



Pacific Island Landbird Monitoring Annual Report, National Park of American Samoa, Ta'u and Tutuila Units, 2011

Natural Resource Technical Report NPS/PACN/NRTR—2013/666



ON THE COVER

Wattled Honeyeater (*Foulehaio carunculata*)

Photograph by: Emily Weiser

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Abstract

The National Park of American Samoa (NPSA) was surveyed for landbirds and habitat characteristics from June through August, 2011. This information provides the first data in the time-series of landbird monitoring for long-term trends in forest bird distribution, density, and abundance within the NPSA. The NPSA survey area was comprised of the terrestrial portions of the Ta'u and Tutuila Units. Each Unit was surveyed using point-transect distance sampling to estimate bird abundance. Sampling was conducted using a split-panel design where legacy transects are visited during each sampling occasion and newly, randomly located transects are visited only during one sampling occasion. This design optimizes trend detection while allowing for measuring and correcting for estimator bias.

A total of 2,516 birds was detected from 13 species in both Units. All species were either endemic or indigenous to the islands of American Samoa. Numbers of detections ranged from 7 to 1,111. Nearly every species detected was broadly distributed in the predominantly native forests of NPSA. Sufficient detections were made of seven species, allowing for density estimation. Densities of species were higher in the Tutuila Unit; with the exception of the Wattled Honeyeater (*Foulehaio carunculata*), which was the most abundant species in both Units. The species occurred at nearly every station sampled and had densities much higher than the Samoan Starling (*Aplonis atrifusca*), Polynesian Starling (*Aplonis tabuensis*), and Collared Kingfisher (*Halcyon chloris*) which occurred in modest densities. The remaining species detected occurred at less than 20% of stations sampled and we were only able to determine the number of birds per station and percent occurrence. The White-rumped Swiftlet (*Aerodramus spodiopygius*) and Cardinal Honeyeater (*Myzomela cardinalis*) were detected in small numbers, but both species can be difficult to detect in closed canopy forests. The Purple Swamphen (*Porphyrio porphyrio*) and Banded Rail (*Gallirallus philippensis*) were most often detected in areas close to villages and agroforestry plantations. The Blue-crowned Lorikeet (*Vini australis*) and Fiji Shrikebill (*Clytorhynchus vitiensis*) only occur in the Manu'a Island Group. The former was detected in most survey areas and the latter was patchily distributed in the Ta'u Unit. The Many-colored Fruit-dove (*Ptilinopus perousii*), a species of concern, was detected in very small numbers in both Units. The Spotless Crake (*Porzana tabuensis*), which is extirpated on Tutuila Island, has been incidentally detected in small numbers on Ta'u Island. However, the species was neither seen nor heard during this survey and remains a species of concern.

NPSA canopy and understory composition was predominantly native, and trees formed a dense closed canopy at nearly 90% of the stations sampled. More than half of the tree heights in both units were taller than 5 m and the majority of slopes were steeper than 20 degrees. There were no clear dominant tree species in the mixed native forests. The most common tree species documented included *Syzygium* spp., *Dysoxylum* spp., *Ficus* spp., *Hibiscus tiliaceus* and *Rhus taitensis* (among others). There were significant differences in the distribution of bird densities between legacy and random transects. Determining differences in detection probabilities cannot be definitively assessed from a single survey. We recommend both panels be sampled in the future until bias in density and abundance can be evaluated, or if sampling may be reduced.

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Introduction

The National Park of American Samoa (NPSA), the only paleotropical rainforest in the U. S. National Park system, harbors a diverse array of flora and avifauna. Native birds and fruit bats are major pollinators and seed dispersers that drive ecological processes in the Samoan Archipelago (Webb 1996, Freifeld 1996, 1999, Craig 2009). Agriculture, hunting, logging, development, and the introduction of numerous alien species have had negative effects on landbird populations. The avifauna has also suffered declines in part because of the high frequency of very destructive hurricanes in the archipelago. The negative feedback of human activities on landbird populations is further exacerbated by episodic hurricanes. For example, bird abundances declined after forests were ravaged by Hurricane Val in 1991. Afterwards, popular native game birds were nearly driven to extinction until a strict hunting ban was enforced in 1992 (Craig et al. 1994). Fortunately the majority of Samoa's terrestrial vertebrates have rebounded after such events, with the exception of the Mao Honeyeater (*Gymnomyza samoensis*), which has been extirpated in American Samoa (Watling 1982, Engbring and Ramsey 1989). However, the effects of hurricanes on avian communities may persist for years and can be compounded by human pressures. Protection of large units of native rainforest, such as is in NPSA, has been a great benefit to Samoa's native birds (Watling 1982).

Repeated surveys identify temporal changes of populations (Skalski 1990) allowing park managers to monitor declines, as well as document increases related to management (Camp et al. 2011). Island-wide inventories by Amerson et al. (1982), Engbring and Ramsey (1989), as well as monitoring by the American Samoa Department of Marine and Wildlife Resources (DMWR; 1995, 1996) provided detailed information describing Samoa's landbird composition, distribution, and abundance. Surveys by Engbring and Ramsey (1989) established baseline population data in American Samoa, which included sampling stations within NPSA, and their work established the basis for long-term monitoring (Camp et al. 2011). Research surveys (Trail et al. 1992, Freifeld 1996, 1999, Freifeld et al. 2004) have facilitated long-term monitoring programs, and have elucidated aspects of breeding biology, habitat preference, and temporal fluctuations of landbird populations in American Samoa. DMWR, in particular, focused on landbird recovery after destructive hurricanes, which provided valuable information on which species are most vulnerable to large scale disturbances (DMWR 1994, 1996).

The National Park Service (NPS) created the Inventory and Monitoring (I&M) Program following the National Park Omnibus Management Act of 1998 to acquire data needed to support effective management and protection of native habitats located on park lands. The role of the I&M Program is to collect, organize, and make available natural resource data and contribute to the National Park Service's institutional knowledge by facilitating the transformation of data into information through analysis, synthesis and modeling (Fancy et al. 2009). In concordance with the stated role of the I&M Program, the objectives of this survey were to provide information for monitoring long-term trends in forest bird distribution and abundance in NPSA. Ultimately, this information will help to inform and implement management actions for bird conservation.

Methods

The landbird vital sign monitoring protocol conducted by the Pacific Islands Network (PACN) I&M Program surveys five parks on a rotating basis. Each park will be surveyed once every five years to determine landbird status and trends (Camp et al. 2011). NPSA is comprised of three Units on three islands in American Samoa: the main island of Tutuila, and Ofu and Ta'u of the Manu'a Island Group (100 km east of Tutuila). The Protocol was implemented in 2011 at NPSA; in both the Tutuila and Ta'u Units. Point-transect distance sampling was conducted according to a split panel (1:1, fixed: random sampling stations) design. Both the fixed and random panel stations were surveyed for birds and habitat (see Camp et al. 2011 for details).

Unit Descriptions

The flora of the Samoan Archipelago is diverse, consisting of approximately 225 ferns and 550 flowering plants, of which 250 are estimated to be tree species (Whistler 2004). Orchidaceae is the largest plant family with more than 100 species (Whistler 2004). Despite a long history of large scale disturbance from human activities and hurricanes, NPSA is one of the best representations of mature native tropical rain forest in the South Pacific (Webb 1999).

Tutuila

American Samoa, an unincorporated territory of the United States, is comprised of five main volcanic islands and two atolls. Tutuila is the largest (145 km²) and most populated island in American Samoa. The island is dominated by numerous rugged volcanic slopes, the highest point being Matafao Peak (652 m). In NPSA, the Tutuila Unit is 1,021 ha of steep north facing slopes and canyons. Dense forested ridges stretch towards the ocean from the summit of Mt. Alava (491 m) and Maugaloa Ridge (Figure 1). Vatia, Pago Pago and Fagasa villages border the eastern and western boundaries of the unit, separated by a steep and rocky coastline. Temperatures are warm, averaging 27°C, and rainfall is highly variable; ranging between 381 and 635 cm (<http://www4.ncdc.noaa.gov/ol/climate/stationlocator.html>).

The NPSA interior on Tutuila is dominated by Rain Forest and Rhus Secondary Forest (Figure 1; Liu et al. 2011). Native angiosperms dominate the forests; such as *Alphitonia zyzyphoides*, *Dysoxylum samoense*, *Erythrina variegata*, *Ficus scabra*, *Macaranga harveyana*, *Pipturus argenteus*, and *Rhus taitensis*. Common exotic trees include *Cananga odorata*, *Cocos nucifera*, *Morinda citrifolia*, and *Musa* spp. (Whistler 1995, Freifeld 1999). The most invasive tree species were *Falcataria moluccana*, *Adenanthera pavonina*, and *Syzygium samarangense* (Monello 2004). Flowering and fruiting stands of *Syzygium inophylloides*, *Diospyros samoensis*, *Myristica inutilis* and *Dysoxylum maota* offer foraging opportunities for landbirds (Amerson 1982a, Whistler 1992, 1995, Freifeld 1996). The most serious non-tree invasive species were *Clidemia hirta* and *Mikania micrantha*, both of which occur along disturbed areas; however, *C. hirta* has become established throughout NPSA (Monello 2004).

Ta'u

Ta'u Island is a small shield volcano, formed approximately 300,000 yr B.P. (Nunn 1998) and is the youngest high island in the Samoan Archipelago. Warm and humid, we presume the climate to be similar to Tutuila, which is about 100 km distant, and where there is available weather data. In NPSA, the Ta'u Unit (2,146 ha) is more than half the entire island (Figure 2). The unit is covered by dense and difficult to access forests that are rarely visited by visitors or residents. The

slopes of Mt. Lata (966 m) and Mataalaosagamai Ridge descend precipitously to the south. The steep slopes are dominated by Summit Scrub and descend to large intact stands of Rain Forest, Secondary Scrub and Rhus Secondary Forest (Liu et al. 2011). Summit Scrub slopes are covered by a dense tangle of native ferns (*Asplenium* spp., *Cyathea* spp.), vines (*Freycinetia* spp.) and small trees (*Dysoxylum huntii*, *Melastoma* spp., *Reynoldsia lanutoensis*, *Psychotria* spp.). (Amerson 1982a, Whistler 1992, 1995). The Liu Bench is dominated by Secondary Scrub (*Hibiscus tiliaceus*, *Macaranga harveyana*) and Rhus Secondary Forest (*Rhus tatiensis*, *Alphitonia zizyphoides*; *Dysoxylum maota*; Whistler 2002, Webb 2006, Liu et al. 2011). Undisturbed steep coastal rain forests are dominated by *Dysoxylum samoense*, *Planchonella samoense*, *Asplenium nidus*, and *Syzygium inophylloides* (Whistler 1992, 2002, Webb 2006). Large undisturbed Rhus Secondary Forest and Summit Scrub extend to the northern boundary of NPSA.

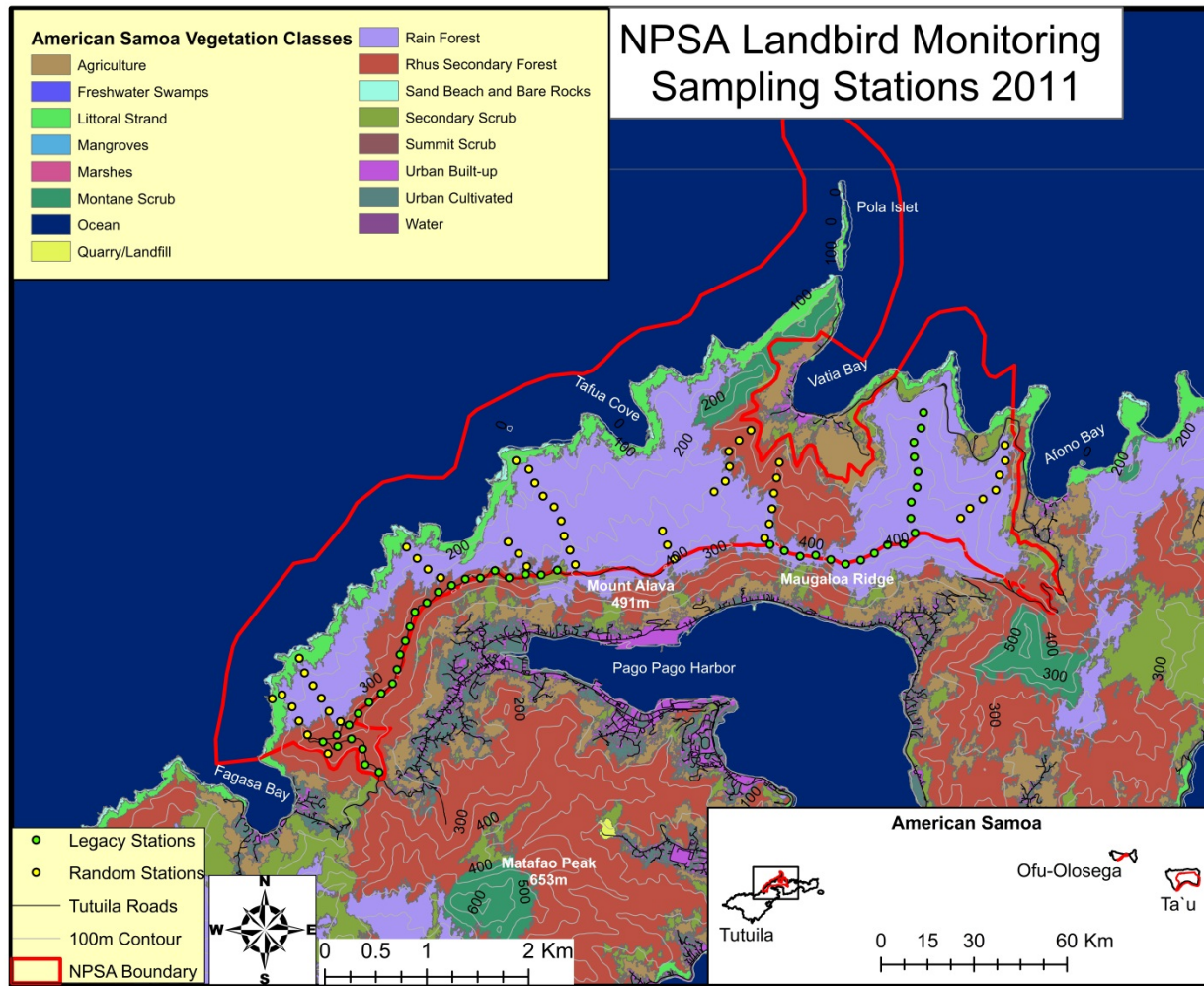


Figure 1. Tutuila Unit landbird monitoring transects. Native Rain Forest and Rhus Secondary Forest dominate surveyed areas (Liu et al. 2011).

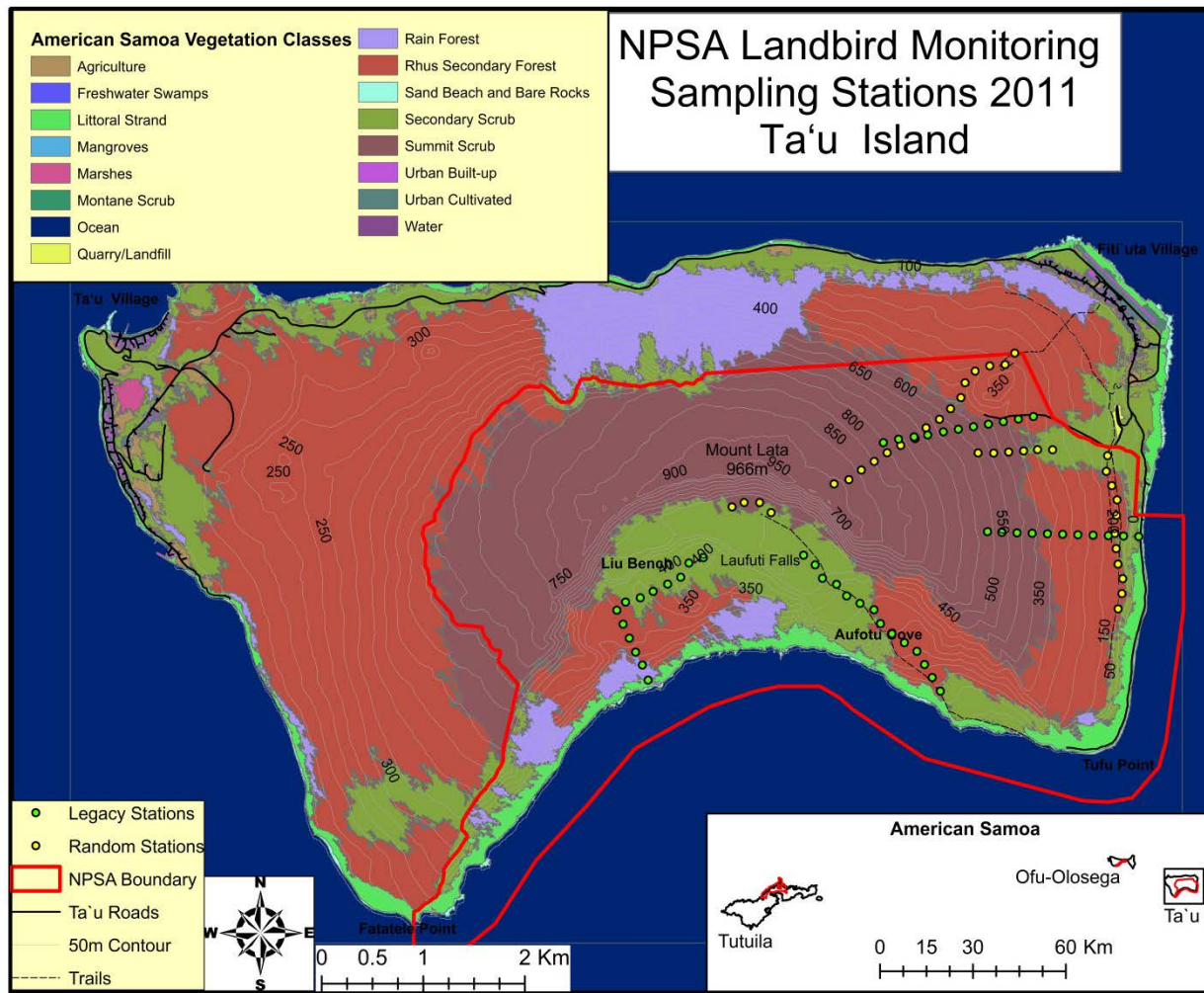


Figure 2. Ta'u Unit landbird monitoring transects. Surveyed area included the slopes of Mount Lata, which are dominated by Summit Scrub, Secondary Scrub and Rhus Secondary Forest dominate lower elevations, and smaller patches of Rain Forest in the southwest (Liu et al. 2011).

Sampling

We sampled for landbirds in the forested portions of the park on Tutuila, and then on Ta'u in the Manu'a Island Group. The small and primarily coastal Ofu Unit of NPSA was not sampled. Sampling followed a split-panel design of [1-0,1-n] sampling where the first member panel, [1-0], is an "always revisit" during each sampling occasion, which optimizes trend detection, and consists of legacy transects. The second member, [1-n], is a "never revisit" panel which optimizes status estimation. This member is populated with newly, randomly located transects during each sampling occasion. The legacy transects in the "always revisit" panel have the potential to produce biased estimates, but we can measure and correct this bias by comparing the estimate with those produced from the "never revisit" panel (see Camp et al. 2011 for details). On Tutuila, from June 17 to June 30, 2011, we sampled landbirds at 99 stations on 11 transects. On Ta'u, from July 26 to August 8, 2011, we sampled 86 stations on nine transects using the same method. Appendix A summarizes the field methods and survey effort. Landbird counts began soon after dawn, or when the sunlight would strike treetops, and were concluded by 11:00 hrs or earlier. Stations, spaced 150 m apart, were surveyed using point-transect sampling methods lasting eight minutes. We recorded species, distance in meters from observer to each bird detected, and detection type (seen, heard or both). Point-transect distance sampling methods allow for estimating detection probabilities by modeling a species-specific detection function to estimate absolute abundance (Buckland et al. 2001). This methodology thus accounts for individuals that go undetected, and produces unbiased absolute abundance. Robust estimates are reliant upon the critical assumptions that all birds are detected with certainty at the station center point, birds are detected prior to any responsive movement, and distances are measured without error. In addition, weather conditions were recorded at each station, which can be used to increase precision. Details of landbird sampling can be found in Camp et al. (2011).

Landbird habitat data were also collected at each of the point-transect sampling stations. A 50-m radius plot was established at each point-count station using the station as the center. At each plot, the dominant canopy species composition, canopy height and cover, dominant understory species composition, and the horizontal vegetation profile were described. In addition to habitat characteristics, topographical attributes were collected at each station. Habitat surveys were collected after completing bird counts (either after completing the station count, or after completing the daily counts). Details of landbird habitat sampling can be found in Camp et al. (2011).

Data Analysis

Indices

Indices of bird abundance were calculated for each species by Unit. Percent occurrence was calculated as the number of stations occupied divided by the total number of stations sampled within a Unit. Similarly, relative abundance (birds per station; BPS) was calculated as the number of individuals detected divided by the total number of stations sampled within a Unit.

Density Estimation

Species-specific density estimates (birds ha⁻¹) were calculated for seven species—Blue-crowned Lorikeet, Collared Kingfisher, Pacific Pigeon, Purple-capped Fruit-dove, Polynesian Starling, Samoan Starling, and Wattled Honeyeater—that had sufficient detections to adequately characterize detectability (Buckland et al. 2001) using program DISTANCE, version 6.0, release 2 (Thomas et al. 2010). The candidate detection function models were limited to half normal and

hazard-rate detection functions with expansion series of order two (Buckland et al. 2001). Following recommendations by Buckland et al. 2001, the half normal was paired with cosine and Hermite polynomial adjustments, and the hazard-rate was paired with cosine and simple polynomial adjustments. Model precision was improved by incorporating sampling covariates in the multiple covariate distance sampling (MCDS) engine of DISTANCE (Marques and Buckland 2004, Thomas et al. 2010). Covariates included cloud cover, rain, wind, gust, observer, time of detection, canopy cover, canopy height, and unit (Appendix B). All covariates were treated as a factor, except time of detection, which was treated as both a factor and a continuous covariate. Assessing time of detection as a continuous covariate helped to determine if the detection rate varied during the morning. Each detectability model in the candidate set was fit to data pooled across units for each species, and the model selected was that with the lowest 2nd-order Akaike's Information Criterion corrected for small sample sizes (AICc) (Buckland et al. 2001, Burnham and Anderson 2002; Appendix B). Data were truncated at a distance where the detection probability was approximately 10%. This procedure facilitates modeling by deleting outliers and reducing the number of parameters needed to modify the detection function. Species-specific densities by unit were estimated from the global detection function using the post-stratification procedure, and variances and confidence intervals were derived by bootstrap methods in DISTANCE from 999 iterations (Thomas et al. 2010). Absolute abundance was calculated as mean density of unit estimates weighted by unit area for each species.

Comparison of Panel Data

The Protocol prescribes monitoring using a panel design (Camp et al. 2011). Panel designs possess several major advantages over conventional time-series data sets (Hsiao 2003), including improved efficiency of estimates through large degrees of freedom and reduced collinearity among explanatory variables. Time-series data refer to observations of a given unit made over time, and are often referred to as longitudinal data. Longitudinal data analysis was not possible at this point because only one temporal measurement has been made. Selection and placement of the legacy transects may influence sampling the current landbird populations resulting in biased estimates. Panel designs allow for assessing selection bias by comparing the distribution of bird densities between the fixed and random transects (data pooled across species) using a quantile-quantile (q-q) plot and Kolmogorov-Smirnov test in program R (version 2.7.0; R Foundation for Statistical Computing). The jitter function was used to eliminate ties while calculating p-values, which have little effect on the overall distributions and yielded reliable p-values (Judge et al. 2011).

