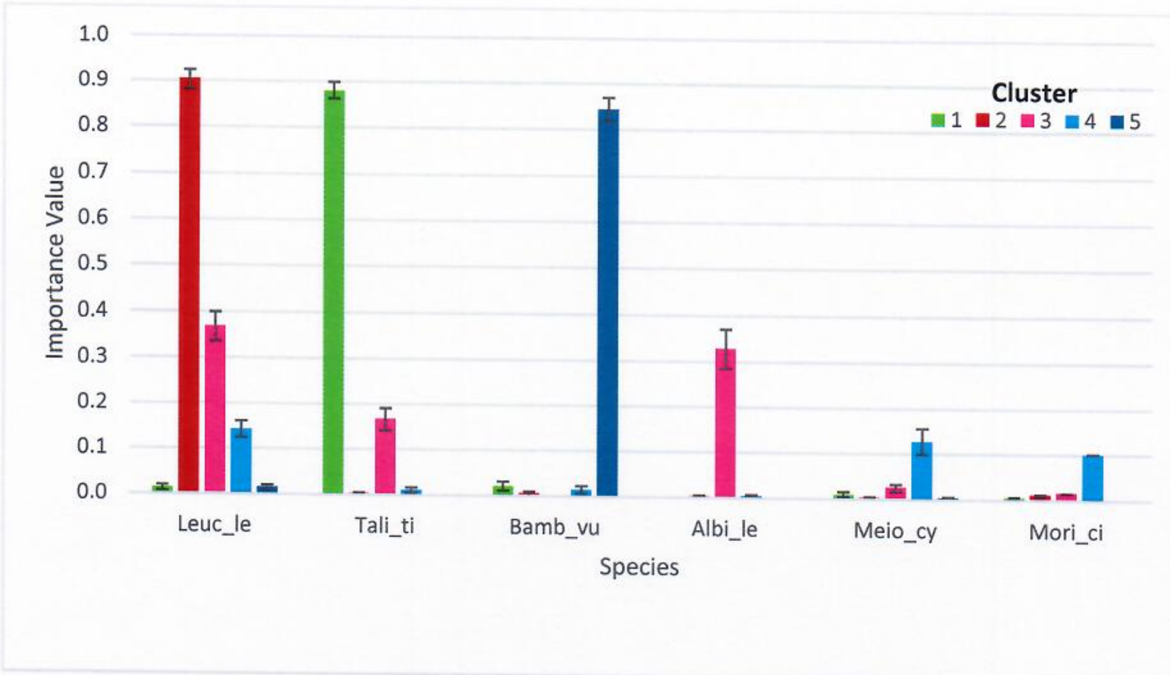

Figure 9. Mean importance values with 95 percent confidence intervals for the six most dominant tree species for five plant community groups derived from hierarchical cluster analysis. Leuc_le = tångantångan (*Leucaena leucocephala*), Tali_ti = hibiscus/pago (*Talipariti tiliaceum*), Bamb_vu = bamboo (*Bambusa vulgaris*), Aibi_le = siris tree (*Albizia lebbeck*), Meio_cy = fingersop/paipai (*Meiogyne cylindrocarpa*), and Mori_ci = noni/lada (*Morinda citrifolia*).

While results suggest a preference for specific habitats, we were interested in estimating the landscape composition of these habitats within home ranges estimated from the telemetry locations. Our original project design included using the classified vegetation plots from both this project and the 2018 island-wide survey on Saipan to train classification of 8-band imagery from the WorldView satellite constellation to create an updated land use land cover (LULC) map of the island. However, procurement of the satellite imagery was delayed and it was therefore unavailable for this project. The best available LULC map of Saipan was developed by the United States Fish and Wildlife Service for the year 2016 (Amidon et al. 2017). We conducted an accuracy assessment to determine agreement between the vegetation classes identified in the 2016 LULC and the vegetation data we collected for this project.

We assessed the agreement of the 2016 LULC and the 2019/2020 classified vegetation plots using two metrics: producer's and user's accuracy (Table 1). Producer's accuracy is the rate of correctly classified pixels within the 2016 LULC map using the vegetation plots we sampled as the known true classifiers. User's accuracy is the rate of correctly classified vegetation plots assuming the LULC is the correct classification. To simplify assessment, we combined the Bamboo Thickets vegetation plots into the Mixed Introduced Forest classes within the 2016 LULC. Based on the accuracy assessment, the LULC map correctly classifies Bamboo Thickets well and had moderate performance in correctly classifying Mixed Introduced Forests. However, the majority of the error can be contributed to misclassification of *Leucaena* Thickets with both Mixed Grass/Herb and Mixed Introduced Forests. Overall, the accuracy assessment suggests relatively poor agreement between the 2016 LULC and vegetation plots and indicates the need to update a current LULC map of Saipan for understanding landscape composition. However, the 2016 LULC map was the only data source available and we continued our analysis despite the known errors.