Results

Landbird Results

A total of 2,516 birds of 13 landbird species were detected during the survey (Tables 1 and 2). In addition, eight species of seabirds were observed. All species detected during the survey were either indigenous or endemic to the Samoa Archipelago. Indices of bird occurrence and relative abundance were calculated for all species detected (Table 2). The Wattled Honeyeater was the most widespread and abundant bird occurring on all or almost all stations, at about six birds per station. Occurrence maps displaying extent and number of detections of each species are presented in Appendix C. There were sufficient detections of seven species to determine densities (Table 3). Bird densities were generally greater in the Tutuila Unit than in the Ta'u Unit, however abundances were greater in the Ta'u Unit for five of the seven species because it was more than twice as large as the Tutuila Unit. The Wattled Honeyeater was the most abundant bird with abundances more than twice that of the other birds (Figure 3).

Table 1. List of species detected during the 2011 Landbird survey in NPSA. Abbreviated species code and origin (E=endemic, I=indigenous) of birds are presented.

Species Name	Samoan Name	Scientific Name	Species Code	Origin
Banded Rail	Ve'a	<i>Gallirallus philippensis</i>	BARA	I
Blue-crowned Lorikeet	Sega	<i>Vini australis</i>	BCLO	I
Cardinal Honeyeater	Segasegamau'u	<i>Myzomela cardinalis</i>	CAHO	I
Collared Kingfisher	Ti'otala	<i>Halcyon chloris</i>	COKI	I
Fiji Shrikebill	Sega 'olevau	<i>Clytorhynchus vitiensis powelli</i>	FISH	E
Many-colored Fruit-dove	Manuma	<i>Ptilinopus perousii</i>	MCFD	I
Pacific Pigeon	Lupe	<i>Ducula pacifica</i>	PAPI	I
Purple-capped Fruit-dove	Manutagi	<i>Ptilinopus porphyraceus</i>	PCFD	I
Polynesian Starling	Miti vao	<i>Aplonis tabuensis</i>	POST	I
Purple Swamphen	Manu ali'i	<i>Porphyrio porphyrio</i>	PUSW	I
Samoan Starling	Fuia	<i>Aplonis atrifusca</i>	SAST	E
Wattled Honeyeater	Iao	<i>Foulehaio carunculata</i>	WAHO	I
White-rumped Swiftlet	Pe'ape'a	<i>Aerodramus spodiopygius</i>	WRSW	I

Table 2. Number of birds detected, indices of bird occurrence (Percent Occurrence), and relative abundance (BPS) by unit in NPSA.

		Tutuila				Ta'u			
Species Name	Total # Detected	# Birds Detected	# Stations Occupied	Percent Occurrence	BPS	# Birds Detected	# Stations Occupied	Percent Occurrence	BPS
Banded Rail	13	11	11	11.1	0.11	2	3	3.5	0.02
Purple Swamphen	7	6	6	6.1	0.06	1	1	1.2	0.01
Many-colored Fruit-dove	16	13	11	11.1	0.13	3	3	3.5	0.03
Purple-capped Fruit-dove	338	238	84	84.8	2.40	100	48	55.8	1.16
Blue-crowned Lorikeet	101	0	0	0.0	0.00	101	40	46.5	1.17
White-rumped Swiftlet	87	46	18	18.2	0.46	41	21	24.4	0.48
Collared Kingfisher	73	58	42	42.4	0.59	15	11	12.8	0.17
Fiji Shrikebill	15	0	0	0.0	0.00	15	10	11.6	0.17
Samoan Starling	354	237	89	89.9	2.39	117	58	67.4	1.36
Polynesian Starling	187	136	72	72.7	1.37	51	32	37.2	0.59
Cardinal Honeyeater	17	17	10	10.1	0.17	0	0	0.0	0.00
Wattled Honeyeater	1111	597	99	100.0	6.02	514	85	98.8	5.98
Pacific Pigeon	197	171	74	74.7	1.73	26	20	23.3	0.30

Table 3. Densities (birds/Ha) and abundances (birds/Unit) of landbirds by unit in NPSA. Confidence intervals ($\bar{x} \pm SE$) are in parentheses. Total abundance was calculated as mean density of Unit estimates weighted by Unit area for each species.

Species	Tutuila		Ta'u	
	Density	Abundance	Density	Abundance
Blue-crowned Lorikeet	0	0	4.38 $\pm$ 0.85 (2.77—6.15)	9,404 $\pm$ 1,814 (5,954—13,196)
Collared Kingfisher	0.41 $\pm$ 0.28 (0.18—1.23)	423 $\pm$ 285 (188—1,261)	0.15 $\pm$ 0.10 (0.04—0.45)	316 $\pm$ 225 (95—976)
Pacific Pigeon	1.17 $\pm$ 0.21 (0.83—1.63)	1,199 $\pm$ 210 (846—1,664)	0.25 $\pm$ 0.07 (0.14—0.40)	532 $\pm$ 149 (293—849)
Purple-capped Fruit-dove	1.32 $\pm$ 0.25 (0.94—1.88)	1,344 $\pm$ 255 (960—1,919)	0.75 $\pm$ 0.15 (0.52—1.11)	1,617 $\pm$ 313 (1,116—2,381)
Polynesian Starling	7.71 $\pm$ 2.03 (4.86—12.60)	7,869 $\pm$ 2,069 (4,958—12,863)	4.39 $\pm$ 1.29 (2.43—7.33)	9,422 $\pm$ 2,762 (5,219—15,731)
Samoan Starling	9.20 $\pm$ 1.48 (6.59—12.35)	9,394 $\pm$ 1,507 (6,729—12,608)	6.76 $\pm$ 1.29 (4.54—9.48)	14,497 $\pm$ 2,768 (9,742—20,344)
Wattled Honeyeater	42.10 $\pm$ 9.29 (25.56—62.24)	42,979 $\pm$ 9,481 (26,097—63,551)	48.96 $\pm$ 10.95 (29.32—72.12)	105,068 $\pm$ 23,504 (62,927—154,776)

Species Summaries

Banded Rail

Banded Rails (*Rallus philippensis*) were detected in low numbers on Tutuila and Ta'u (11 and 3, respectively; Table 2). The species was detected off the jeep trail on Maugaloa Ridge on Tutuila; but, most detections were below 300 m in coastal forests where the species forages for insects in open understory (Appendix C). Banded Rails were also seen incidentally near the forest edge in disturbed areas and low elevation agroforest. The species' tendency to occupy areas close to villages may make it vulnerable to depredation by feral and domestic animals.

Blue-crowned Lorikeet

Absent on Tutuila, Blue-crowned Lorikeets (*Vini australis*) are common in the Manu'a Island Group. In the Ta'u Unit, the species occupied most of the stations surveyed on the Liu Bench and abundance was estimated to be about 9,400 individuals in the unit (Table 3; Appendix C). At 1.17 BPS and 4.38 birds/ha, the lorikeet was one of the more abundant species detected in the survey (Tables 2 and 3). They were also common outside NPSA in villages where they can be seen foraging on flowers of *Cocos nucifera* and *Erythrina variegata*. Engbring and Ramsey (1989), who also conducted landbird surveys by the point-transect distance sampling method within and outside the current NPSA boundary, reported an abundance of 6,946 individuals, well below what we found just in the Ta'u unit.

Cardinal Honeyeater

The Cardinal Honeyeater (*Myzomela cardinalis*) was detected in very low numbers. The species occurred at about 10% of the stations; only 17 were recorded in the Tutuila unit (the species does not occur in the Manu'a Island Group; Table 2; Appendix C). The low abundance may be misleading because the species is cryptic and strongly associated with disturbed lowland habitats

outside the park. The species infrequently makes short and quiet chirps that can be missed during surveys. Individuals were seen incidentally foraging in ginger flowers near the summit of Mt. Alava and outside the park in village areas feeding on nectar of ornamental and agricultural trees such as *Carica* spp., *Hibiscus* spp., and *Morinda* spp. (Freifeld 1999). Furthermore, there may be a competitive exclusion by the larger and aggressive Wattled Honeyeater (Freifeld 1999), which was the most abundant species detected.

Collared Kingfisher

Widely distributed but at low densities in the Tutuila and Ta'u Units (0.41 and 0.25 birds/ha, respectively; Tables 2 and 3; Appendix C) the Collared Kingfisher (*Halcyon chloris*) was conspicuous during surveys. Their calls are loud and individuals were readily seen perched in the lower canopy as they scanned the forest floor for insects and other prey (Amerson et al. 1982). The species was detected in a variety of habitats, including low-elevation mixed and agroforests (Watling 1982, Engbring and Ramsey 1989). This resilient species was one of the first to recover after hurricanes (DMWR 1996), and currently number 423 and 316 birds in the Tutuila and Ta'u Units, respectively (Table 3).

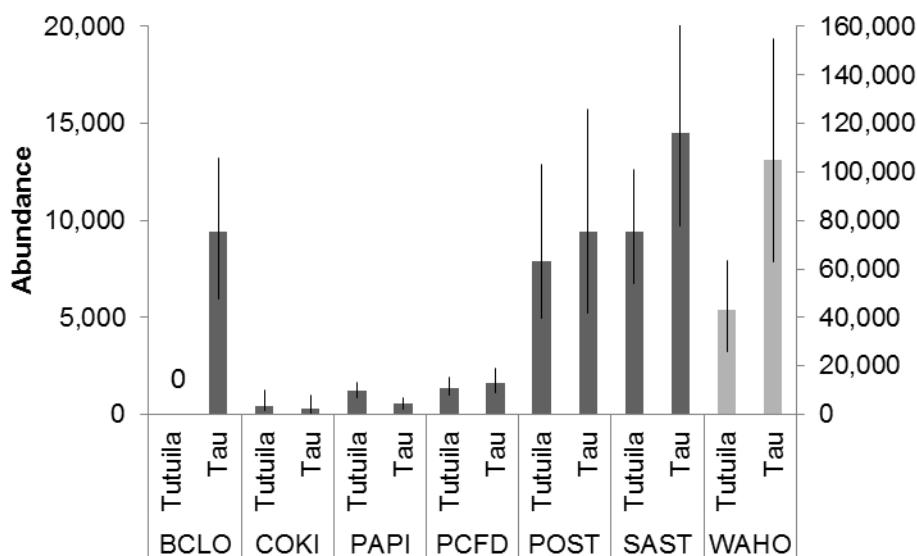


Figure 3. Population abundance and 95% confidence intervals for birds in NPSA. Species abbreviations are: Blue-crowned Lorikeet – BLCO; Collared Kingfisher – COKI; Pacific Pigeon – PAPI; Purple-capped Fruit-dove – PCFD; Polynesian Starling – POST; Samoan Starling – SAST; Wattled Honeyeater – WAHO. Wattled Honeyeater estimates use the right-hand y-axis.

Fiji Shrikebill

A subspecies endemic to the Manu'a Island Group, the Fiji Shrikebill (*Clytorhynchus vitiensis powelli*) was detected only in the Liu Bench area in low numbers (Table 2; Appendix C). Only 17 individuals were detected during surveys, which was insufficient for estimating density. Engbring and Ramsey (1989) estimated 4,695 birds on Ta'u Island. The Samoan subspecies resides on the far eastern edge of a range of other subspecies in Fiji, Rotuma, Futuna, Alofi and Tonga (Watling 1982). Each subspecies has unique forms of bills and plumage (Pratt 2010). Further monitoring is suggested to determine current abundance of this unique flycatcher.

Many-colored Fruit-dove

Detected in very low numbers, the Many-colored Fruit-dove (*Ptilinopus perousii*) appears to be rare in NPSA. Just 14 individuals were detected in the Tutuila Unit and only three in the Ta'u Unit (Table 2; Appendix C). Estimates have been low for this species throughout American Samoa (Amerson et al. 1982b, Engbring and Ramsey 1986, DMWR 1996). The species has suffered losses due to subsistence harvest (Craig 1994), hurricanes (DMWR 1996), and the loss of key tree food resources, such as *Ficus* spp., due to deforestation. It is believed that their numbers have been slowly increasing because of storm hiatus and the ban on hunting (DMWR 1996).

Pacific Pigeon

The Pacific Pigeon (*Ducula pacifica*) was detected in modest densities in the Tutuila Unit (1.17 birds/ha) and low densities in the Ta'u Unit (0.25 birds/ha; Tables 2 and 3; Appendix C). Detections of Pacific Pigeons on Tutuila were widespread throughout the Unit (Table 2; Appendix C). On Ta'u, occurrence was highest in isolated Rain Forests and Secondary Forests of the Liu Bench (Appendix C). The species has suffered many apparent declines. Before subsistence harvest of the species was outlawed in 1992, Craig et al. (1994) estimated an annual take of 2,100—4,200 pigeons on Tutuila. Take was especially severe after hurricanes when the species was more visible (Craig et al. 1994). We estimated 1,199 individuals in the Tutuila Unit and only 532 in the much larger Ta'u Unit. Lower densities on Ta'u may be due to a combination of slow recovery after Hurricanes Heta and Olaf, and a lack of mature native trees on which the species relies, such as *Bischoffia*, *Dysoxylum*, *Elaeocarpus*, *Ficus*, *Guettarda*, *Myristica*, *Rhus*, and *Syzygium* (Watling 1982, Steadman and Freifeld 1999, Freifeld 1999).

Polynesian Starling

The Polynesian Starling (*Aplonis tabuensis*) was detected at modest densities in the Tutuila and Ta'u Units (7.71 and 4.39 birds/ha, respectively; Table 3). The species was broadly distributed and detected at most stations in both units (Table 2; Appendix C). A generalist feeder, this starling can be readily seen foraging for fruits, berries, and insects (Watling 1982, Engbring and Ramsey 1989). Pratt (2010) suggested that the Polynesian Starling requires better classification because of widespread variation of phenotypic characters in the South Pacific. The Tutuila Unit population numbered 7,869 birds (4,900—12,800; Table 3). The Ta'u Unit population was slightly larger numbering 5,200—15,200, with a mean abundance of 9,422 birds (Table 3).

Purple-capped Fruit-dove

The Purple-capped Fruit-dove (*Ptilinopus porphyraceus*) was widely distributed (Table 2; Appendix C) and detected at modest densities in the Tutuila and Ta'u Units (1.32 and 0.75 birds/ha, respectively; Table 3). More of a generalist feeder than its sister species *P. perousii*,

this fruit-dove has demonstrated population increases due to the prohibition of hunting and preservation of native forests (Engbring and Ramsey 1989, DMWR 1996, Freifeld 1999). This fruit-dove is restricted to native forest and most often can be observed foraging in fruiting *Ficus* spp. (Freifeld 1999).

Purple Swampphen

The Purple Swampphen (*Porphyrio porphyrio*) was detected in coastal and low elevation rainforests in the Tutuila and Ta'u Units (1 and 6, respectively; Table 2; Appendix C). The species was seen incidentally on numerous occasions along roadsides in both Units, primarily in agroforest habitats. The species, once a popular gamebird and considered a pest by some landowners (Amerson 1982), occurs in low numbers on Tutuila and Ta'u Islands (Freifeld 1999). Curiously, the species was rarely encountered in suitable habitats in the isolated areas of either Unit.

Samoan Starling

Endemic to the Samoan Archipelago, the Samoan Starling (*Aplonis atrifusca*) was widely distributed (Table 2; Appendix C) and occurred in relatively high densities in the Tutuila and Ta'u Units (9.20 and 6.76 birds/ha, respectively; Table 3). Vocal and visible, the species was conspicuous in most areas. The starling utilizes a wide variety of native habitat and can often be seen foraging in fruiting *Dysoxylum samoense*, *Erythrina* spp., *Macaranga harveyana*, and *Pipturus* spp. (Freifeld 1999). Samoan Starlings occupied most habitats in both Units, and also inhabits human dominated and disturbed forests outside NPSA (Amerson et al. 1982, Engbring and Ramsey 1989, Freifeld 1999). There were approximately 14,500 and 9,400 starlings in the Tutuila and Ta'u Units, respectively (Table 3).

Wattled Honeyeater

The Wattled Honeyeater (*Foulehaio carunculata*) was the most ubiquitous and abundant species detected during the survey (Tables 2 and 3; Appendix C). Current densities in the Tutuila and Ta'u Units (42.10 and 48.96 birds/ha, respectively; Table 3) were much higher than what Engbring and Ramsey (1989) reported of 8.68 birds/ha. We estimated nearly 43,000 in the Tutuila Unit and more than 105,000 individuals in the Ta'u Unit (Table 3).

White-rumped Swiftlet

White-rumped Swiftlets (*Aerodramus spodiopygius*) were detected in modest numbers in the Tutuila and Ta'u Units (46 and 41, respectively; Table 2; Appendix C). In the Tutuila Unit, the species was observed flying along the jeep trail to Mt. Alava summit and near high ridges where it takes insects on the wing. Because of the species' biology the assumption of no movement is violated, thus distance sampling is not a reliable method for calculating this species' density and abundance. This species is cryptic and very small, and calls infrequently. Thus, detections were likely missed in closed canopy forests. The species does not perch in trees and only nests and rests on the walls of caves (typically sea caves), which are vulnerable to human disturbance and tsunamis (Watling 1982).

Incidentally Observed and Undetected Landbird Species

Friendly Ground-dove

A single individual Friendly Ground-Dove (*Gallicolumba stairi*) was incidentally heard near the middle of transect-8L in the Ta'u Unit (Figure 2); however, the individual was not visually confirmed. The size of this population has not been estimated recently, but it is believed to be

stable with small populations persisting on the islands of Ofu and Olosega in the Manu'a Island Group (Engbring and Ramsey 1989, USFWS 2011). The ground-dove is a candidate for Endangered Species Act listing (USFWS 2011). A range expansion and establishment of a population on Ta'u would be beneficial for this vulnerable species (IUCN red list 2011). Further surveys are needed and we recommend implementation of a Rare Bird Search (RBS) as prescribed in the Protocol (Camp et al. 2011) to confirm its presence and colonization on Ta'u. Additional management to facilitate its success on Ta'u may be warranted.

Long-tailed Cuckoo

An individual Long-tailed Cuckoo (*Eudynamis taitensis*) was incidentally seen and heard on Ta'u Island, just outside the NPSA boundary on the trail near Judd's Crater on July 21st. This migratory species breeds in New Zealand and migrates north to spend winter months in Polynesia. Shy and secretive, the species is considered an uncommon migrant and population estimates have not been determined in American Samoa (Amerson et al. 1982, Engbring and Ramsey 1989).

Spotless Crake

The Spotless Crake (*Porzana tabuensi*) was not detected during this survey. The Spotless Crake is a candidate for Endangered Species Act listing (USFWS 2011). The species' cryptic nature, small size, dark plumage, and rarely heard calls have made it difficult to determine its distribution and status on Ta'u Island. Rauzon and Fiaula (2003) describe their calls as "churring" and "bup-bup-bup bup," and Engbring and Ramsey (1986) described the calls as "mechanical clicking to a low crooning, including chirping whistles." An individual was seen off the Lata Trail in short stature montane forest by DMWR personnel in 2011 (Adam Miles, pers. comm.). Rauzon and Fiaula (2003) heard and saw individuals during several seabird surveys in high elevation Summit Scrub dominated by species of *Freycinetia* and *Cyrtandra*, along with native and alien melastomes. They also encountered moderate densities of the Norway Rat (*Rattus norvegicus*), which has been broadly documented as detrimental to many land and seabird species, and has apparently contributed to the extinction of the Spotless Crake on Raoul Island in the Kermadec Island Group (Steadman 1989). We recommend that additional surveys following RBS survey protocol (described in Camp et al. 2011) should be performed to better estimate the population distribution and abundance of this species. Furthermore, the RBS surveys should include the use of audio recording units, playback recordings, and dawn and dusk surveys.

Non-native Birds

Three species of introduced birds are common in non-native habitats in American Samoa. The Common and Jungle Mynas (*Acridotheres tristis* and *A. fuscus*, respectively), and the Red-vented Bulbul (*Pycnonotus cafer*) are readily observed in and close to villages and plantations. They are especially common on the Tafuna Plain on Tutuila Island where these species forage in agricultural fields and ornamental vegetation. There were no detections of these species in the predominately native forests we sampled in either NPSA unit.

Seabird Observations

Tutuila

Several species of seabirds were detected during this landbird survey. However, we made no attempt to estimate abundances (see O'Connor and Rauzon 2003 for current information).

Colonies of Brown Boobies (*Sula leucogaster*) and Red-footed Boobies (*S. sula*) were seen nesting in trees on the steep northwestern coastline, and several late-stage chicks were seen resting in nests during landbird surveys in July. White Terns (*Gygis alba*) and White-tailed Tropicbirds (*Phaethon lepturus*) were commonly observed resting and flying over steep ridgelines and coastal areas of NPSA. Brown Noddies (*Anous stolidus*) and Black Noddies (*A. minutus*) were also seen flying offshore and near most coasts. Blue-grey Noddies (*Procelsterna cerulea*) were seen flying near the tide pools along the lower Sauma Ridge Trail.

Ta'u

On Ta'u, observations of seabirds included: Great Frigatebirds (*Fregata minor*), White Terns, White-tailed Tropicbirds, and Brown Noddies. Most notably, there appeared to be several thousand Black Noddies foraging, nesting, and resting in coastal forests of NPSA. Densities were highest in southern coastal areas, but were also observed in mid-elevation Rain Forest (approximately 300 m). Large flocks were seen flying eastward at dawn hours or shortly thereafter. No petrels or shearwaters were seen or heard, which was not surprising, because they forage far offshore and only come to land at night during the breeding season. For example, Tahiti Petrels (*Pseudobulweria rostrata*) and Audubon's Shearwaters (*Puffinus l'herminieri*) may be detected from December-May when birds are nesting (O'Connor and Rauzon 2003).

Habitat

Canopy and Understory Composition

Tutuila

We sampled 95 stations for canopy and understory composition in the Tutuila Unit. The flora formed a diverse mosaic of native and non-native trees with no clear dominance by any one or two species. The most common canopy tree species were the native *Syzygium inophylloides*, *Ficus scabra*, *Calophyllum neo-ebudicum*, *Buchanania merrillii* and *Rhus taitensis*; of which each occurred at more than 80% of the stations (Table 4). Understory tall and short shrubs included *Alyxia bractelosa*, *Angiopteris evecta*, *Ficus tinctoria*, *Lomagramma cordipinna* and *Psychotria insularum*; which each occurred at more than 80% of stations. The invasive *Clidemia hirta* occurred at nearly 90% of stations. The non-native *Falcataria moluccana* and *Adenanthra pavonina* were not detected at sampling sites, due to ongoing removal by NPSA personnel. Liana species which occurred at more than 80% of stations included *Faradaya amicum*, the non-native *Mikania micrantha*, and *Piper graeffei*.

Ta'u

Ta'u canopy and understory species are also diverse, and similar to Tutuila, with no clear dominance of one or two species. We sampled 75 stations for habitat characteristics in the Ta'u Unit. Native canopy species with the highest occurrence (above 60%) among stations included *Alphitonia zyziphoides*, *Hibiscus tiliaceus*, *Rhus taitensis* and *Syzygium inophylloides* (Table 5). The most dominant tall shrub sub-canopy species was *Cordyline fruticosa*, which occurred at more than 90% of the stations. Additional sub-canopy species that occurred at more than 60% of the stations included *Ficus scabra*, *Ficus tinctoria*, *Macaranga harveyana* and *Psychotria insularum*. Ground cover was densely dominated by *Angiopteris evecta*, *Cyrtandra* spp., *Faradaya amicum*, *Freycinetia* spp., and *Tectaria dissecta*; each occurring at more than 90% of the stations. The fern *Asplenium nidus* was common in Secondary Forests, occurring at 89% of the stations. The invasive shrub, *Clidemia hirta*, occurred at 88% of the stations. Terrestrial orchids included *Phaeius* spp., *Dendrobium* spp., and *Bulbophyllum* spp.; each family occurred at more than 60% of stations.

Table 4. Common native plants documented during landbird habitat sampling in the Tutuila Unit.

Species	Samoa Name	Native or Invasive	Strata	Family	Stations Occupied
<i>Alyxia bractelosa</i>	Lau maile	Native	Short shrub	Apocynaceae	89%
<i>Angiopteris evecta</i>	Gase	Native	Tall shrub	Matattiaceae	89%
<i>Asplenium nidus</i>	Laugapapa	Native	Short shrub	Asplenium	86%
<i>Buchanania merrillii</i>		Native	Canopy	Anarcadicaceae	86%
<i>Calophyllum neo-ebudicum</i>	Tamanu	Native	Canopy	Clucsiaceae	86%
<i>Clidemia hirta</i>	Laau-fulu	Invasive	Short shrub	Melastomaceae	89%
<i>Dendrobium</i> spp.		Native	Short shrub	Orchidaceae	32%
<i>Dysoxylum maota</i>	Maota	Native	Canopy	Meliaceae	80%
<i>Dysoxylum samoensis</i>	Mamala	Native	Canopy	Meliaceae	82%
<i>Elaeocarpus ulianus</i>	Fia a'amati'e	Native	Canopy	Elaeocapaceae	62%
<i>Faradaya amicornum</i>	Mamalupe	Native	Liana	Verbenaceae	89%
<i>Ficus scabra</i>	Matiyao	Native	Canopy	Moraceae	89%
<i>Ficus tinctoria</i>	Mati	native	Tall shrub	Moraceae	89%
<i>Freycinetia</i> spp.	'le'ie	Native	Liana	Panadanaceae	83%
<i>Lomagramma cordipinna</i>		Native	Short shrub	Dryopteridaceae	89%
<i>Macaranga harveyana</i>	Lau papata	Native	Canopy	Euphorbiaceae	63%
<i>Meremia peltata</i>	Fue lautetele	Invasive	Liana	Convolvulaceae	76%
<i>Mikania micrantha</i>	Fuesaina	Invasive	Liana	Asteraceae	81%
<i>Neonauclea forsteri</i>	Afa	Native	Canopy	Rubiaceae	76%
<i>Nephrolepis</i> spp.	Vaotuaniu	Native	Short shrub	Lomariopsidaceae	76%
<i>Phaius</i> spp.		Native	Short shrub	Orchidaceae	49%
<i>Piper graeffei</i>	Fue manogi	Native	Liana	Araceae	89%
<i>Planchonella garberi</i>	'Ala'a	Native	Canopy	Sapotaceae	77%
<i>Psychotria insularum</i>	Matalafi	Native	Tall shrub	Rubiaceae	87%
<i>Rhus taitensis</i>	Tavai	Native	Canopy	Anacardiaceae	84%
<i>Syzygium inophylloides</i>	Asi	Native	Canopy	Myrtaceae	89%

Table 5. Common plants documented during landbird habitat sampling at 75 stations in the Ta'u Unit.

Species	Samoa name	Native or Invasive	Strata	Family	Stations Occupied
<i>Alphitonia zyziphoidea</i>	Toi	Native	Canopy	Rhamnaceae	72%
<i>Alyxia bractelosa</i>	Laumaile	Native	Liana	Apocynaceae	65%
<i>Angiopteris evecta</i>	Gase	Native	Short Shrub	Marattiaceae	93%
<i>Asplenium nidus</i>	Laugapapa	Native	Short Shrub	Aspleniaceae	89%
<i>Bulbophyllum</i> spp.		Native	Short Shrub	Orchidaceae	64%
<i>Clidemia hirta</i>		Invasive	Short Shrub	Melastomaceae	88%
<i>Cordyline fruticosa</i>	Tiyao	Native	Tall Shrub	Agaveaceae	91%
<i>Cyathea</i> spp.		Native	Short Shrub	Cyatheaceae	96%
<i>Cyrtandra</i> spp.	Momole'a	Native	Short Shrub	Gesneriaceae	96%
<i>Dendrobium</i> spp.		Native	Shrub	Orchidaceae	64%
<i>Dysoxylum maota</i>	Maota	Native	Canopy	Meliaceae	31%
<i>Dysoxylum samoense</i>	Mamala	Native	Canopy	Meliaceae	17%
<i>Faradaya amicornum</i>	Mamalupe	Native	Liana	Verbenaceae	96%
<i>Ficus scabra</i>	Matiyao	Native	Tall Shrub	Moraceae	72%
<i>Ficus tinctoria</i>	Mati	Native	Tall Shrub	Moraceae	64%
<i>Flacourtia rukam</i>	Filimoto	Native	Tall shrub	Flacourtiaceae	48%
<i>Freycinetia</i> spp.	'le'le	Native	Liana	Pandanaceae	92%
<i>Gynoctodes epiphytica</i>		Native	Liana	Rubiaceae	25%
<i>Hibiscus tiliaceus</i>	Fau	Native	Canopy	Malvaceae	69%
<i>Lomagramma cordipina</i>		Native	Short Shrub	Dryopteridaceae	71%
<i>Macaranga harveyana</i>	Laupapata	Native	Tall Shrub	Euphorbiaceae	63%
<i>Meremia peltata</i>	Fue lautetele	Invasive	Liana	Convolvulaceae	16%
<i>Mikania micrantha</i>	Fuesaina	Invasive	Liana	Asteraceae	49%
<i>Nephrolepis biserrata</i>	Vao tuaniu	Native	Short Shrub	Lomariopsidaceae	73%
<i>Phaius</i> spp.		Native	Short Shrub	Orchidaceae	63%
<i>Phymatosaurus grossus</i>	Lau auta	Native	Short Shrub	Polypodiaceae	69%
<i>Piper graeffei</i>	Fue manogi	Native	Liana	Araceae	73%
<i>Psychotria insularum</i>	Matalafi	Native	Tall Shrub	Rubiaceae	73%
<i>Rhus taitensis</i>	Tavai	Native	Canopy	Anacardiaceae	61%
<i>Syzygium inophylloides</i>	Asi	Native	Canopy	Myrtaceae	71%
<i>Tectaria dissecta</i>		Native	Short Shrub	Tectariaceae	96%

Canopy Cover and Height

Tutuila

More than 88% of the stations in the Tutuila Unit had a closed canopy (Table 6). Canopy cover was greater than 60% of the overhead view and crowns were interlocked. Canopy was only open (<60%) near roads or trails where the forest had been cleared. Almost three quarters (73.4%) of stations had trees taller than 5 m (Table 6). Generally, trees were taller in Secondary Forests and shorter on steep ridges.

Ta'u

Nearly 89% of the stations in the Ta'u Unit had a closed canopy (Table 6). Canopy cover was predominantly open or scattered (25-60% or 5-25%, respectively) in human modified areas and in high elevation Summit Scrub. Trees 5-10 m tall dominated the stations (52.1%; Table 6). Trees over 10 m were mostly in undisturbed low elevation areas. Summit Scrub trees were of short stature (below 5 m tall).

Table 6. Percent canopy cover and height of stations sampled in the Tutuila and Ta'u Units.

Unit	Canopy Cover	Count	Percent	Canopy Height	Count	Percent
Tutuila	Closed (>60% cover)	83	88.3%	1 (2-5m tall)	7	7.4%
Tutuila	Open (25-60% cover)	11	11.7%	2 (5-10m tall)	69	73.4%
Tutuila	Scattered (5-25% cover)	0	0.0%	3 (>10m tall)	18	19.1%
Ta'u	Closed (>60% cover)	63	88.8%	1 (2-5m tall)	24	33.8%
Ta'u	Open (25-60% cover)	4	5.6%	2 (5-10m tall)	37	52.1%
Ta'u	Scattered (5-25% cover)	4	5.6%	3 (>10m tall)	10	14.1%

Slope

Tutuila

Slope measurements were taken at 94 of the 99 stations in the Tutuila Unit. The majority of slopes were steep—85% of the stations were steeper than 20 degrees and of those 19% were more than 60 degrees (Table 7). Variability of slope was evenly distributed between low, medium and high at approximately 33% (Table 8). The steepest stations lied on ridgelines or on canyon faces. Gentle grades were in lower elevation areas or on the Mount Alava jeep trail.

Ta'u

Slope measurements were taken at 69 of the 86 stations in the Ta'u Unit. The majority of the stations were on gradual slopes where nearly 70% of the stations had 11—30 degree grade (Table 7). A majority (88%) of stations were of medium slope variability (Table 8). Coastal areas were the steepest and then transects would gently incline to the upper slopes and benches of the shield volcano.

Table 7. Slope grade and percent of total stations of given slope in the Tutuila and Ta'u Units.

Tutuila Unit			Ta'u Unit		
Slope % grade	Count	Percent	Slope % grade	Count	Percent
0-10	2	2.1%	0-10	11	15.9%
11-20	12	12.8%	11-20	20	29.0%
21-30	23	24.5%	21-30	27	39.1%
31-40	17	18.1%	31-40	6	8.7%
41-50	13	13.8%	41-50	2	2.9%
51-60	9	9.6%	51-60	2	2.9%
>60	18	19.1%	>60	1	1.5%
Total	94	100.0%	Total	69	100.0%

Table 8. Slope variability of stations sampled in the Tutuila and Ta'u Units. Slope variability describes the up and down variability across the plot, categorized as low, medium (med) or high.

Unit	Slope Variability	Stations Sampled	Percentage
Tutuila	high	31	33.0%
Tutuila	med	37	39.4%
Tutuila	low	26	28.0%
Ta'u	high	1	1.4%
Ta'u	med	61	88.4%
Ta'u	low	7	10.1%

Aspect

Tutuila

NPSA on Tutuila Island lies on the north facing slope of Mount Alava; however, transects traversed ridgelines and canyons. The majority of stations sampled either faced the North, East or West (Table 9). Aspect was medium to highly variable for the majority of stations (Table 10). We found aspect measurements to be subjective because stations were often on sharp ridges where the steepest slope was difficult to determine.

Ta'u

Slightly more than half (56%) of stations in the Ta'u Unit faced East (Table 9). Aspect measurements largely were of medium variability (Table 10). Because of the very thick vegetation and low visibility at most stations, we found aspect difficult to determine accurately.

Table 9. Aspect of stations sampled in the Tutuila and Ta'u Units.

Unit	Aspect (degrees)	Stations Sampled	Percentage
Tutuila	North (45-315°)	24	25.5%
Tutuila	East (45-115°)	22	23.4%
Tutuila	South (115-225°)	10	10.7%
Tutuila	West (225-315°)	38	40.4%
Ta'u	North (45-315°)	14	20.3%
Ta'u	East (45-115°)	39	56.5%
Ta'u	South (115-225°)	9	13.1%
Ta'u	West (225-315°)	7	10.1%

Table 10. Aspect variability of stations sampled in the Tutuila and Ta'u Units. Aspect variability describes the variability in the aspect across the plot, categorized as low, medium (med) or high.

Unit	Aspect Variability	Stations Sampled	Percent
Tutuila	high	30	31.9%
Tutuila	med	38	40.4%
Tutuila	low	26	27.7%
Ta'u	high	1	1.4%
Ta'u	med	60	87.0%
Ta'u	low	8	11.6%

Comparison of Panel Data

As evidenced by the q-q plots, distributions of bird densities differed between the fixed and random member panels in both Units (Figure 4). These differences were statistically significant (two-sample Kolmogorov-Smirnov test: Tutuila $D=0.2034$, $p<0.001$; Ta'u $D=0.1523$, $p=0.002$). Because of these differences between the panel members, abundance estimates from the legacy transects may be biased, thus transects from both panels should be sampled during subsequent surveys.

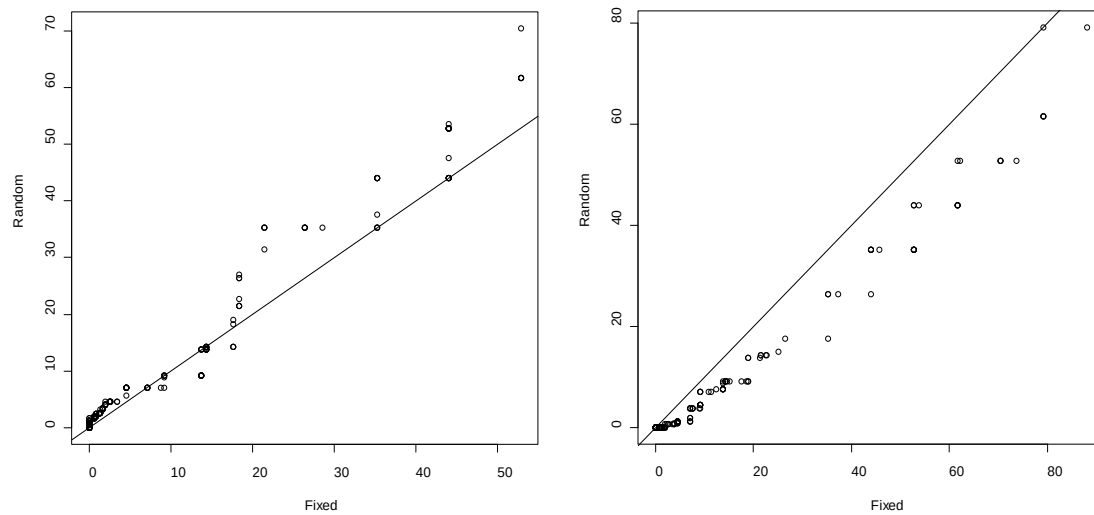


Figure 4. Q-Q plot of panel design member densities. Distribution of station-specific density estimates for the legacy transects (x-axis) plotted against estimates from the random transects (y-axis). The line represents a 1:1 relationship. There was very strong evidence of a difference between the member distributions on the Tutuila Unit ($p < 0.0001$; left panel). There was strong evidence of a difference between the member distributions on the Ta'u Unit ($p = 0.002$; right panel). Therefore, given the current data both panels should be sampled during subsequent surveys.

Discussion

Landbirds

NPSA continues to harbor an abundant and diverse avian community. Population estimates from our surveys were similar or higher than previous island-wide surveys on both Tutuila and Ta'u (Amerson 1982, Engbring and Ramsey 1989, Freifeld 1999). The Wattled Honeyeater was the most conspicuous, widespread and abundant species in both Units (almost 150,000 birds). A generalist and aggressive forager, the species has taken advantage of NPSA's numerous flowering plants and has perhaps forced other birds, such as the Cardinal Honeyeater, to forage in areas closer to villages and plantations (Freifeld 1999). In both Units, the Polynesian Starling, Samoan Starling, Collared Kingfisher, Pacific Pigeon and Purple-capped Fruit-dove occurred in modest to high numbers (300 to 14,500 birds). We expect these populations to remain stable with continued preservation and protection of NPSA's resources. The Banded Rail and Purple Swamphen occurred in low numbers (14 and 7 detections, respectively) close to developed areas. Both of these species, which travel and forage on the forest floor, may be vulnerable to depredation by feral domestic cats and dogs (Foin and Brenchley-Jackson 1991, Mack et al. 2000, Diamond 2007). The impact of depredation on those birds should be investigated and threats mitigated if needed. Unique to the Manu'a Island Group, the Blue-crowned Lorikeet occurred in modest densities within NPSA on Ta'u, about 9,400 birds. One Fiji Shrikebill was detected in the Ta'u Unit, which according to Pratt (2010) may be worthy of an endemic species ranking in American Samoa and may warrant further monitoring. Likewise, more information is needed to determine the current status of the Spotless Crake and Friendly Ground-dove, which may be the rarest landbirds in American Samoa, and both of which are candidates for listing under the Endangered Species Act (USFWS 2011).

Human activities have and continue to modify landbird habitats and populations. Severe storms exacerbate the negative consequences of human impacts. The Samoan Archipelago is under constant threat from destructive hurricanes, which in the past has caused significant declines of every landbird species (DMWR 1996). Hurricane Tusi in 1987, Hurricane Ofa in 1990, and the very severe Hurricane Val in 1991, caused catastrophic losses to residential and commercial structures, as well as stripping foliage off large areas of native forests. There were less than 50 individuals of Many-colored Fruit-doves on all of Tutuila Island in 1995 following Hurricane Val (DMWR 1996). The Collared Kingfisher, Wattled Honeyeater and Purple-capped Fruit-dove have shown signs of recovery (DMWR 1996). For example, Purple-capped Fruit-dove numbers increased, but only to 13% of the 1986 estimate (Engbring and Ramsey 1989, DMWR 1996).

In our surveys, the Many-colored Fruit-dove was detected in very low numbers; however, this species is known to be patchily distributed (Amerson 1982, Engbring and Ramsey 1989). Opportunities to observe and collect distribution information depend on the availability of fruits, especially *Ficus* spp. On Ta'u, the dove may have been negatively impacted by the recent Hurricanes Heta (in January 2004) and Olaf (in February 2005). Densities of the majority of landbirds detected there were lower than estimates on Tutuila, which was not as severely impacted by those hurricanes.

Landbirds were not evenly distributed within the park units. Abundance of landbird species in Summit Scrub in the Ta'u Unit were very low. High elevation scrub and small stature trees do not appear to harbor diverse nor abundant landbird assemblages in NPSA. Of the total stations

sampled, 23% were in Summit Scrub habitat (or above 500 m), but only 11% of the bird detections occurred there. Furthermore, only half of the 12 species detected occurred in Summit Scrub, whereas all species were detected at lower elevations. Pacific Pigeons, Fiji Shrikebills, and Collared Kingfishers were conspicuously absent, and even common species such as the Purple-capped Fruit-dove and Blue-crowned Lorikeet were detected in very low numbers. It is likely that there are few foraging opportunities in the small stature trees and dense fern understory at higher elevations. We also suspect that populations of landbirds in Summit Scrub are vulnerable to disturbance and may still be recovering from Hurricanes Heta and Olaf.

We expect distributions of landbirds in NPSA to fluctuate over time, particularly in localized areas that birds frequent because of foraging opportunities. Availability of fruits is dependent on plant phenology and weather events. Freifeld et al. (2004) found that populations of the Purple-capped Fruit-dove and Wattled Honeyeater demonstrated significant seasonal variations, but had little change in island-wide abundance. Given that the 2011 landbird sampling stations were broadly distributed throughout NPSA, we consider our estimates to be a good representation of species abundance.

The 2011 NPSA survey provides park-specific baseline information on landbird distribution, density and abundance. Repeated monitoring will be required to establish long-term trend information for the distribution and abundance of each population. This will facilitate management efforts for restoring and preserving populations, as well as contribute to the identification of habitat critical for landbird preservation.

Habitats

Canopy and understory composition in NPSA were predominantly native vegetation. There were no clear dominant species in most sampling areas. The Tutuila Unit is an exemplary representation of mixed paleotropical Rain Forest in American Samoa. Nearly 90% of stations sampled consisted of dense closed canopy and approximately 75% of the trees were over 5 m tall, and 19% of the trees were over 10 m tall. In addition, the slopes of the Tutuila Unit were steep—85% of the stations sampled were steeper than 20 degrees. The steepness of the Tutuila Unit may be one of the most important factors in the ongoing success of landbird populations. Cliff-sides and steep slopes can offer protection from predators and inhibit harvest of forest resources. Similarly in the Ta'u Unit, the vegetation was nearly all native and canopy cover was closed at most sampling stations. Tree stature was short (< 5 m) at high elevation Summit Scrub sites where there were few landbird detections. In contrast, half of trees at lower elevations (below 500 m) were taller than 5 m, and one-fifth of those were taller than 10 m.

Why densities of landbirds in the Tutuila Unit are higher than in Ta'u is perplexing. The Ta'u Unit is more isolated from villages and plantations, and much larger than the Tutuila Unit. Habitat was similarly native and most areas appeared relatively undisturbed. We did, however, record many taller trees in Tutuila, and there may be a lack of large fruiting trees in Ta'u that can sustain diverse populations of landbirds. We also suspect that landbird populations in the Ta'u Unit may still be recovering from the hurricanes that recently struck Ta'u Island. As noted above, the structure of the forests in the two Units appeared different and the lower statured Ta'u forests may not be able to sustain diverse and large bird populations.

Habitat descriptions in NPSA provide a general overview of the study plot conditions. Canopy cover and composition influence food availability, which may affect landbird densities (Fretz 2002). Having long-term habitat information allows for better resolution of reasons behind changes in landbird populations. This information can be used to better understand the dynamics of habitat structure and trends of landbird populations.

Panel Data

The Tutuila and Ta'u sampling frames were limited to the NPSA portions of islands, thus inference from these surveys are also limited to these park Units. Random selection of transect and station placement ensures that the sample is representative of the larger population, and is a requirement of distance sampling, i.e., randomly placed within the Units (Buckland et al. 2001, Fewster et al. 2009). The PACN landbirds vital sign monitoring protocol prescribes sampling using a panel design: legacy transects assigned to the fixed member and new transects assigned to the random member (Camp et al. 2011). The fixed panel members were a carryover from previous surveys, and were initially established under a different sampling frame (island-wide versus park Unit). A random subset of the fixed-panel transects was selected and sampled for the fixed member panel to maximize the representativeness to the park unit sampling frames. However, including them in the current I&M survey may have introduced a bias in estimates of density and variance. This bias may yield a systematic error in the estimates as a result of non-random sampling of the population, and the estimates may not be representative of the entire population. Testing for this difference between the fixed and random panel members was therefore necessary to determine if the fixed panel member remains representative of the sampling frame. There was very strong and strong evidence that the distribution of bird densities from the fixed and random transects were different in the Tutuila and Ta'u Units, respectively.

Future investigation of the bird distributions is warranted when additional data are available. We have no explanation for the differences between the two member panels; however, our analytical approach investigating the cross-sectional data set is more appropriate for examining precision than for examining bias. The random panel provides the necessary information to allow for bias assessment. That is, the random panel member data is independent of the survey data of the fixed panel members. Selecting and sampling random panel member data will be necessary during the next sampling occasion, and with continued surveys bias, precision and other sources of non-sampling error (e.g., panel conditioning) can be investigated (O'Muircheartaigh 1989, Hsiao 2003). If non-sampling error persists modifications of field procedures may be necessitated.

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Appendix A. Field Report: Summary of Field Efforts in 2011

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Abstract

This abstract summarizes the field methods and survey effort for the 2011 landbird survey within the National Park of American Samoa (NPSA). This study was conducted under a cooperative agreement between the National Park Service and the Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit (HPI-CESU), joint agreement H8080090008. Fieldwork preparation and data collection methods were followed as prescribed in the Landbird Vital Sign Monitoring Protocol (hereafter Protocol; Camp et al. 2011) except where noted.

A total of 185 stations on 20 transects were surveyed for landbirds and landbird habitat with the NPSA units on Tutuila and Ta'u Islands. Landbird surveys on Tutuila began on June 17 and concluded June 30, 2011. On Ta'u, surveys began on July 26 and concluded August 8, 2011. Two primary counters surveyed the 185 stations over 35 survey days. A total of 2,516 bird detections of 13 different species were recorded. Of the 185 stations, 90% were sampled for landbird habitat characteristics.

Six legacy transects will be surveyed every five years and randomly designated transects will be selected for each survey. In 2011, we sampled 14 random transects, many of which had to be moved to the nearest passable ridge because of hazardous conditions. To avoid unnecessary risks to surveyors, we suggest random transects surveyed in 2011 be sampled again in the future. Data necessary to calculate unbiased species composition were not collected because primary counters sampled each station only once and secondary counters were not utilized. Sufficient time to conduct repeat visits by primary counters or additional trained counters will be required to establish landbird species composition in NPSA.

Introduction

The PACN landbird vital sign monitoring protocol (hereafter Protocol) field season of 2011 was conducted in the Tutuila and Ta‘u Units of the National Park of American Samoa (NPSA). The terrestrial area of the park on each island was surveyed to estimate species-specific bird abundance, density and distribution, as well as to describe landbird habitat. Training and sampling procedures followed the Protocol (Camp et al. 2011). This report documents the field effort and describes the logistical needs and considerations for future sampling of each unit. In addition, this report identified deviations from the procedures prescribed in the Protocol.

Two primary counters (Appendix A—Table 1) conducted the field work, including field preparation, training, data collection, and data management. Visa Vaivai, of NPSA, provided much expertise in landbird identification and habitat characteristics. Seth Judge, the Project Field Lead, was responsible for organizing the field schedule, data collection, data entry, data summary, analysis and reporting. Patrick Hart (Department of Biology, University of Hawaii at Hilo) served as the project Principal Investigator and assisted with planning, preparations, and reporting. Richard Camp (Hawaii Cooperative Studies Unit, University of Hawaii at Hilo) assisted with data analysis and reporting, and issues pertaining to the Protocol. NPSA superintendent Mike Reynolds provided logistical assistance. Greg Kudray (PACN Inventory and Monitoring Program) offered further support with project and permitting needs. Invaluable field assistance was provided by volunteers in park (VIPs), each of whom provided much effort in establishing transects through dense forests.