Table 1. Confusion matrix of vegetation plots measured from home range boundaries and classified with hierarchical clustering compared to land cover classes from the 2016 land use land cover map of Saipan.

	Plot Classification from Cluster Analysis					
	Bamboo Thicket	Grassland	Hibiscus Thicket	*Leucaena* Thicket	Mixed Introduced	User's Accuracy
Casuarina Forest	--	--	--	1	--	**0.0**
Developed	--	2	--	--	--	**0.0**
Emergent Wetland	--	4	--	1	1	**66.7**
Grassland	--	9	--	2	--	**81.8**
Leucaena Thicket	--	3	4	31	11	**63.3**
Mixed Grass/Herb	1	24	1	44	9	**30.4**
Mixed Introduced	12	13	22	36	56	**48.9**
Scrub Shrub	--	1	1	6	5	**7.7**
Producer's Accuracy	**92.3**	**66.1**	**3.6**	**25.6**	**68.3**	

Using the home ranges estimated by the H-plugin and LSCV methods, we overlaid the home range boundaries with the 2016 LULC map to calculate the landscape composition of Nightingale Reed-warbler habitat. Although there were high levels of uncertainty due to variation between the estimated areas of home range sizes, the average landscape composition within home ranges was similar between the H-plugin and LSCV methods (Figure 10). Average percent land cover for H-plugin estimates were 44.9% Mixed Introduced Forest, 22.4% *Leucaena* Thicket, 19.6% Mixed Grass/Herb, 7.7% Grassland, 3.5% Scrub Shrub, and 1.0% Agriculture. Average percent land cover for LSCV estimates were 33.9% Mixed Introduced Forest, 30.6% *Leucaena* Thicket, 21.2% Mixed Grass/Herb, 8.5% Grassland, 4.1% Scrub Shrub, and 1.0% Agriculture.

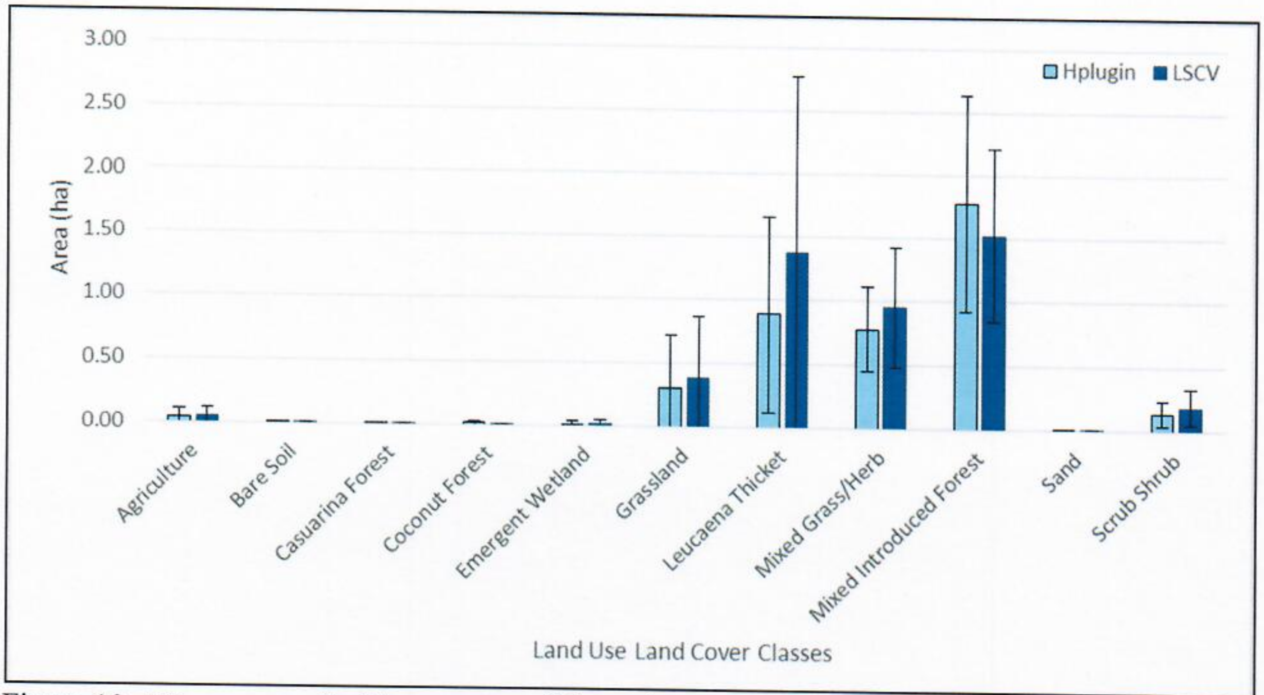

Figure 10. Mean area with 95 percent confidence intervals of land use land cover classes within Nightingale Reed-warbler home ranges derived from H-plugin and Least Squares Cross Validation (LSCV) estimators for Saipan.