Appendix A—Table 1. List of observers for Landbird Monitoring field data collection.

Observer	Observer Code	Contact information
Seth W. Judge	SWJ	sethjjudge@hotmail.com
Visa Vaivai	VXV	Visa_Vaivai@nps.gov

Methods

Training

Bird Identification

Training for bird identification and calibration for distance measurements were conducted according to the Protocol (Camp et al. 2011). Valuable literary contributions were studied to gain expertise in American Samoa’s dramatic geologic, ecological, and human history. Ecosystem surveys by Amerson (1982a, b), Engbring and Ramsey (1989), and the American Samoa Division of Marine and Wildlife Resources (1994, 1996) provided recent estimates of the population size and distribution of American Samoa’s native and exotic land and seabird species. Craig’s “Natural History Guide to American Samoa” (2009) and Watling’s “Birds of Fiji, Tonga and Samoa” (1982) were excellent source of images, life histories, and distributions of Samoa’s avifauna. Training and calibration were conducted in NPSA as well as outside the park where the island’s avifauna could be seen and heard.

Distance Measurement Training

In addition to bird identification, the crew practiced estimating distances from observer to flagging. Distance calibration training followed the Protocol procedures (Camp et al. 2011).

Training for distance measurements were conducted repeatedly within NPSA. Between 3 and 20 strips of colored flagging were tied to objects about the station, typically trees, and each counter estimated the distance, in meters, from the station center-point to the flagging. The differences between the actual and estimated distance were calculated and recorded in field books.

Calibration continued until both crewmembers obtained an accuracy of less than 10% difference between the actual and estimated distances for more than 80% of all measurements. It was important to practice distance measurements in a variety of habitats, such as open shrubland or dense forest. Distance measurements varied by habitat, thus requiring counters to make mental adjustments to accommodate for the surrounding habitats.

Habitat Identification

Training for habitat data collection focused on field methods outlined in the Protocol (Camp et al. 2011). Field guides by Amerson (1982a), Whistler (1992, 1994, 1995, 2002 and 2004) and Webb (1999, 2006) were studied to gain expertise and background into American Samoa's flora. In addition, V. Vaivai of NPSA had more than 10 years of vegetation survey experience in American Samoa.

Establishing Transects and Stations

Transects were navigated using GPS units and magnetic compasses as prescribed in the Protocol (Camp et al. 2011). The GPS units have a compass function, however, the crew found it to be more accurate in closed canopy forests to navigate to stations by reading the bearing in degrees from the GPS and following that bearing using a magnetic compass. The Garmin 60CSX units typically had an accuracy of three to six meters and stations were established one to two meters from the given position preloaded into the GPS.

Transects were marked with blue flagging for ease of navigation by future surveyors. Flag spacing depended on the density of the forest and understory, but typically was placed five-20 m apart so that the next or previous flag was always visible. Orange flagging was placed approximately five and 10 m away from the station to prevent surveyors from accidentally missing the station. Stations on legacy transects were marked with a 1 m length of $\frac{3}{4}$ inch PVC pipe with a metal tag indicating transect and station number as prescribed in the Protocol (Camp et al. 2011). A strip of pink flagging was tied to the pipe and a few strips were also tied to the nearest tree. The pipes were drilled with a small hole and wire was used to attach the metal tag approximately 5 cm below the top. A PVC cap was placed on the exposed end to prevent rain from filling the hollow pipe. Steel stakes, 45 cm long, were hammered about halfway into the ground and Simpson High Strength Epoxy-Tie® Anchoring Adhesive was squeezed onto the base of the exposed stake to seal the PVC and stake together. The PVC pipe was hammered a few inches into the ground over the stake and epoxy. The epoxy at the base of the stake prevented the PVC pipe from filling with water from below and held the stake and PVC pipe together permanently.

Data Collection

Point-transect distance sampling methods were used to survey landbirds and followed techniques described in the Protocol (Camp et al. 2011). Surveys were conducted at sampling stations spaced 150 m apart on transects. All birds seen or heard at each station were recorded during an 8-minute sampling period. The species, method of detection, and distance between observer and bird was measured to the nearest meter. Rounding of measurements to the nearest five or 10 m

was strictly avoided to eliminate “heaping.” Unnecessary noise and movement was avoided during counts to prevent altering bird activity. Binoculars were used to facilitate species identification. Counts were temporarily stopped during wind gusts or disturbances (e.g., helicopters, barking dogs, etc.). There were no differences between the Protocol prescribed and applied sampling methods. Data necessary to calculate unbiased species composition were not collected. Multiple visits are needed to create a detection history for each species at each station (Camp et al. 2011). This was not done because primary counters sampled each station only once and secondary counters were not utilized.

Habitat data was collected as described in the Protocol (Camp et al. 2011). Slope was determined using a clinometer. Aspect of sampling stations was determined by compass. Topographic position in each station was gauged by relative slope or geographic position on mountainside, from sea level to summit or ridge top areas. Canopy cover was estimated using a spherical densitometer. Percent canopy cover fell into four classes: closed canopy (>60% cover), open canopy (25-60% cover), scattered trees (5-25% cover) or very scattered (<5% cover). Canopy height was visually estimated into three classes: low stature trees (2-5 m tall), moderate stature (5-10 m tall) and tall stature (>10 m tall). Tree species composing more than 25% of the total crown cover at each 50 m radius plot was recorded to determine canopy tree composition. Understory composition was also documented as prescribed in the Protocol (Camp et al. 2011).

Summary of Units

The NPSA Tutuila and Ta'u Units were surveyed for birds and habitat during the 2011 field season. Field efforts were scheduled according to Unit, landowner permission, and observer availability. Each Unit had unique considerations regarding access, ease of navigation, and overnight stays. Workload was quantified by "survey days," or the number of primary point counters available per day. On Tutuila, one counter and VIP could stake and survey approximately 10 stations per day. Ta'u required much more effort to establish and sample stations in most areas (5 stations per day). Each transect was isolated from human habitations, and at higher elevations the vegetation was an incredible tangle of ferns and vines. Strenuous machete work was required to flag and mark stations along transects; thus, establishing some transects on Ta'u required 3-5 days.

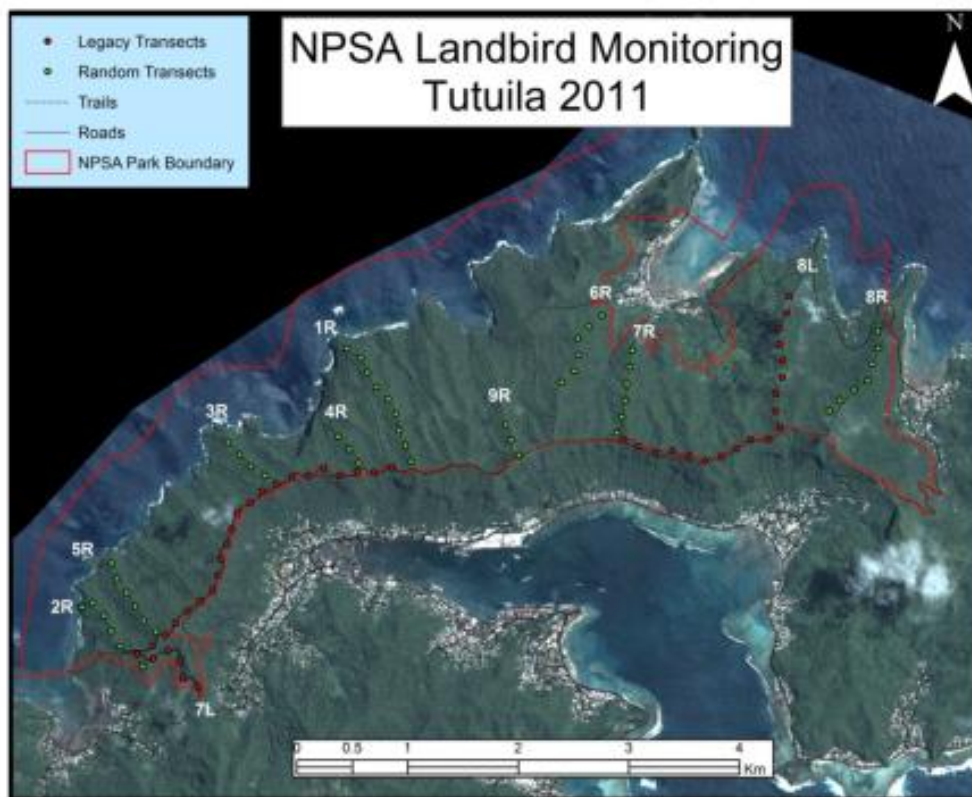
Transect Descriptions

Tutuila

Legacy transect seven begins near the western boundary of NPSA and follows the jeep trail that runs along the Maugaloa Ridge and approaches the Mt. Alava Summit (Appendix A—Figure 1; Appendix A—Table 2). Each survey station is on the roadside and marked on trees with pink flagging and a metal tag. The transect is long at 27 stations, but travel between stations is relatively quick; thus, in good weather the transect can be finished in two survey days.

Legacy transect eight begins on the Sauma trail near the eastern boundary of NPSA (Appendix A—Figure 1; Appendix A—Table 2). Each station falls on the maintained trail and is marked on the nearest tree with pink flagging and a metal tag. The transect, at 19 stations long, can be finished in one survey day, but we suggest it be done in two survey days, so counts can finish earlier when most birds are still very active.

Random transects surveyed in 2011 were provided in the Protocol (Camp et al. 2011). Many of the designated transects in the Protocol were too steep and dangerous to survey, so sampling stations were moved to the nearest passable ridge, or within 200 m of the closest given station (Appendix A—Figure 1; Appendix A—Table 2).



Appendix A—Figure 1. NPSA landbird monitoring transects on Tutuila Island (2011). Legacy transects (7L and 8L) are to be surveyed every five years, and random transects (1R, 2R, etc.) are one time only sites. Stations are spaced 150m apart and often lie on passable ridges and trails.

Ta'u

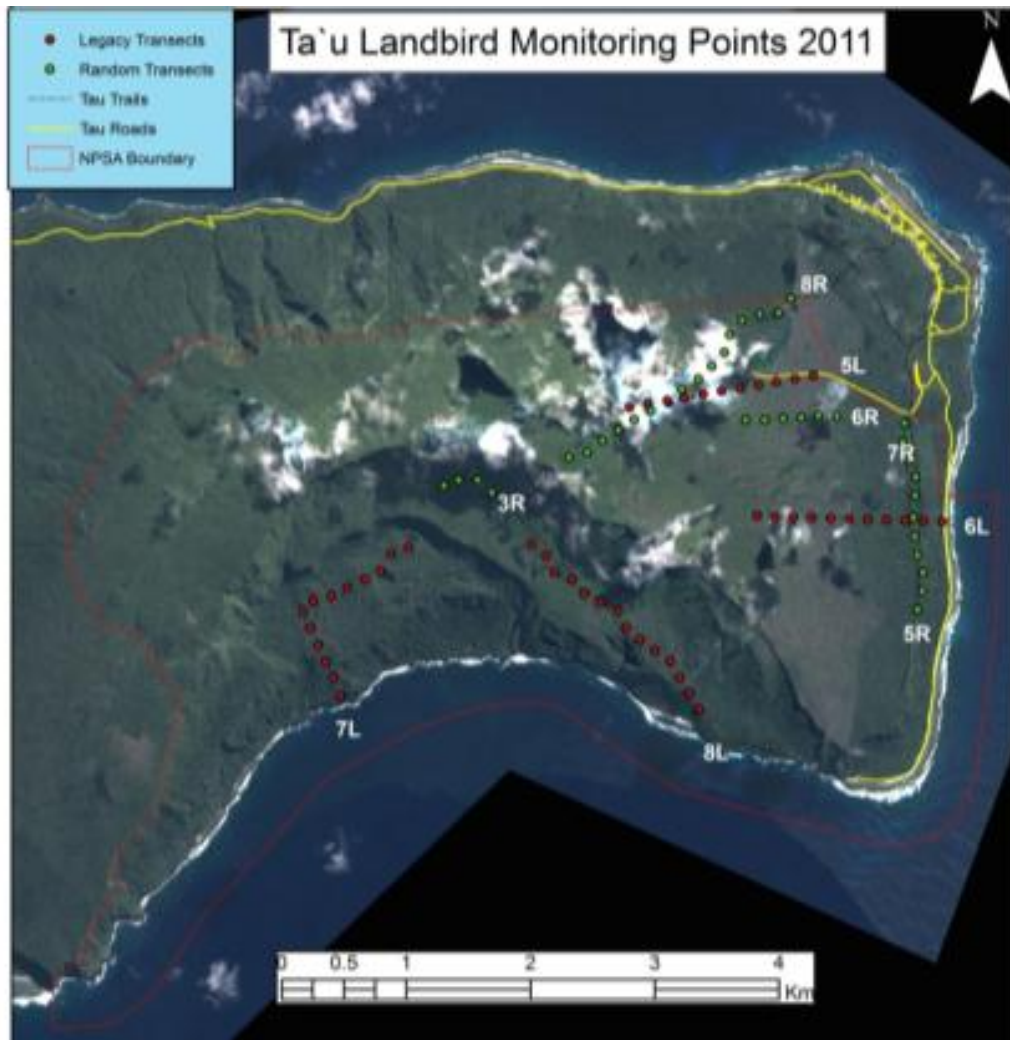
Legacy transect five was a short hike out of Fitiuta Village (Appendix A—Figure 2, Appendix A—Table 3). The crew established a connector trail from the dirt road up to the transect. The trail was marked with blue flagging and followed the southern edge of a rock quarry. Above the quarry, the trail meanders in and out of a stream bed up to the first sampling station. The transect is thick with vines and difficult to cut and hike, but can be surveyed in three days.

Legacy transect six begins near the road that follows the eastern coastline within the park (Appendix A—Figure 2; Appendix A—Table 3). Station one is approximately 5 m from the road. Station two is on a very steep cliff area. Access to that station required several hours of machete work to cut through the dense tangle of vines and trees. Sheer cliffs occur between stations two and three. Surveyors must traverse north above station two to find a pathway up through the cliff area, the path is marked with blue flagging. If foot access to stations two and three is too difficult, we suggest surveyor's follow the pig snare trail above the cliff side. The snare trail may be accessed from the legacy transect five connector trail. The trail is not regularly maintained and may require flagging and clearing. The transect can be cut and surveyed in four days.

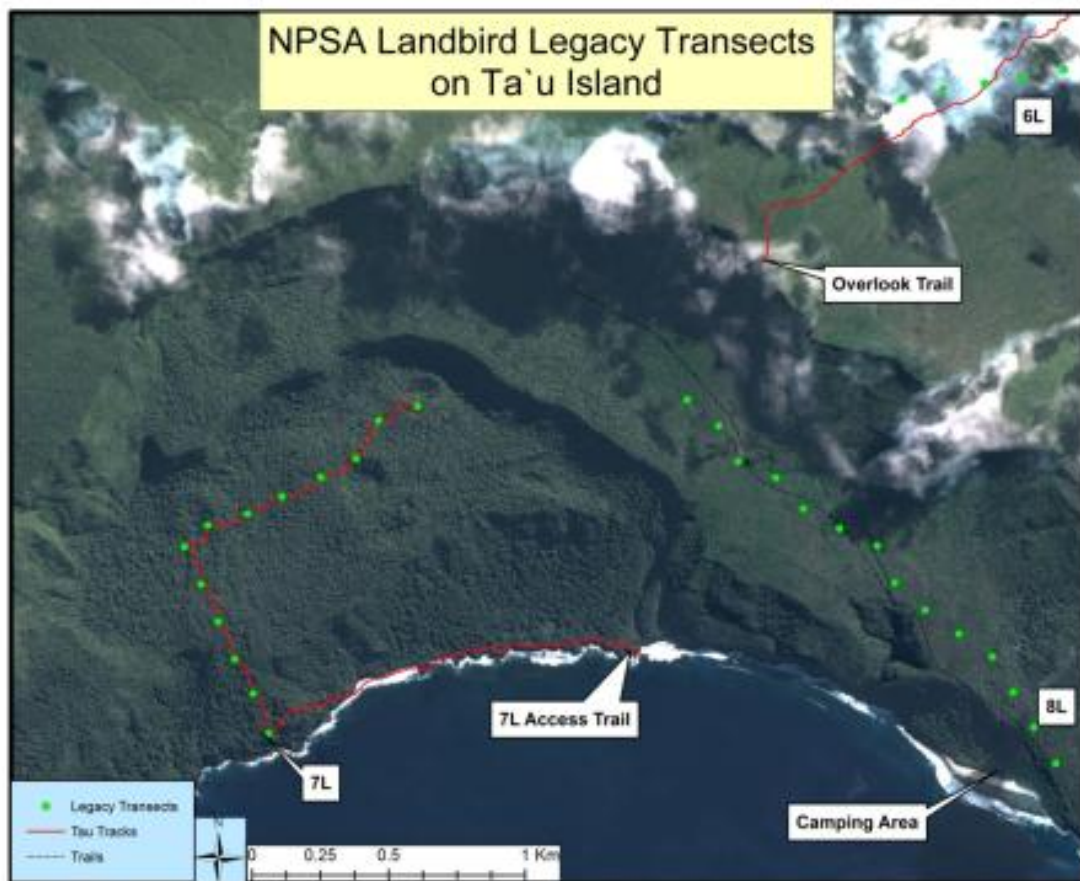
Legacy transects seven and eight required overnight camping stays by the beach near the Laufuti stream or near the Liu Bench trail (Appendix A—Figure 3). Transect seven was very isolated and difficult to access. The transect took five days to complete (three to flag and two to survey). From the campsite at the beach area surveyors started hiking the southern coastline in the pre-dawn hours and reached the first station after more than two hours of treacherous hiking. The coastal path meanders in and out of the forest, along the rocky coast, which is slippery and subject to large waves, and through dense forest; the topography is steep in most areas. This transect should only be surveyed by physically fit and experienced backcountry hikers. There are no streams near the transect so camping near the transect would require campers to carry several liters of water, thus, the crew opted to travel to and from the transect on long day trips.

Legacy transect eight was either accessed from the beach area or surveyors would camp on the Liu Bench near the middle of the transect (Appendix A—Figure 3). The transect follows the trail along the bench and traverses the Laufuti Stream. Stations are marked with pink flagging on trees close to the trail. At 14 stations long, the transect can be surveyed in one or two days.

Each random transect took two to three days to complete (one-two days to flag and one day to survey). The lower stations on each transect were relatively easier to cut and traverse. The higher stations, by contrast, were densely covered by vines and required several hours of machete work to access the end of the transect. Each transect was flagged so the crew could follow it later; all flagging was removed on the last day of survey because the random transects are one time only survey sites. Random transect eight (8R; Appendix A—Figure 3) was along the trail to the Mt. Lata summit area. The trail follows a small stream bed in mid- to high-elevations. This trail was surveyed instead of the random transect prescribed in the Protocol.



Appendix A—Figure 2. NPSA landbird monitoring transects on Ta'u Island (2011). Legacy transects (5L, 6L, 7L and 8L) are to be surveyed every four to five years. Random transects (3R, 5R, 6R, 7R and 8R) are one time only sites. Stations are spaced 150 m apart and predominately lie away from gulches and cliffs.



Appendix A—Figure 3. Liu Bench and legacy transects on Ta'u Island. 7L can be accessed from the beach camping area by hiking the coastline. An access trail (above) was marked with blue flagging and alternates between rocky shorelines and dense forest. 8L follows the trail to Laufuti Stream and is either accessed by the beach camping area or by camping near the top of the transect.

Results

Landbird and landbird habitat surveys in the Tutuila Unit began on June 17 and concluded June 30, 2011. Surveys in the Ta'u Unit began July 26 and concluded August 8, 2011. In total, two primary point counters required 35 survey days to conduct landbird and habitat sampling. Of the 20 transects sampled, six were permanent legacy transects and 14 were random transects. Each transect had a variable number of stations, ranging from four to 27 stations, and required variable effort. Legacy transects averaged 10 stations, and for this survey required flagging and installing permanent station markers; however, marking stations will not be repeated in future surveys. Random transects also averaged 10 stations, and required a variable amount of effort depending on forest density and the isolation of the transect. In total, 185 stations were surveyed for landbirds, and 90% of the stations were also surveyed to describe habitat characteristics.

Discussion

The 2011 PACN landbird vital sign monitoring field season by and large was conducted smoothly and efficiently. The weather was good for the majority of the sampling period and did not hamper data collection. The good weather was rather unusual and we would expect future surveys to experience inclement weather, thus they would take more time to complete. Two primary counters is sufficient for data collection and it is necessary for each counter to be accompanied by a technician or volunteer to assist with sampling and trail clearing. Technicians preferably should have experience identifying landbirds to assist with species composition estimates. However, in American Samoa, because of language barriers and personnel availability, it may be difficult to find qualified secondary counters. Very little machete work was required in the Tutuila Unit, where the understory was relatively open and easy to travel through. However, many areas were too steep to sample and randomly generated transects often traversed canyons too dangerous for foot travel. Random transects were moved to the nearest passable ridge and we suggest that those ridges and others in the park be surveyed for landbirds in the future. Legacy transects in the Tutuila Unit followed maintained trails.

Sampling in the Ta'u Unit was logistically and physically more challenging than in the Tutuila Unit. Each transect required strenuous machete work to clear pathways for foot travel. Primary counters and one or two volunteers rotated cutting to share the effort. Only experienced and trained hikers should be allowed to access transects in the Ta'u Unit and it is suggested all surveyors and volunteers receive training in and practice safe machete handling.

The transects and permanent stations were marked clearly following procedures detailed in the Protocol. It should be noted that flagging often degrades in windy and sunny conditions. On Ta'u, we noticed that arthropods were chewing the flagging only days after being deployed. The next NPSA surveys were scheduled to occur in 2015 or 2016 (Camp et al. 2011). By that time, much of the flagging could be degraded, so it will be essential for future counters to navigate by GPS and replace much of the flagging. The PVC pipes and stainless steel stakes should remain in position for many years, but the metal tag could corrode in the wet conditions of NPSA. Counters should also expect to replace tags and rewrite transect and station numbers as needed.

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Appendix A—Table 2. NPSA landbird monitoring points on Tutuila Island sampled in 2011.

Unit	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Tutuila	10R1-TUT	10R	1	-14.28135023	-170.7176673	8421138	530451
Tutuila	1R-1-TUT	1R	1	-14.26456799	-170.6951769	8422991	532880
Tutuila	1R-2-TUT	1R	2	-14.26328061	-170.6956748	8423134	532826
Tutuila	1R-3-TUT	1R	3	-14.26203959	-170.6962069	8423271	532769
Tutuila	1R-4-TUT	1R	4	-14.26068532	-170.6964657	8423421	532741
Tutuila	1R-5-TUT	1R	5	-14.2594474	-170.6971164	8423558	532671
Tutuila	1R-6-TUT	1R	6	-14.25848759	-170.6981202	8423664	532563
Tutuila	1R-7-TUT	1R	7	-14.25732443	-170.6988671	8423793	532483
Tutuila	1R-8-TUT	1R	8	-14.25611492	-170.699408	8423927	532425
Tutuila	1R-9-TUT	1R	9	-14.25535343	-170.7005868	8424011	532297
Tutuila	2R-1-TUT	2R	1	-14.27967545	-170.7195347	8421324	530250
Tutuila	2R-2-TUT	2R	2	-14.27846342	-170.7203002	8421458	530168
Tutuila	2R-3-TUT	2R	3	-14.2772074	-170.7209252	8421597	530101
Tutuila	2R-4-TUT	2R	4	-14.27614482	-170.721846	8421715	530001
Tutuila	2R-5-TUT	2R	5	-14.27649619	-170.7227463	8421676	529904
Tutuila	3R-1-TUT	3R	1	-14.26573592	-170.7074376	8422864	531557
Tutuila	3R-2-TUT	3R	2	-14.26499111	-170.7085931	8422946	531432
Tutuila	3R-3-TUT	3R	3	-14.26402979	-170.7095709	8423053	531327
Tutuila	3R-4-TUT	3R	4	-14.26301876	-170.7105373	8423165	531223
Tutuila	4R-1-TUT	4R	1	-14.26472842	-170.6995977	8422974	532403
Tutuila	4R-2-TUT	4R	2	-14.26358412	-170.7003619	8423101	532321
Tutuila	4R-3-TUT	4R	3	-14.26255574	-170.7013009	8423215	532219
Tutuila	5R-1-TUT	5R	1	-14.27850609	-170.716532	8421453	530574
Tutuila	5R-2-TUT	5R	2	-14.277599	-170.7175715	8421553	530462
Tutuila	5R-3-TUT	5R	3	-14.27644263	-170.7182701	8421681	530387
Tutuila	5R-4-TUT	5R	4	-14.27531736	-170.719022	8421806	530306
Tutuila	5R-5-TUT	5R	5	-14.27418949	-170.7198042	8421931	530222

Appendix A—Table 2 cont.

Unit	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Tutuila	5R-6-TUT	5R	6	-14.2729	-170.72	8422074	530171
Tutuila	6R-1-TUT	6R	1	-14.2526	-170.679	8424311	534601
Tutuila	6R-2-TUT	6R	2	-14.2535	-170.68	8424212	534486
Tutuila	6R-3-TUT	6R	3	-14.2545	-170.681	8424104	534386
Tutuila	6R-4-TUT	6R	4	-14.2558	-170.681	8423954	534393
Tutuila	6R-5-TUT	6R	5	-14.2571	-170.682	8423811	534351
Tutuila	6R-6-TUT	6R	6	-14.2581	-170.683	8423708	534240
Tutuila	7L-10-TUT	7L	10	-14.2768	-170.714	8421642	530855
Tutuila	7L-11-TUT	7L	11	-14.276	-170.713	8421728	530974
Tutuila	7L-12-TUT	7L	12	-14.2751	-170.712	8421825	531085
Tutuila	7L-13-TUT	7L	13	-14.2739	-170.711	8421965	531130
Tutuila	7L-14-TUT	7L	14	-14.2726	-170.711	8422110	531160
Tutuila	7L-15-TUT	7L	15	-14.2714	-170.711	8422244	531211
Tutuila	7L-16-TUT	7L	16	-14.2701	-170.71	8422383	531256
Tutuila	7L-17-TUT	7L	17	-14.2688	-170.71	8422527	531304
Tutuila	7L-18-TUT	7L	18	-14.268	-170.709	8422619	531422
Tutuila	7L-19-TUT	7L	19	-14.267	-170.708	8422723	531534
Tutuila	7L-1-TUT	7L	1	-14.283	-170.713	8420958	530952
Tutuila	7L-20-TUT	7L	20	-14.2664	-170.706	8422788	531665
Tutuila	7L-21-TUT	7L	21	-14.2659	-170.705	8422851	531800
Tutuila	7L-22-TUT	7L	22	-14.2658	-170.704	8422861	531948
Tutuila	7L-23-TUT	7L	23	-14.2651	-170.702	8422933	532091
Tutuila	7L-24-TUT	7L	24	-14.2657	-170.701	8422863	532230
Tutuila	7L-25-TUT	7L	25	-14.2654	-170.7	8422898	532392
Tutuila	7L-26-TUT	7L	26	-14.2655	-170.698	8422892	532545
Tutuila	7L-27-TUT	7L	27	-14.2651	-170.697	8422938	532703
Tutuila	7L-2-TUT	7L	2	-14.2823	-170.714	8421032	530817

Appendix A—Table 2 cont.

Unit	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Tutuila	7L-3-TUT	7L	3	-14.2809	-170.715	8421185	530792
Tutuila	7L-4-TUT	7L	4	-14.28	-170.716	8421283	530681
Tutuila	7L-5-TUT	7L	5	-14.2807	-170.717	8421210	530547
Tutuila	7L-6-TUT	7L	6	-14.2803	-170.718	8421254	530403
Tutuila	7L-7-TUT	7L	7	-14.2797	-170.717	8421321	530538
Tutuila	7L-8-TUT	7L	8	-14.2788	-170.716	8421418	530658
Tutuila	7L-9-TUT	7L	9	-14.2778	-170.715	8421531	530748
Tutuila	7R-1-TUT	7R	1	-14.2555	-170.677	8423996	534881
Tutuila	7R-2-TUT	7R	2	-14.2568	-170.677	8423845	534854
Tutuila	7R-3-TUT	7R	3	-14.2582	-170.677	8423693	534827
Tutuila	7R-4-TUT	7R	4	-14.2596	-170.677	8423541	534809
Tutuila	7R-5-TUT	7R	5	-14.2609	-170.678	8423393	534782
Tutuila	7R-6-TUT	7R	6	-14.2622	-170.678	8423253	534737
Tutuila	8L-01-TUT	8L	1	-14.2627	-170.677	8423190	534789
Tutuila	8L-02-TUT	8L	2	-14.2633	-170.676	8423128	534930
Tutuila	8L-03-TUT	8L	3	-14.2638	-170.675	8423074	535084
Tutuila	8L-04-TUT	8L	4	-14.2637	-170.673	8423085	535238
Tutuila	8L-05-TUT	8L	5	-14.2641	-170.672	8423041	535385
Tutuila	8L-06-TUT	8L	6	-14.2645	-170.671	8422997	535532
Tutuila	8L-07-TUT	8L	7	-14.2641	-170.669	8423035	535679
Tutuila	8L-08-TUT	8L	8	-14.2635	-170.668	8423104	535814
Tutuila	8L-09-TUT	8L	9	-14.2628	-170.667	8423186	535943
Tutuila	8L-10-TUT	8L	10	-14.2627	-170.665	8423195	536101
Tutuila	8L-11-TUT	8L	11	-14.2617	-170.664	8423303	536212
Tutuila	8L-12-TUT	8L	12	-14.2604	-170.665	8423447	536171
Tutuila	8L-13-TUT	8L	13	-14.259	-170.665	8423606	536175
Tutuila	8L-14-TUT	8L	14	-14.2577	-170.664	8423751	536232

Appendix A—Table 2 cont.

Unit	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Tutuila	8L-15-TUT	8L	15	-14.2563	-170.664	8423904	536241
Tutuila	8L-16-TUT	8L	16	-14.255	-170.664	8424049	536204
Tutuila	8L-17-TUT	8L	17	-14.2537	-170.664	8424194	536200
Tutuila	8L-18-TUT	8L	18	-14.2524	-170.664	8424334	536272
Tutuila	8L-19-TUT	8L	19	-14.251	-170.664	8424484	536296
Tutuila	8R-1-TUT	8R	1	-14.2539	-170.656	8424166	537095
Tutuila	8R-2-TUT	8R	2	-14.2553	-170.656	8424012	537099
Tutuila	8R-3-TUT	8R	3	-14.2566	-170.657	8423872	537039
Tutuila	8R-4-TUT	8R	4	-14.2579	-170.657	8423723	537005
Tutuila	8R-5-TUT	8R	5	-14.2587	-170.658	8423636	536879
Tutuila	8R-6-TUT	8R	6	-14.2595	-170.659	8423544	536751
Tutuila	8R-7-TUT	8R	7	-14.2604	-170.66	8423448	536660
Tutuila	9R-1-TUT	9R	1	-14.264	-170.686	8423049	533852
Tutuila	9R-2-TUT	9R	2	-14.2628	-170.687	8423186	533782
Tutuila	9R-3-TUT	9R	3	-14.2616	-170.687	8423323	533735

Appendix A—Table 3. NPSA landbird monitoring points on Ta'u Island sampled in 2011.

Unit	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Ta'u	3R-05-TAU	3R	5	-14.2358	-169.459	8425649	666278
Ta'u	3R-06-TAU	3R	6	-14.2354	-169.458	8425692	666397
Ta'u	3R-07-TAU	3R	7	-14.2354	-169.456	8425691	666550
Ta'u	3R-08-TAU	3R	8	-14.2362	-169.455	8425593	666663
Ta'u	5L-06-TAU	5L	6	-14.2276	-169.431	8426533	669249
Ta'u	5L-07-TAU	5L	7	-14.2278	-169.433	8426508	669101
Ta'u	5L-08-TAU	5L	8	-14.2281	-169.434	8426483	668953
Ta'u	5L-09-TAU	5L	9	-14.2283	-169.435	8426458	668805
Ta'u	5L-10-TAU	5L	10	-14.2285	-169.437	8426433	668657
Ta'u	5L-11-TAU	5L	11	-14.2288	-169.438	8426409	668509
Ta'u	5L-12-TAU	5L	12	-14.229	-169.44	8426384	668362
Ta'u	5L-13-TAU	5L	13	-14.2293	-169.441	8426353	668207

Appendix A—Table 3 cont.

Unit	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Ta'u	5L-14-TAU	5L	14	-14.2295	-169.442	8426333	668072
Ta'u	5L-15-TAU	5L	15	-14.2297	-169.444	8426312	667919
Ta'u	5L-16-TAU	5L	16	-14.23	-169.445	8426277	667770.
Ta'u	5R-01-TAU	5R	1	-14.2379	-169.424	8425389	670052
Ta'u	5R-02-TAU	5R	2	-14.2392	-169.424	8425241	670065
Ta'u	5R-03-TAU	5R	3	-14.2406	-169.424	8425089	670083
Ta'u	5R-04-TAU	5R	4	-14.2419	-169.423	8424947	670130
Ta'u	5R-05-TAU	5R	5	-14.2432	-169.423	8424801	670122
Ta'u	5R-06-TAU	5R	6	-14.2446	-169.423	8424651	670084
Ta'u	6L-01-TAU	6L	1	-14.2381	-169.422	8425359	670287
Ta'u	6L-02-TAU	6L	2	-14.2381	-169.423	8425363	670137
Ta'u	6L-03-TAU	6L	3	-14.2381	-169.424	8425368	669987
Ta'u	6L-04-TAU	6L	4	-14.2381	-169.426	8425372	669837
Ta'u	6L-05-TAU	6L	5	-14.238	-169.427	8425377	669687
Ta'u	6L-06-TAU	6L	6	-14.231	-169.438	8425381	669537
Ta'u	6L-07-TAU	6L	7	-14.238	-169.43	8425386	669387
Ta'u	6L-08-TAU	6L	8	-14.2379	-169.431	8425390	669237
Ta'u	6L-09-TAU	6L	9	-14.2379	-169.433	8425395	669088
Ta'u	6L-10-TAU	6L	10	-14.2379	-169.434	8425399	668938
Ta'u	6L-11-TAU	6L	11	-14.2378	-169.435	8425407	668796
Ta'u	6R-03-TAU	6R	3	-14.2305	-169.43	8426208	669438
Ta'u	6R-04-TAU	6R	4	-14.2305	-169.431	8426209	669290
Ta'u	6R-05-TAU	6R	5	-14.2306	-169.432	8426197	669153
Ta'u	6R-06-TAU	6R	6	-14.2308	-169.434	8426186	669006
Ta'u	6R-07-TAU	6R	7	-14.2309	-169.435	8426175	668857
Ta'u	6R-08-TAU	6R	8	-14.2308	-169.436	8426177	668703
Ta'u	7L-01-TAU	7L	1	-14.2403	-169.461	8425152	665995

Appendix A—Table 3 cont.

Tract	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Ta'u	7L-02-TAU	7L	2	-14.240751	-169.462736	8425100	665853
Ta'u	7L-03-TAU	7L	3	-14.242014	-169.463483	8424960	665772
Ta'u	7L-04-TAU	7L	4	-14.242633	-169.464675	8424893	665643
Ta'u	7L-05-TAU	7L	5	-14.243286	-169.465994	8424821	665500
Ta'u	7L-06-TAU	7L	6	-14.243857	-169.467163	8424759	665373
Ta'u	7L-07-TAU	7L	7	-14.244247	-169.468502	8424717	665228
Ta'u	7L-08-TAU	7L	8	-14.244968	-169.469292	8424638	665143
Ta'u	7L-09-TAU	7L	9	-14.246201	-169.468714	8424501	665204
Ta'u	7L-10-TAU	7L	10	-14.247434	-169.468136	8424364	665266
Ta'u	7L-11-TAU	7L	11	-14.248667	-169.467558	8424227	665327
Ta'u	7L-12-TAU	7L	12	-14.249799	-169.466931	8424102	665394
Ta'u	7L-13-TAU	7L	13	-14.251132	-169.466401	8423954	665450
Ta'u	7R-01-TAU	7R	1	-14.231016	-169.424561	8426149	669980
Ta'u	7R-02-TAU	7R	2	-14.232406	-169.424662	8425995	669968
Ta'u	7R-03-TAU	7R	3	-14.233661	-169.424151	8425856	670022
Ta'u	7R-04-TAU	7R	4	-14.234919	-169.423664	8425717	670074
Ta'u	7R-05-TAU	7R	5	-14.236285	-169.423704	8425566	670069
Ta'u	8L-01-TAU	8L	1	-14.239993	-169.452271	8425176	666983
Ta'u	8L-02-TAU	8L	2	-14.240847	-169.451206	8425081	667097
Ta'u	8L-03-TAU	8L	3	-14.242026	-169.450533	8424950	667169
Ta'u	8L-04-TAU	8L	4	-14.242549	-169.449248	8424891	667307
Ta'u	8L-05-TAU	8L	5	-14.243569	-169.448311	8424778	667408
Ta'u	8L-06-TAU	8L	6	-14.244221	-169.447084	8424704	667540
Ta'u	8L-07-TAU	8L	7	-14.244775	-169.445803	8424642	667677
Ta'u	8L-08-TAU	8L	8	-14.246004	-169.445198	8424506	667742
Ta'u	8L-09-TAU	8L	9	-14.246895	-169.444158	8424407	667853
Ta'u	8L-10-TAU	8L	10	-14.247673	-169.44301	8424320	667977
Ta'u	8L-11-TAU	8L	11	-14.248429	-169.441864	8424235	668100
Ta'u	8L-12-TAU	8L	12	-14.249591	-169.441152	8424106	668176
Ta'u	8L-13-TAU	8L	13	-14.250737	-169.44044	8423979	668252
Ta'u	8L-14-TAU	8L	14	-14.251937	-169.439691	8423846	668332
Ta'u	8R-01-TAU	8R	1	-14.222	-169.433104	8427153	669065
Ta'u	8R-02-TAU	8R	2	-14.223021	-169.433972	8427041	668970

Appendix A—Table 3 cont.

Tract	Waypoint	Transect	Station	Latitude	Longitude	Y-Projection	X-Projection
Ta'u	8R-03-TAU	8R	3	-14.223145	-169.435375	8427028	668819
Ta'u	8R-04-TAU	8R	4	-14.223616	-169.436709	8426977	668674
Ta'u	8R-05-TAU	8R	5	-14.224654	-169.437618	8426863	668576
Ta'u	8R-06-TAU	8R	6	-14.225967	-169.437992	8426717	668534
Ta'u	8R-07-TAU	8R	7	-14.226957	-169.438931	8426609	668432
Ta'u	8R-08-TAU	8R	8	-14.227897	-169.439938	8426505	668323
Ta'u	8R-09-TAU	8R	9	-14.228655	-169.441158	8426422	668191
Ta'u	8R-10-TAU	8R	10	-14.229618	-169.442154	8426317	668083
Ta'u	8R-11-TAU	8R	11	-14.23023	-169.443468	8426250	667940
Ta'u	8R-12-TAU	8R	12	-14.230883	-169.444699	8426178	667807
Ta'u	8R-13-TAU	8R	13	-14.231662	-169.445875	8426093	667679
Ta'u	8R-14-TAU	8R	14	-14.232434	-169.447044	8426009	667553
Ta'u	8R-15-TAU	8R	15	-14.233286	-169.448172	8425915	667430
Ta'u	8R-16-TAU	8R	16	-14.233676	-169.449528	8425873	667284

Appendix B. Bird Modeling

Appendix B—Table 1. Factors for covariates for the 2011 NPSA Landbird survey. Rain was not used as a covariate. Pooling of covariates was used to increase sample size and increase the likelihood of model convergence.

Cloud	CloudPooled	Wind	WindPooled	Gust	GustPooled
0	1	0	0	0	0
10	1	1	1	1	1
20	1	2	1	2	1
30	1	3	1	3	1
40	1	4	1	4	1
50	1	5	1	5	1
60	2	6	1	6	1
70	2	<>	1	<>	1
80	2				
90	2				
100	2				
<>	2				

Appendix B—Table 2. Models and parameters used to derive population densities by species for the 2011 Landbird Survey.

Species Name	Model	Adjustment terms	Covariates	Truncation	k	LogL	AICc	Justification
Purple-Capped Fruit-Dove	Hazard rate	Key	Observer	102.0	3	-1313.61	2633	Model selected to control for apparent movement
Blue-Crowned Lorikeet	Hazard rate	Key	None	45.0	2	-353.44	711	Model selected to control for apparent movement
White-Collared Kingfisher	Hazard rate	Key	None	93.8	2	-285.57	575	Model selected to control for apparent movement
Samoa Starling	Hazard rate	Key	Unit & Observer	49.7	4	-1096.15	2200	Selected using AICc methods
Polynesian Starling	Hazard rate	Key	None	36.3	2	-518.35	1041	Model selected to control for apparent movement
Wattled Honeyeater	Hazard rate	Simple polynomial (4)	Observer & Cloud	40.9	5	-3430.72	6872	Selected using AICc methods
Pacific Pigeon	Hazard rate	Key	Observer	87.0	3	-699.25	1405	Selected using AICc methods

Appendix B—Table 3. Model Selection Based on AIC. A model incorporating both panel and cover covariates was assessed and did not improve model fit (i.e., greater AICc value than best fit model).

Species Name	Model	Adjustment terms	Covariates	k	LogL	AICc	$\Delta AICc$	wi	Justification
Samoa Starling	H-rate	Key	Unit & Observer	4	-1096.15	2200.43	0	0.9997	
	H-rate	Key	Unit	3	-1105.62	2217.32	16.89	0.0002	
	H-rate	Key	Observer	3	-1106.56	2219.2	18.77	0.0001	
	H-rate	Key	Dect Type	3	-1111.14	2228.36	27.93	0	
	H-rate	Key	None	2	-1112.38	2228.8	28.37	0	
	H-rate	Cos	None	2	-1112.38	2228.8	28.37	0	Key model selected over more parameterized models
	H-rate	S-poly	None	2	-1112.38	2228.8	28.37	0	Key model selected over more parameterized models
	H-rate	Key	Wind	3	-1112.56	2231.2	30.77	0	
	H-rate	Key	Time	3	-1112.87	2231.81	31.38	0	
	H-rate	Key	Cloud	3	-1112.9	2231.88	31.45	0	
	H-rate	Key	Gust	3	-1112.91	2231.89	31.46	0	
	H-norm	Key	None	1	-1115.31	2232.64	32.21	0	
	H-norm	Cos	None	1	-1115.31	2232.64	32.21	0	Key model selected over more parameterized models
	H-norm	H-poly	None						Parameters highly correlated

Appendix B—Table 3 cont.

Wattled Honeyeater	H-rate	S-poly	Observer & Cloud	5	-3430.72	6871.51	0	0.9986	
	H-rate	S-poly	Cloud	4	-3438.86	6885.77	14.26	0.0008	
	H-rate	S-poly	Observer	4	-3439.26	6886.56	15.05	0.0005	
	H-rate	S-poly	Time	4	-3443.87	6895.78	24.27	0	
	H-rate	S-poly	None	3	-3445.04	6896.11	24.6	0	
	H-rate	S-poly	Unit	4	-3444.53	6897.1	25.59	0	
	H-rate	Key	None	2	-3447.06	6898.13	26.62	0	
	H-rate	S-poly	Gust	4	-3446.49	6901.02	29.51	0	
	H-norm	Cos	None	2	-3448.66	6901.33	29.82	0	
	H-rate	S-poly	Wind	4	-3447.17	6902.39	30.88	0	
	H-norm	Key	None	1	-3469.97	6941.93	70.42	0	
	H-norm	H-poly	None						Parameters highly correlated
	H-rate	Cos	None						Invalid model fit
	H-rate	S-poly	Dect Type						Invalid model fit

Appendix B—Table 3 cont.

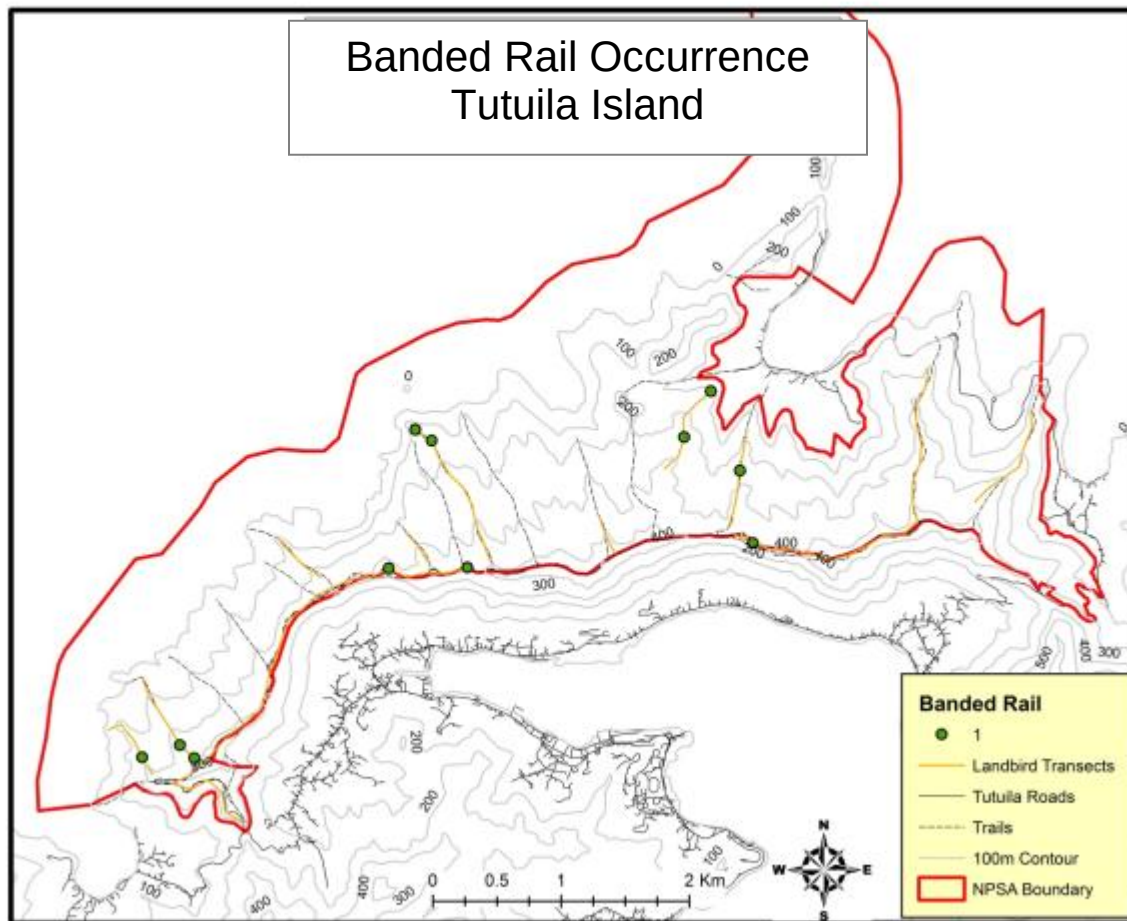
Pacific Pigeon	H-rate	Key	Dect Type	3	-699.25	1404.65	0	1	
	H-rate	Key	Gust	3	-713.83	1433.81	29.16	0	
	H-rate	Key	None	2	-714.96	1433.99	29.34	0	
	H-rate	Key	Wind	3	-714.66	1435.46	30.81	0	
	H-norm	Key	None	1	-716.95	1435.92	31.27	0	
	H-norm	H-poly	None	1	-716.95	1435.92	31.27	0	Key model selected over more parameterized models
	H-rate	Key	Time	3	-715.23	1436.61	31.96	0	
	H-rate	Key	Cloud	3	-715.36	1436.86	32.21	0	
	H-rate	Key	Unit	3	-715.41	1436.97	32.32	0	
	H-rate	Key	Observer	3	-715.48	1437.11	32.46	0	
	H-norm	Cos	None						Invalid model fit
	H-rate	Cos	None						Invalid model fit
	H-rate	S-poly	None						Invalid model fit