We used stepwise logistic regression to predict plot-level habitat for Nightingale Reed-warblers using the substrate, strata height, strata cover, DBH classes, and IVs for the most dominant tree species sampled within vegetation plots: tångantångan, hibiscus, fingersop, siris tree, and bamboo. Only forested plots were used for this analysis. In addition to this project's vegetation plots representing NIRW presences (n=251), we supplemented vegetation plots from the Saipan island-wide surveys conducted in 2018 (presences=4, absences=101) into our training dataset. Model performance was measured using sensitivity (rate of true positives), specificity (rate of true negatives), area under curve (AUC), and true skill statistic (TSS). Performance metrics were calculated for internal validation and five-fold cross validation, where 20% of the data is withheld and then used to validate model results. The model was also externally validated using bird occurrence and vegetation data from 2017 surveys in the Saipan Upland Mitigation Bank (presence=3, absence=86). Variables were reduced until only statistically significant variables remained (Table 2). Chi-square goodness of fit indicated an excellent model fit (P=0.00).

The final logistic regression model suggests that probability of Nightingale Reed-warbler occurrence was inversely related to emergent canopy height (m) and number of stems in the 10-20 cm, 20-30 cm, and 40+ cm DBH classes. Probability of occurrence increased with height in both the herb and shrub layers as well as increased cover of the herb layer, leaf litter, and bare soil. The model performed extremely well for both internal and five-fold cross validation but performed moderately fair to poor for the external dataset (Saipan Upland Mitigation Bank) (Table 3). Specifically, the model tended to overpredict occurrences in the external dataset but this particular dataset has a disproportionally low number of known presences making the sensitivity rate difficult to interpret. Bird surveys and vegetation plots will be resampled in the Saipan Upland Mitigation Bank in FY 2022 and the survey results will be used as new validation data for this model to provide a better assessment of external model performance.

Table 2. Preliminary stepwise logistic regression model variables with estimates, standard deviations, z-values, p-values for predicting Nightingale Reed-warbler occurrence on Saipan.

	Estimate	Standard Error	Z-value	P-value
Intercept	-3.59	0.87	-4.13	0.00
% Leaf Litter	0.06	0.01	5.02	0.00
% Bare Soil	0.05	0.02	3.26	0.00
Emergent Canopy Height (m)	-0.16	0.04	-3.73	0.00
Shrub Height (m)	0.30	0.15	1.99	0.05
Herb Height (m)	0.88	0.31	2.83	0.00
% Herb Cover	0.04	0.01	3.77	0.00
DBH 10-20 cm	-0.36	0.07	-4.85	0.00
DBH 20-30 cm	-0.29	0.09	-3.22	0.00
DBH 40+ cm	-0.15	0.07	-2.11	0.03

Table 3. Validation metrics for stepwise logistic regression model for predicting Nightingale Reed-warbler occurrence on Saipan using internal, five-fold cross, and external validation.

Model	Sensitivity	Specificity	AUC	TSS
Internal	0.93	0.92	0.98	0.86
Five-fold Cross Validation	0.90	0.90	0.97	0.81
External Validation	0.67	0.64	0.75	0.31

8. Project outputs and outcomes:

We conducted a full assessment of Nightingale Reed-warbler detectability across all months for two years. Additionally, we produced a preliminary habitat model to assist in predicting the likelihood that the species will occupy a particular site. Data collected will improve management for this federally-listed species and enhance our technical guidance procedures for development projects on Saipan.

9. Evaluation of project implementation:

Performance toward project objectives primarily followed the anticipated schedule. Issues with procurement of equipment and supplies delayed the start of the project by one year. Initially, we had expected to use 25 transmitters, however, after the first year of the study we decided to expand the number by an additional 10 transmitters to increase our sample size.

10. Project Staff:

Steve Mullin, Amanda Santos, Lorraine Reyes, Bradley Eichelberger (supported this project through the WR grant "Spatial Data Management, Support and Analysis"), Emilie Kohler, Lee Roy Sablan

11. Name, title, phone number, and e-mail address of person compiling this report:

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