Appendix C. NPSA Bird Occurrence Maps

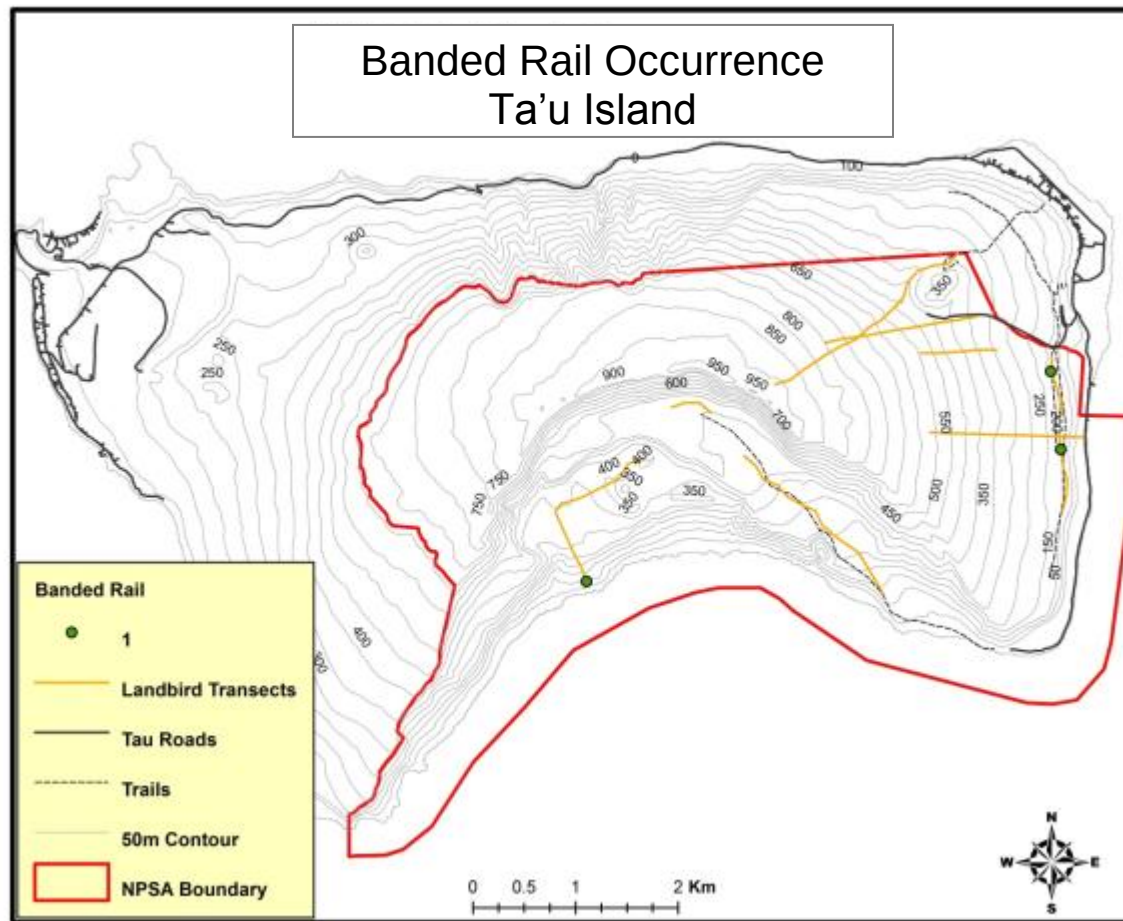
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Appendix C. NPSA Bird Occurrence Maps (continued)

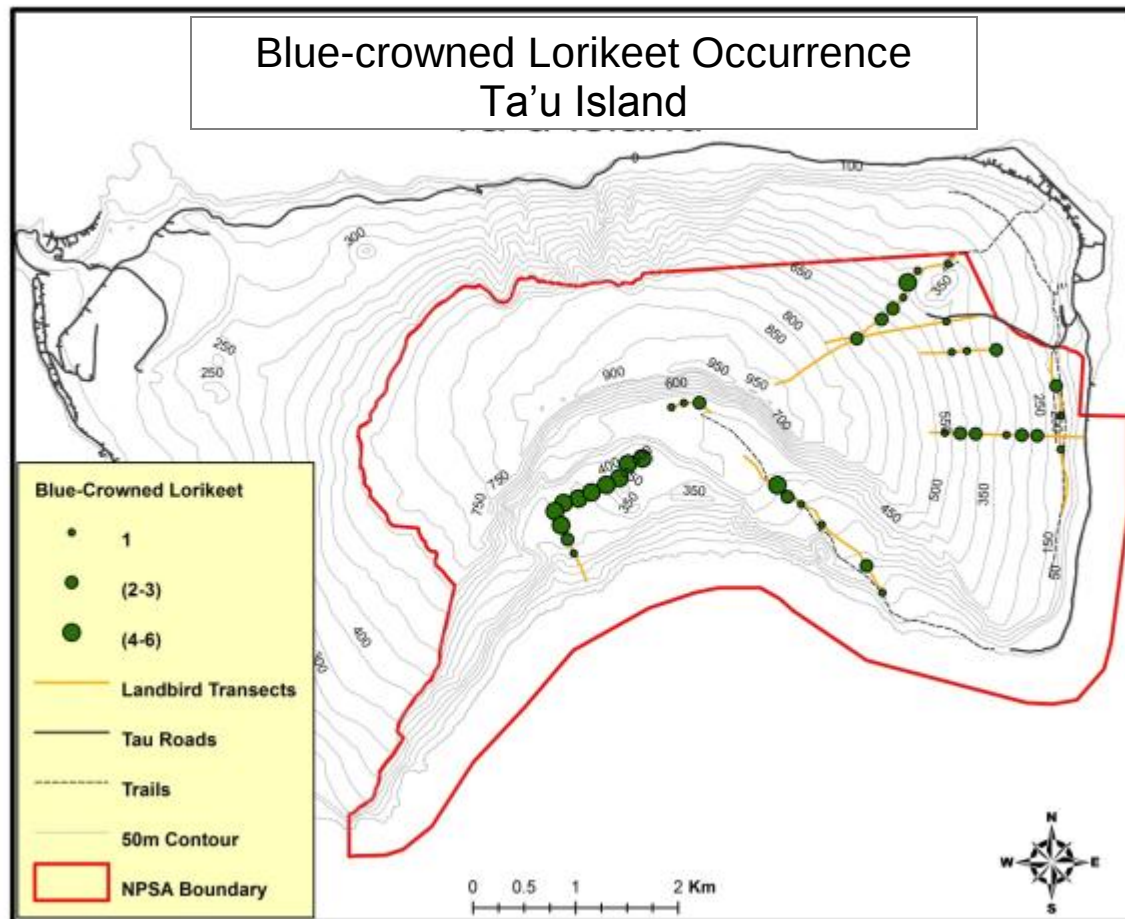
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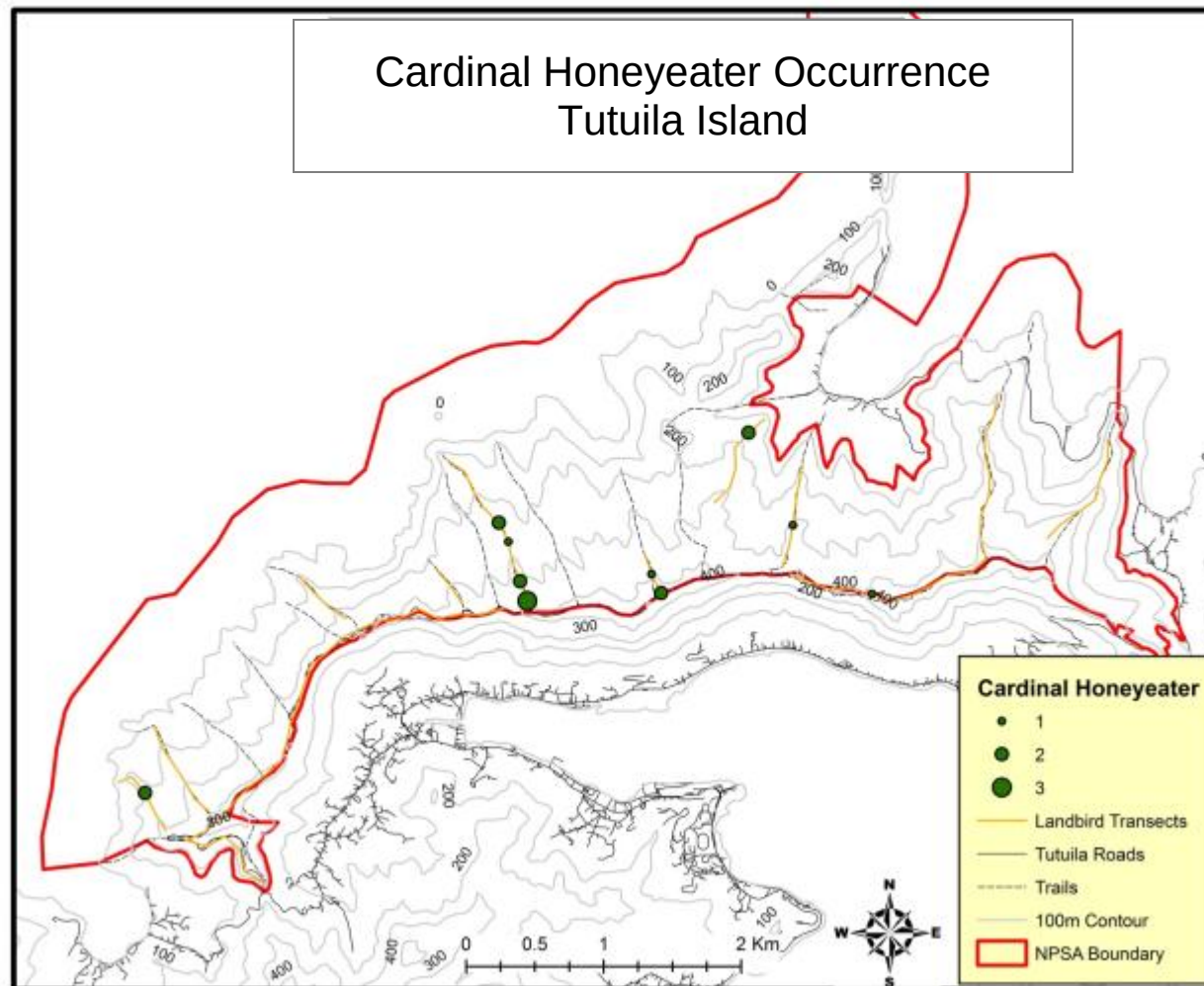
Appendix C—Figure 5. Banded Rail occurrence in the Tutuila unit during the 2010 landbird survey. Graduated symbols display the abundance of individuals detected at each station.



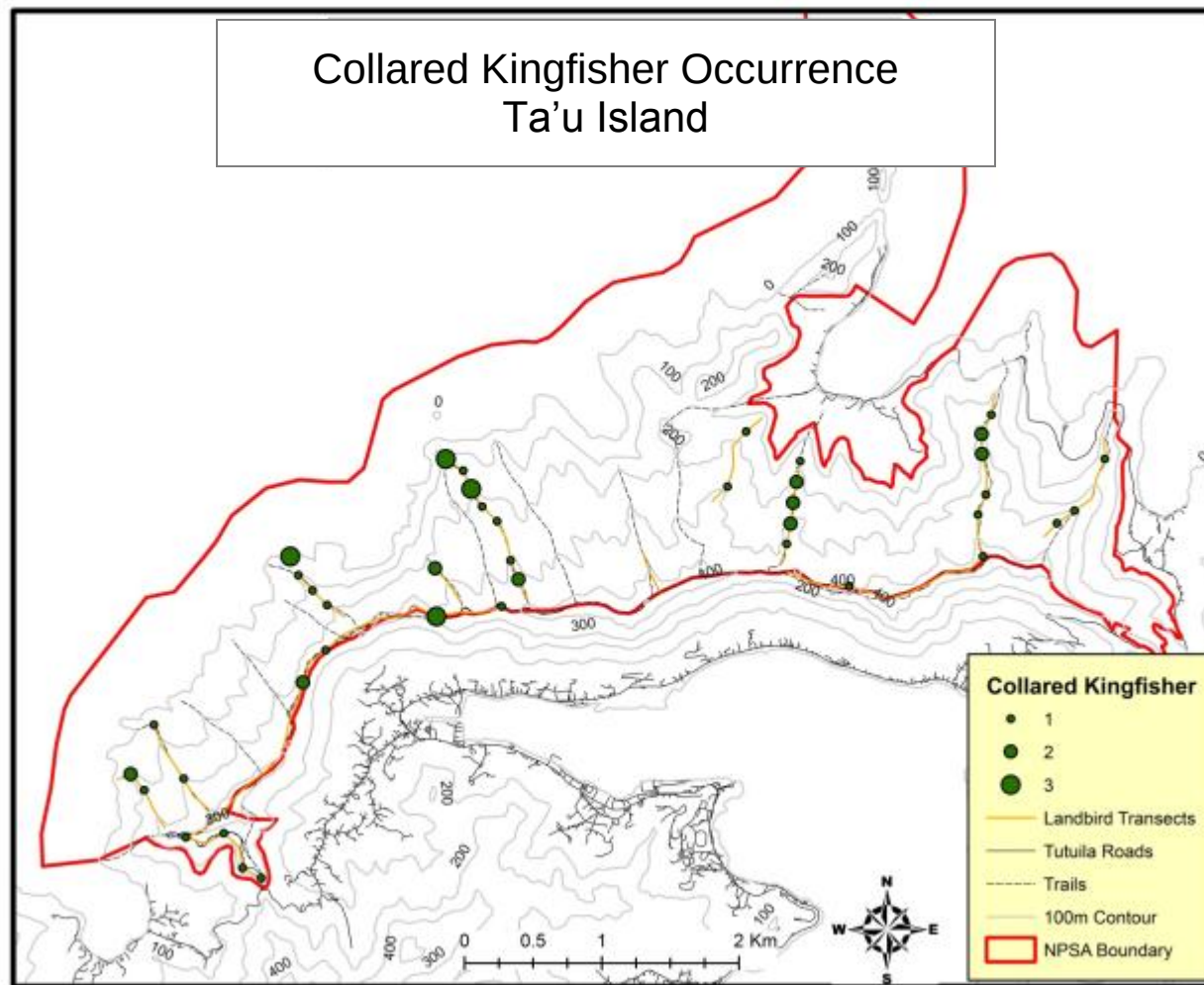
Appendix C—Figure 6. Banded Rail occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



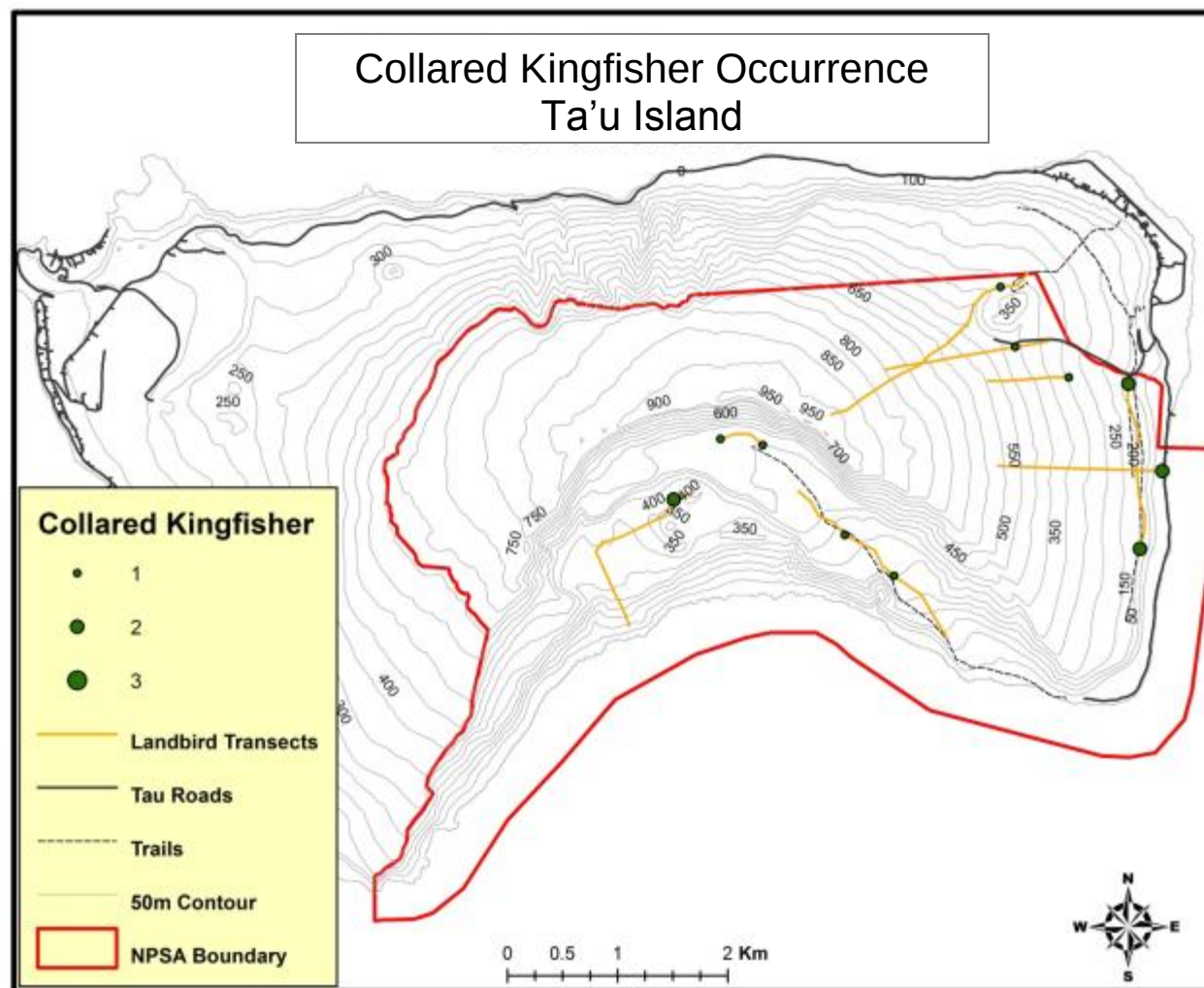
Appendix C—Figure 7. Blue-crowned Lorikeet occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



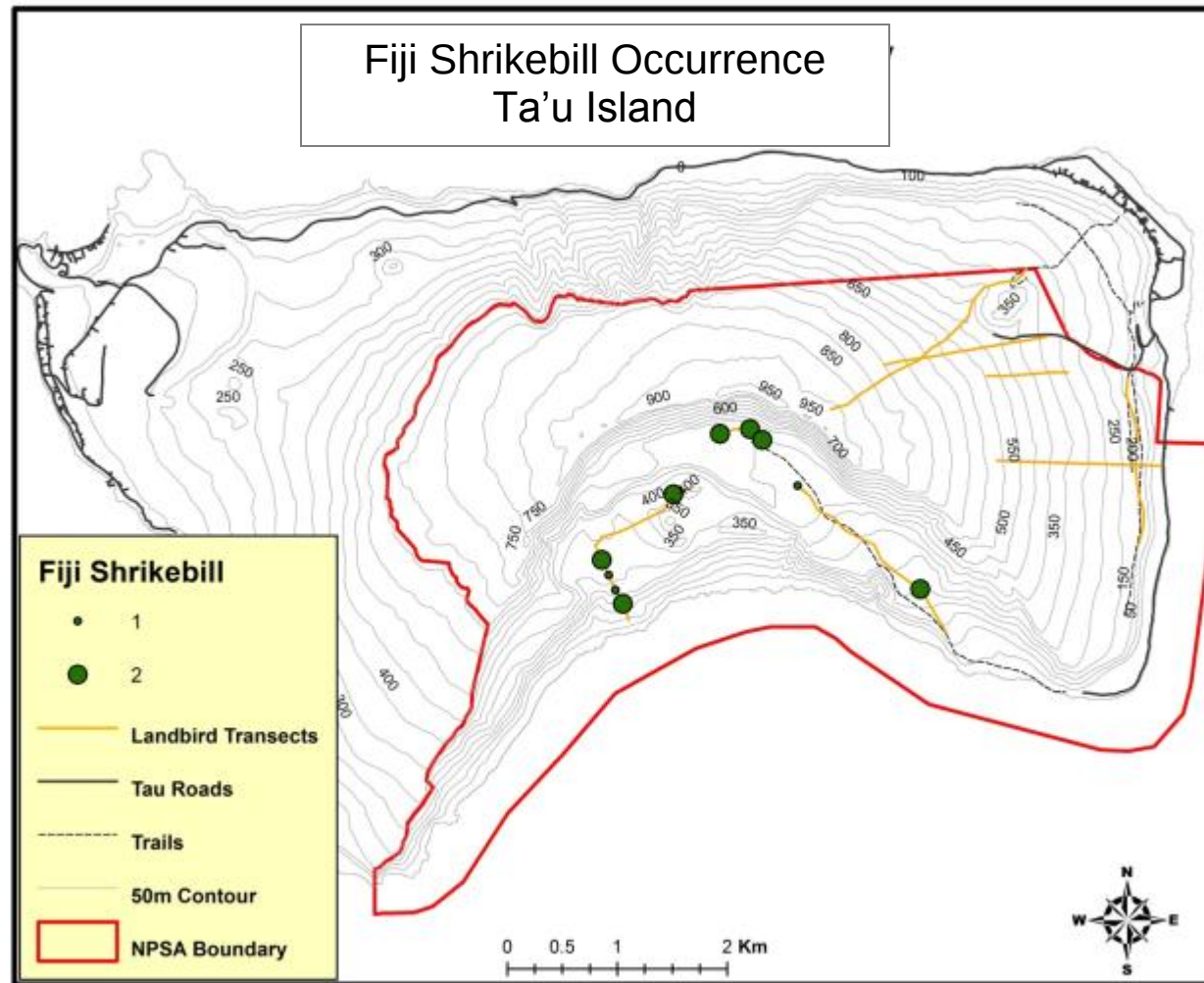
Appendix C—Figure 8 Cardinal Honeyeater occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



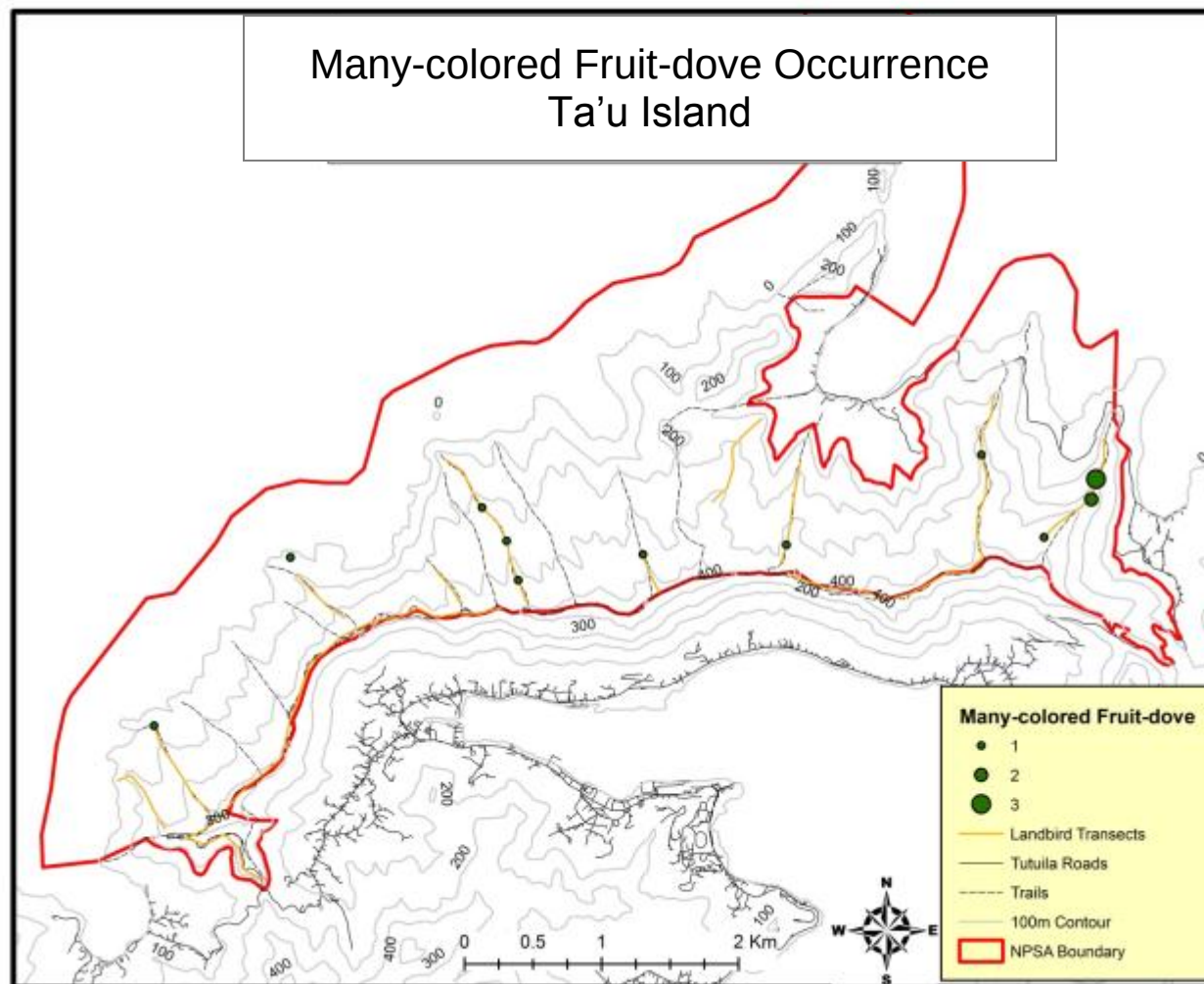
Appendix C—Figure 9 Collared Kingfisher occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



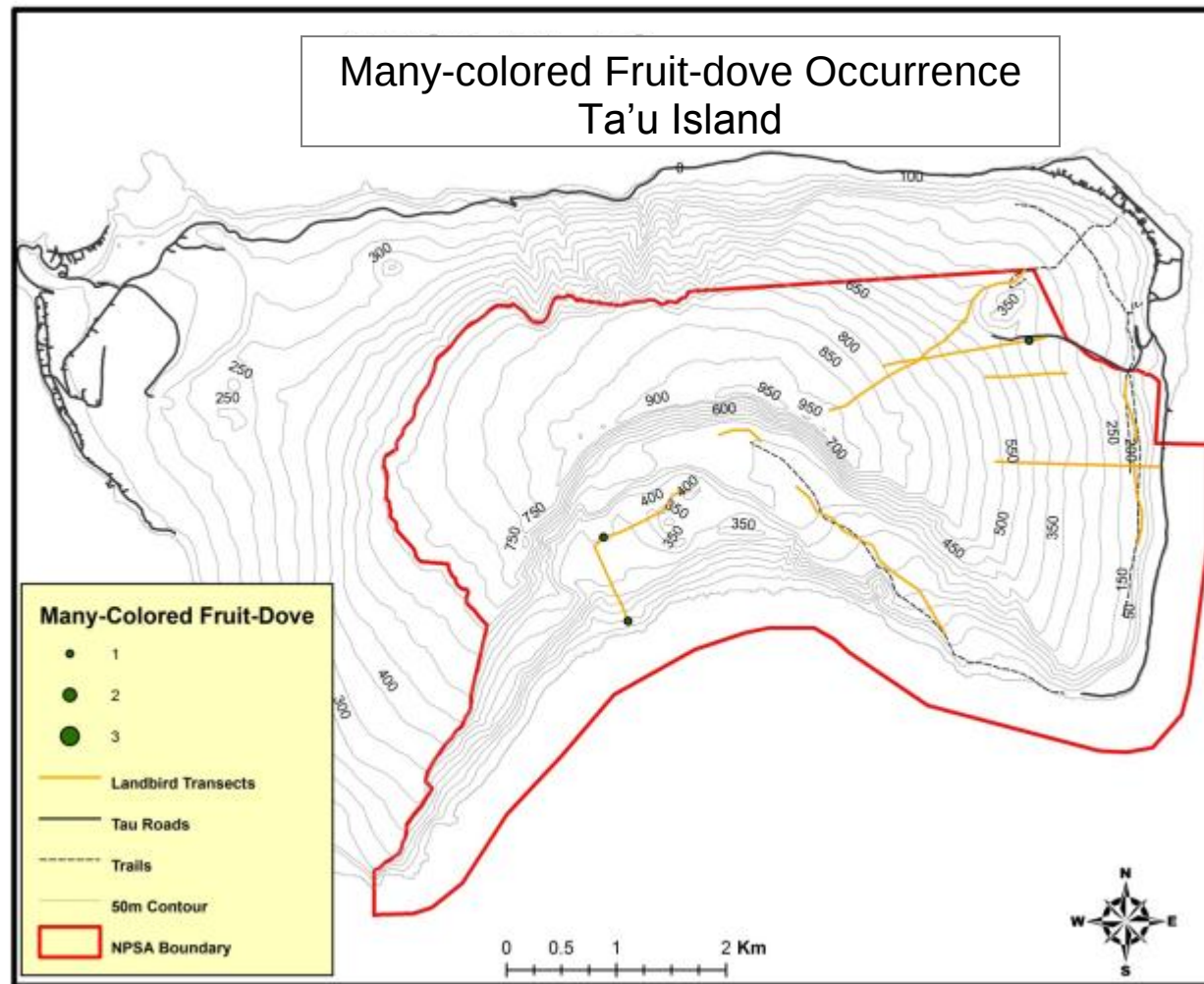
Appendix C—Figure 10 Collared Kingfisher occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



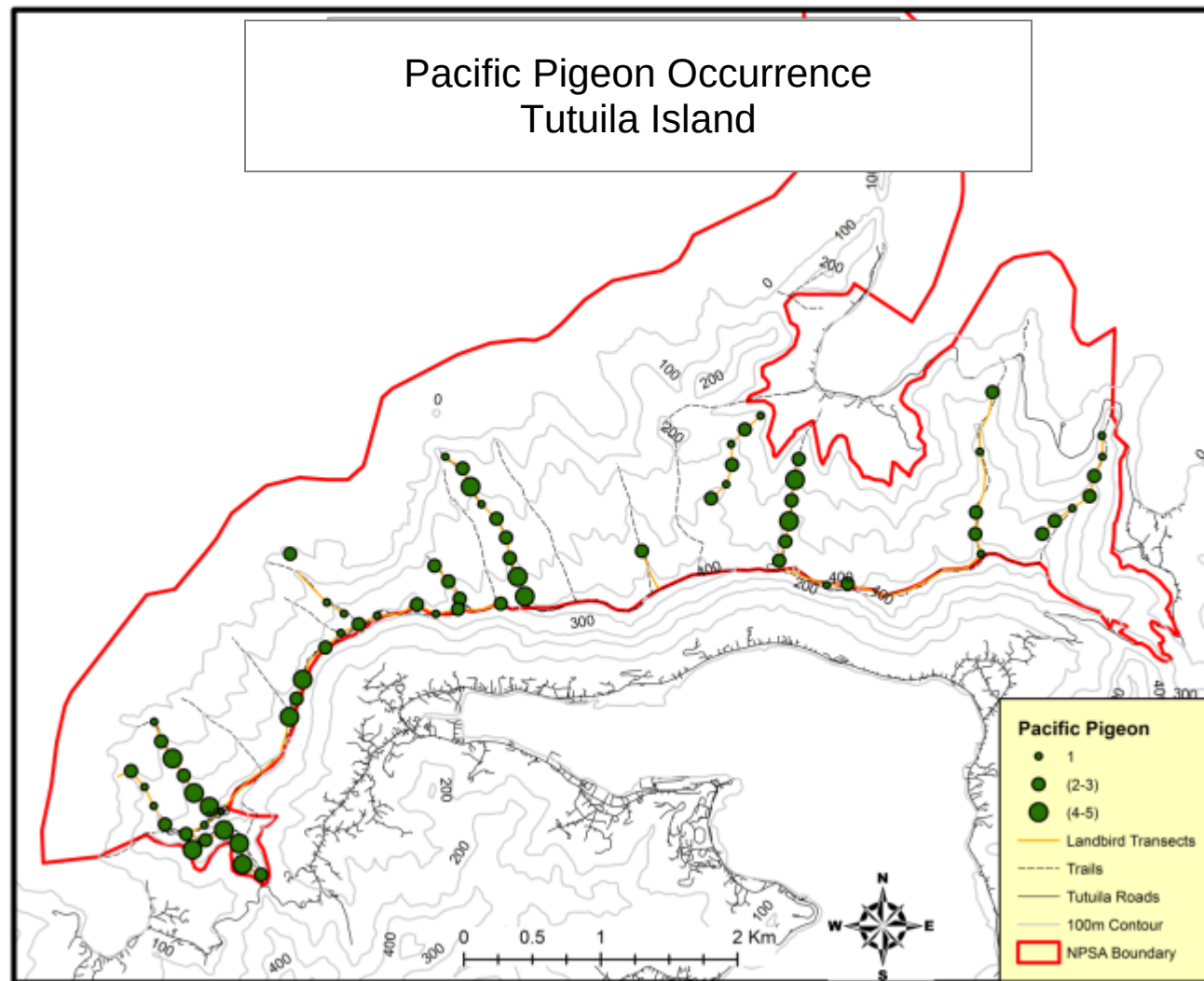
Appendix C—Figure 11. Fiji Shrikebill occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



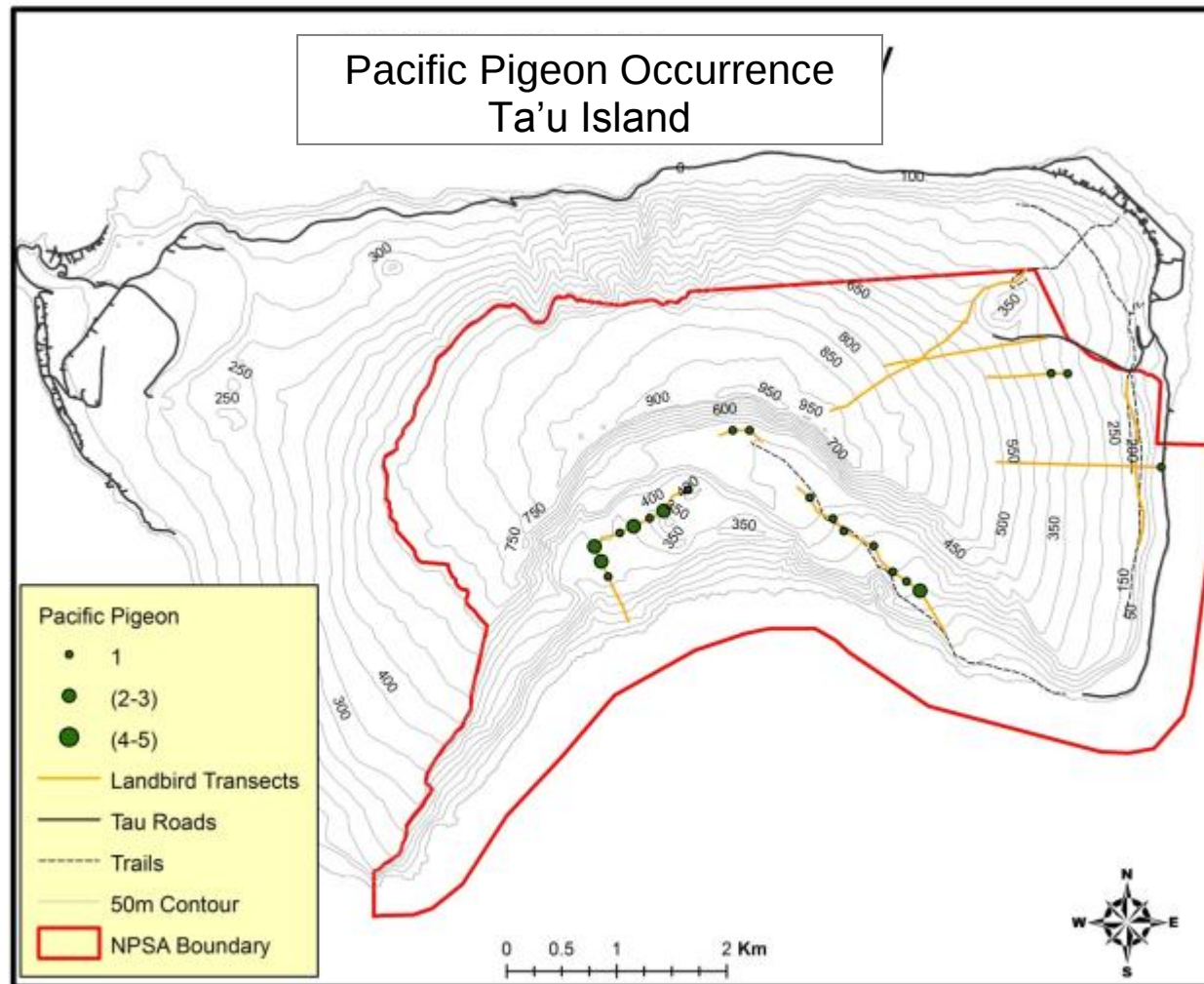
Appendix C—Figure 52. Many-colored Fruit-dove occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



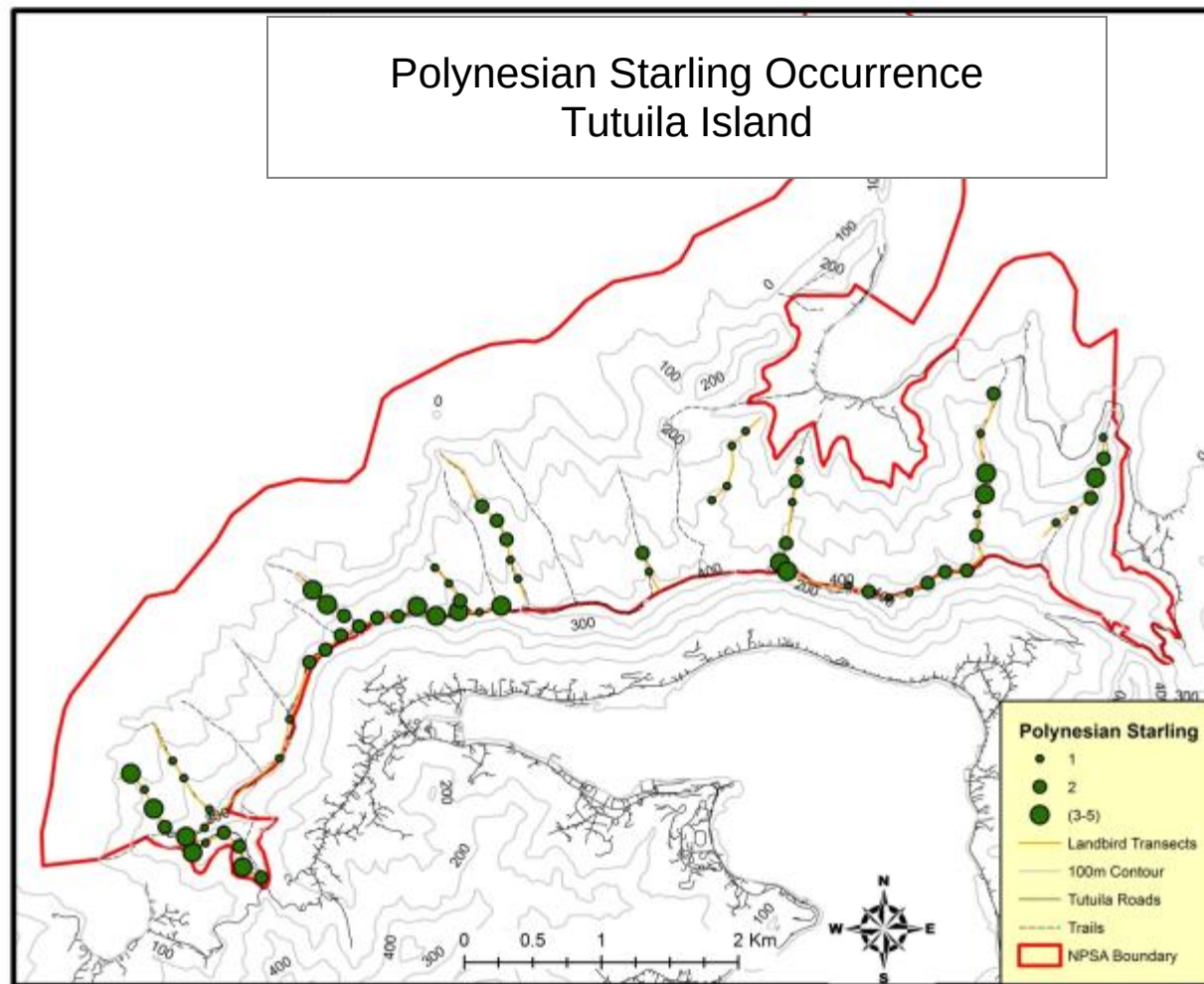
Appendix C—Figure 13 Many-colored Fruit-dove occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



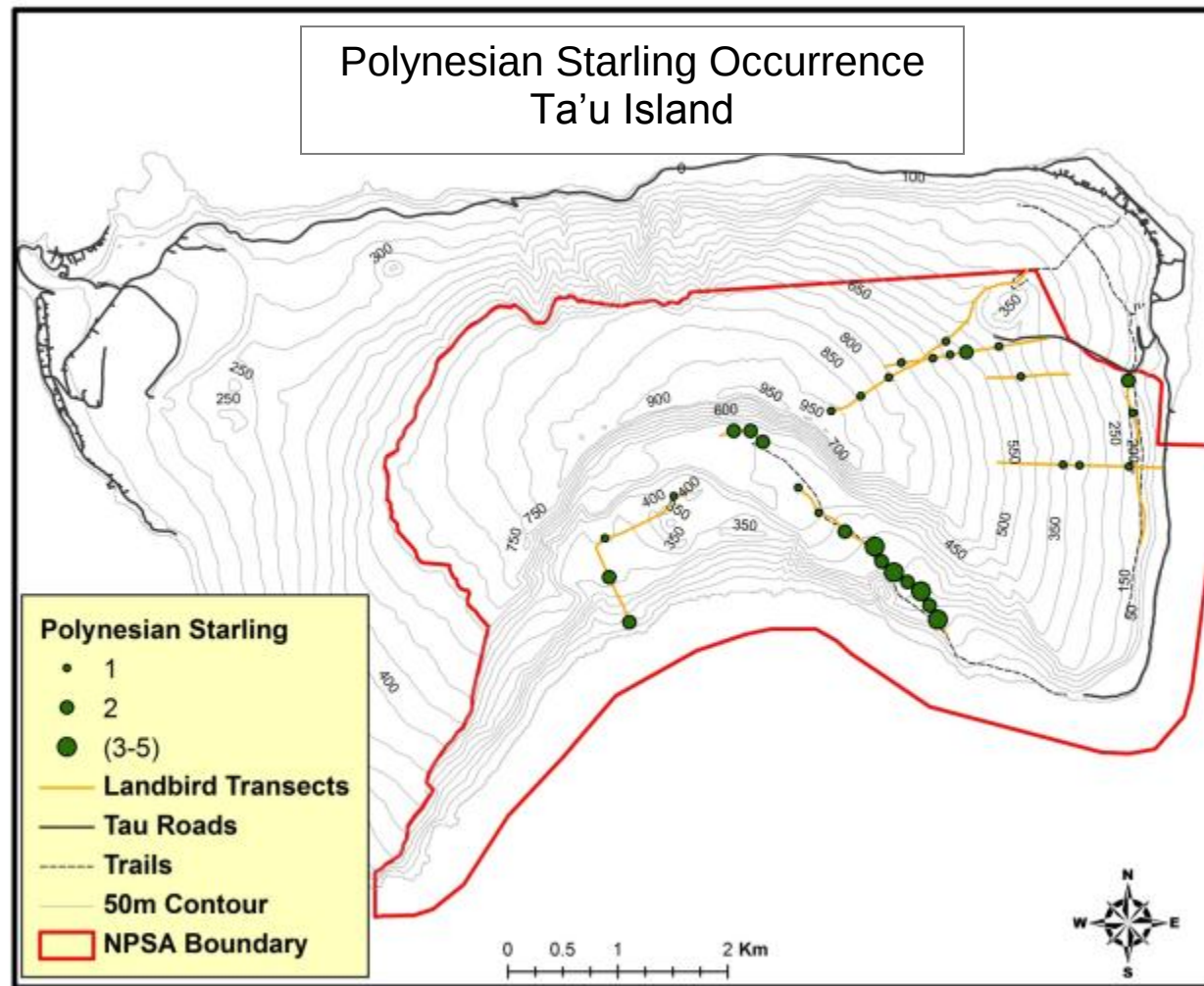
Appendix C—Figure 14. Pacific Pigeon occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



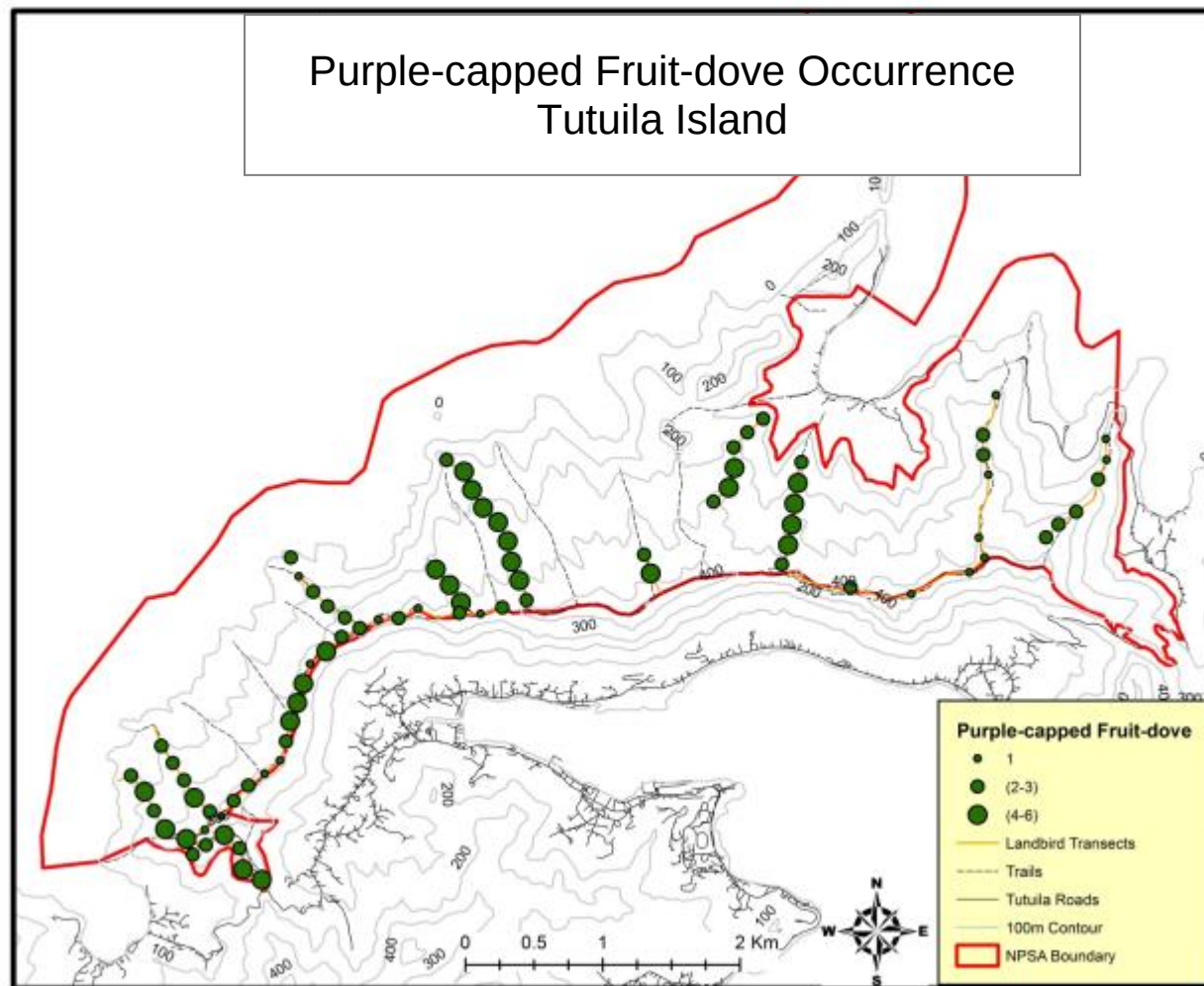
Appendix C—Figure 15. Pacific Pigeon occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graded symbols display the abundance of individuals detected at each station.



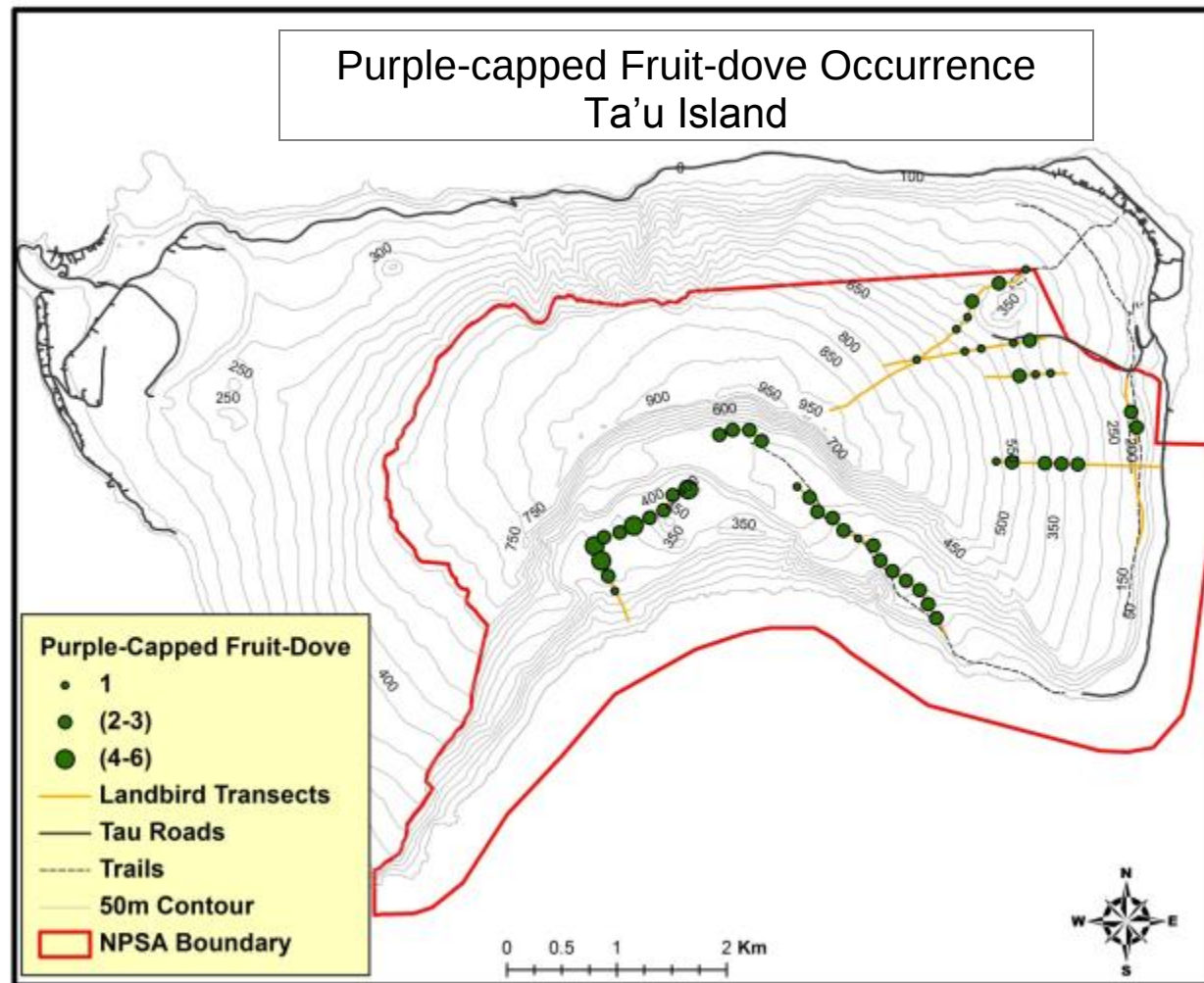
Appendix C—Figure 16. Polynesian Starling occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



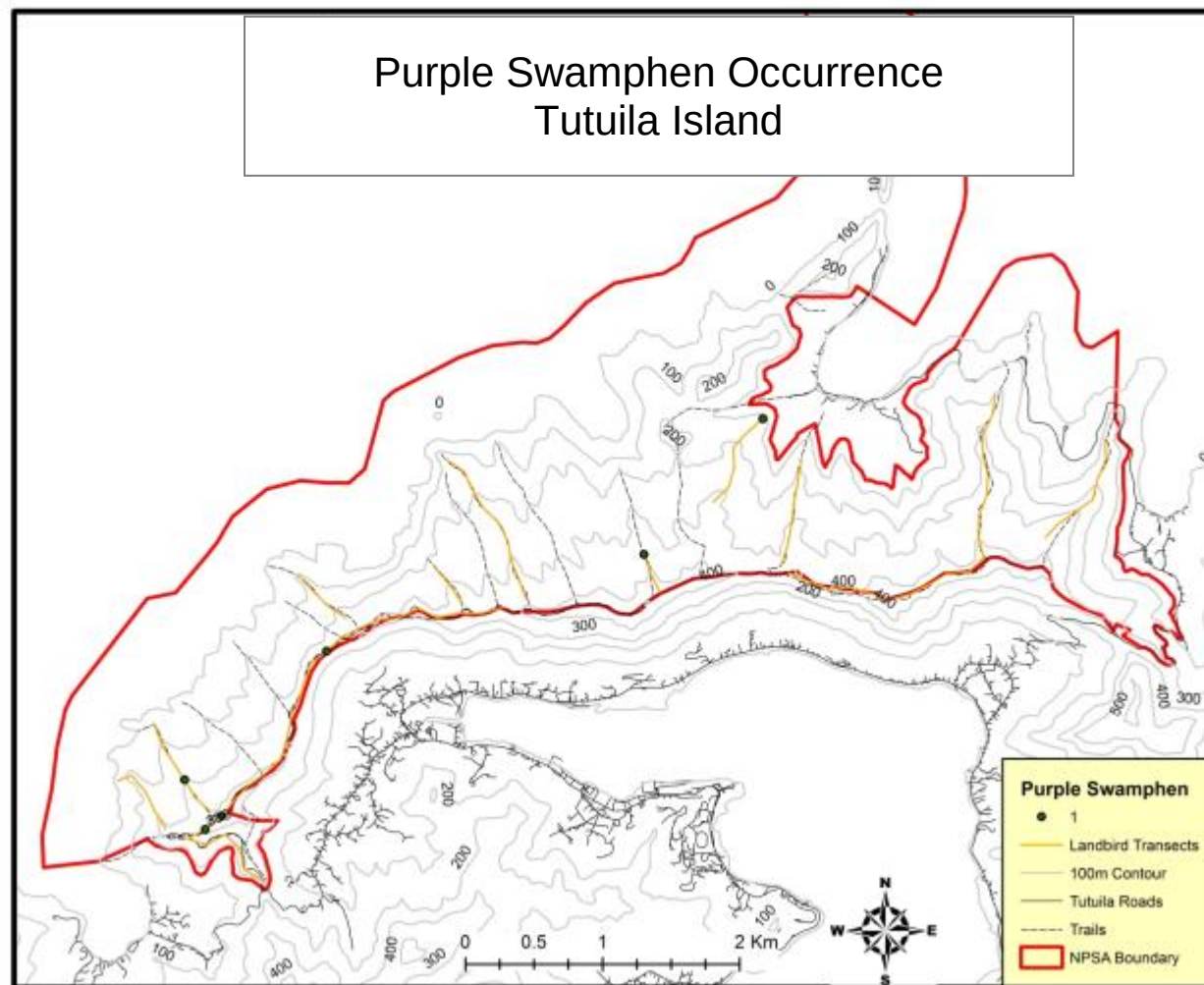
Appendix C—Figure 17. Polynesian Starling occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



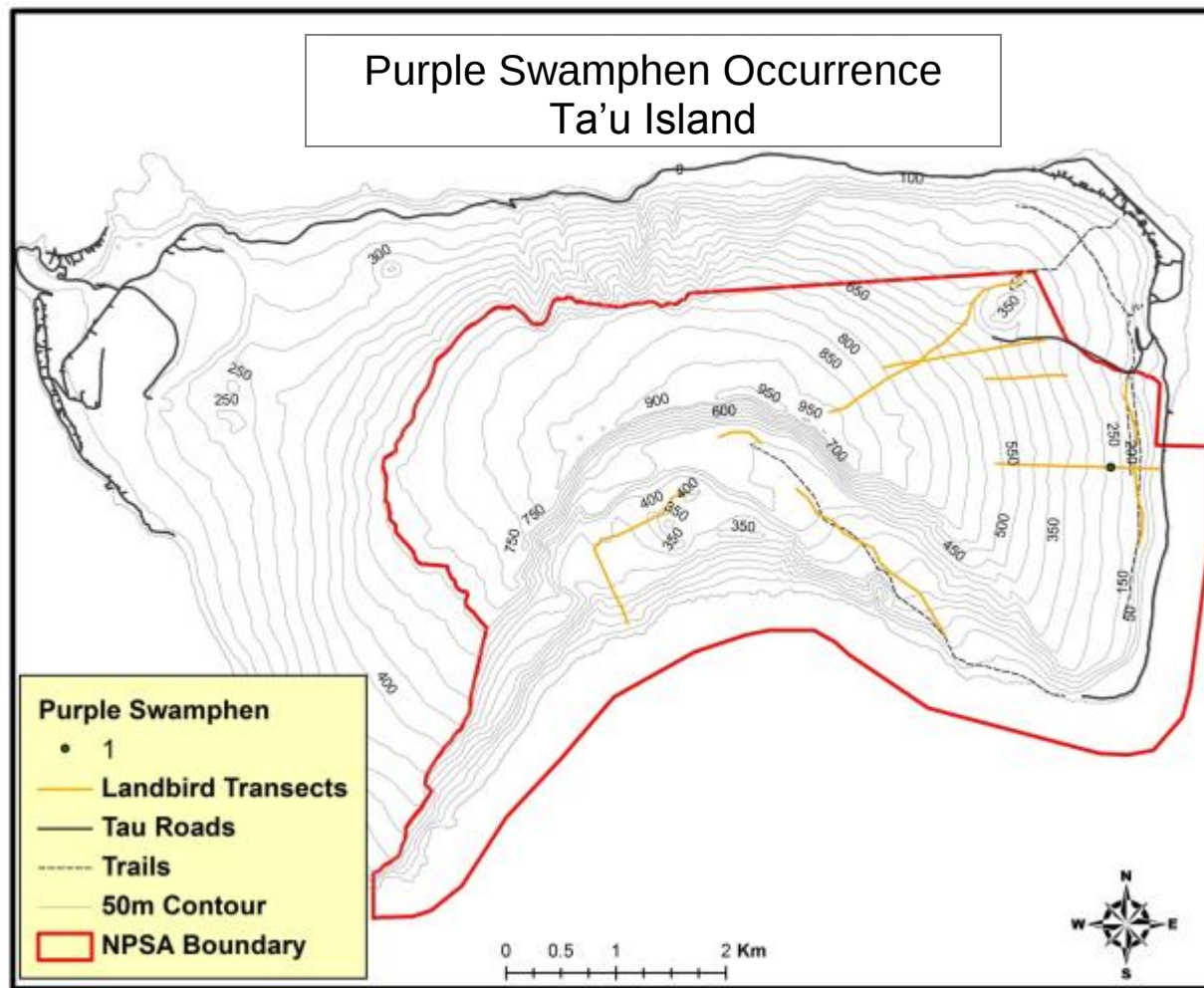
Appendix C—Figure 18. Purple-capped Fruit-dove occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



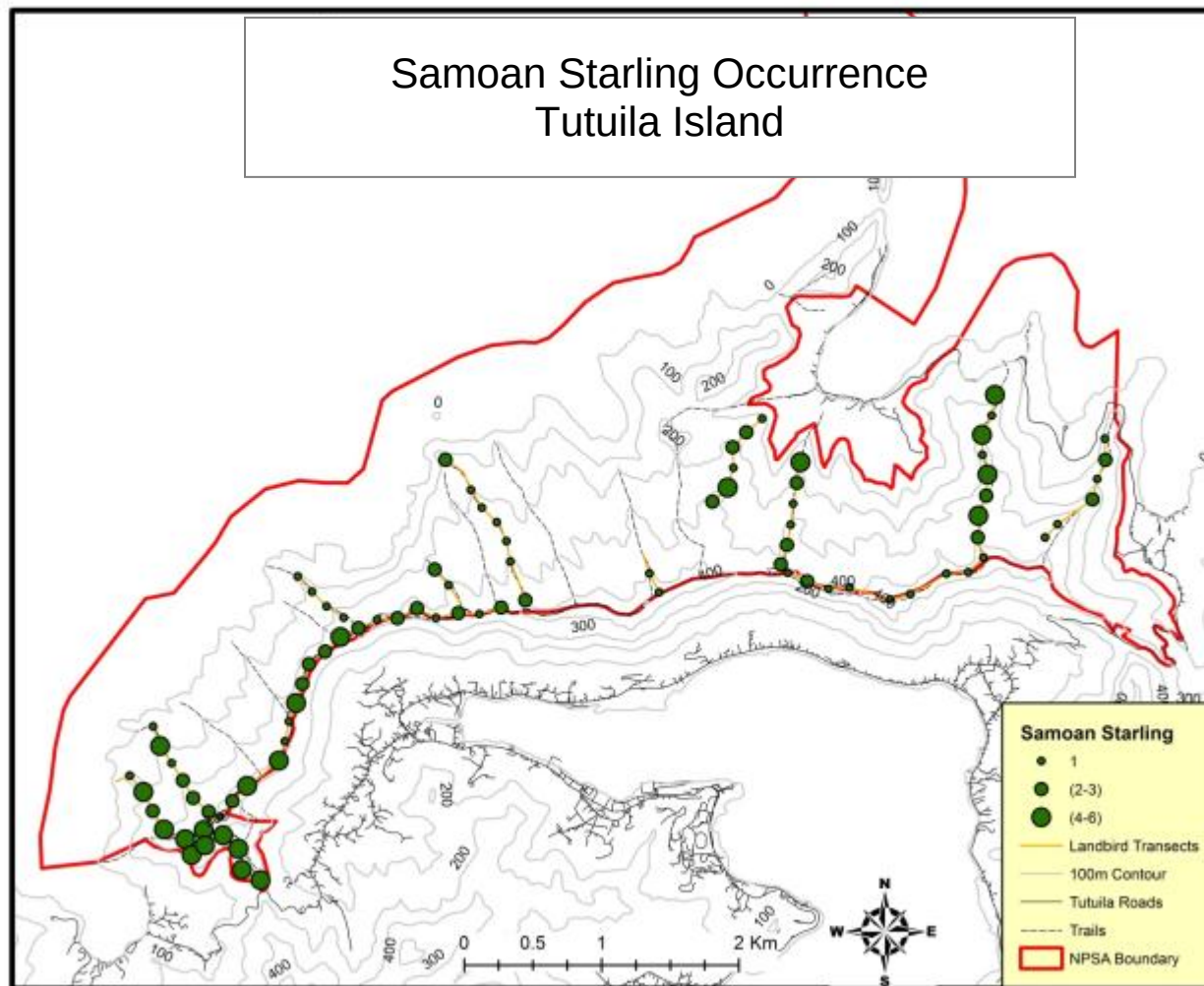
Appendix C—Figure 19. Purple-capped Fruit-dove occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



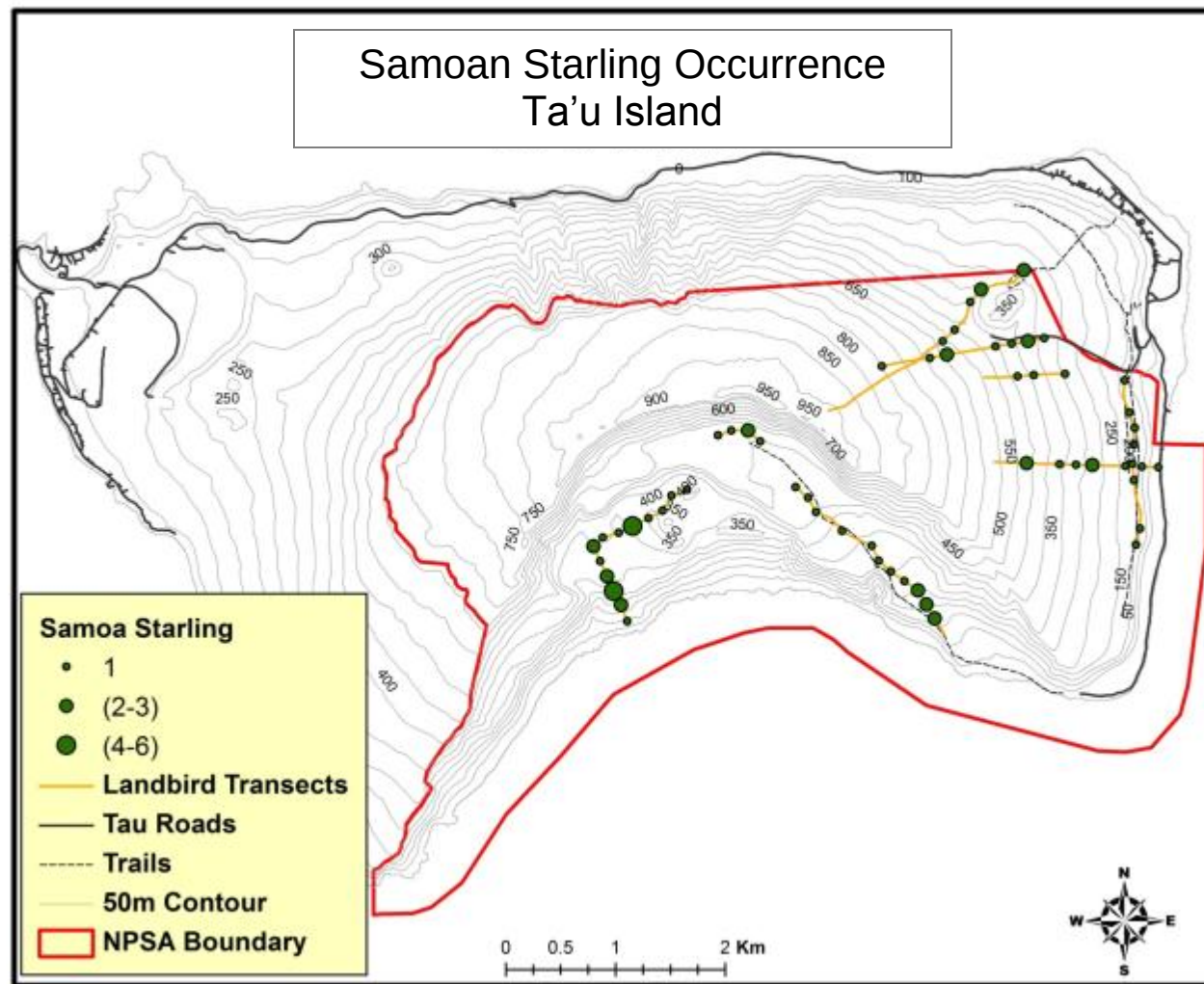
Appendix C—Figure 20. Purple Swamphen occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



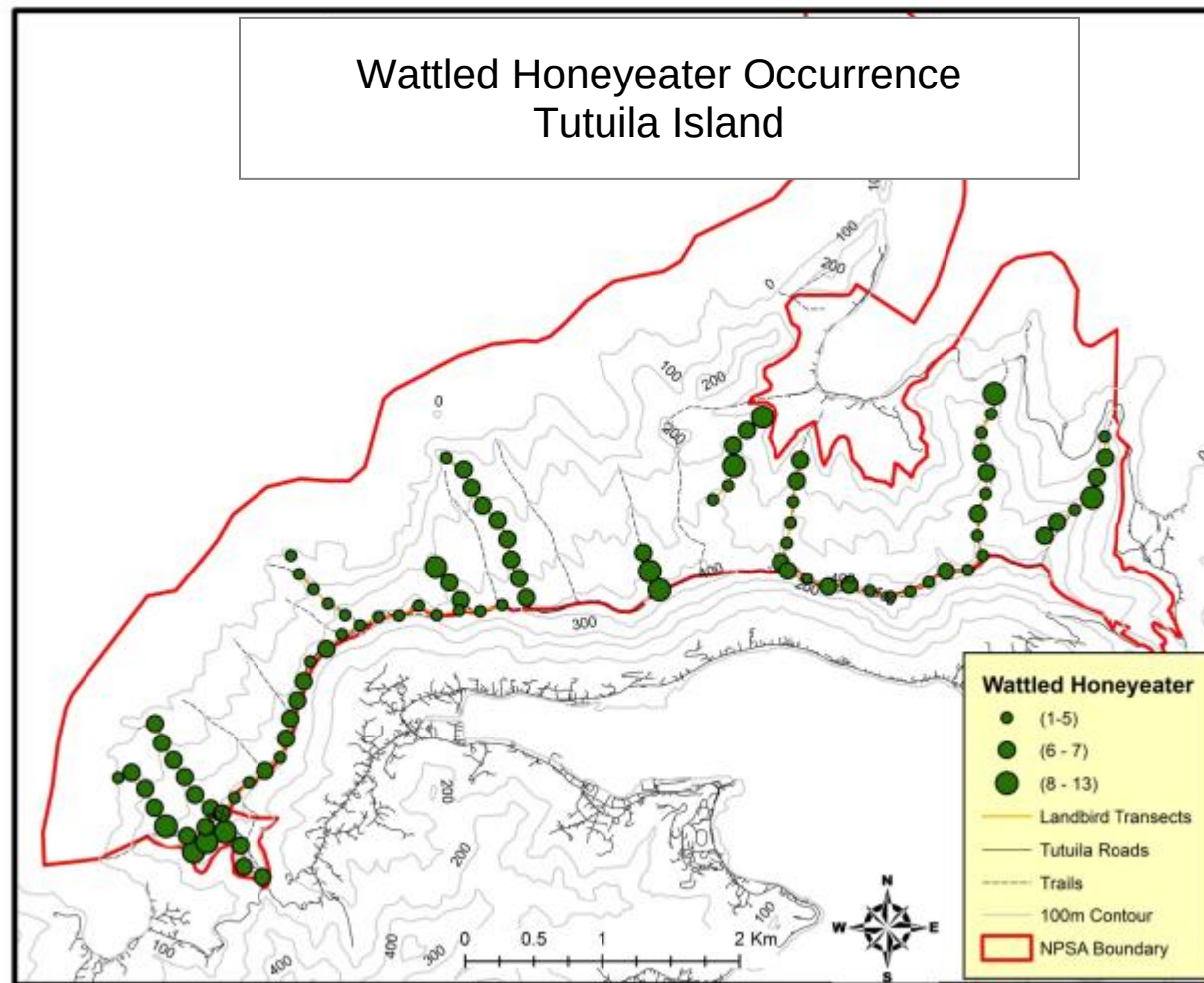
Appendix C—Figure 21. Purple Swamphen occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



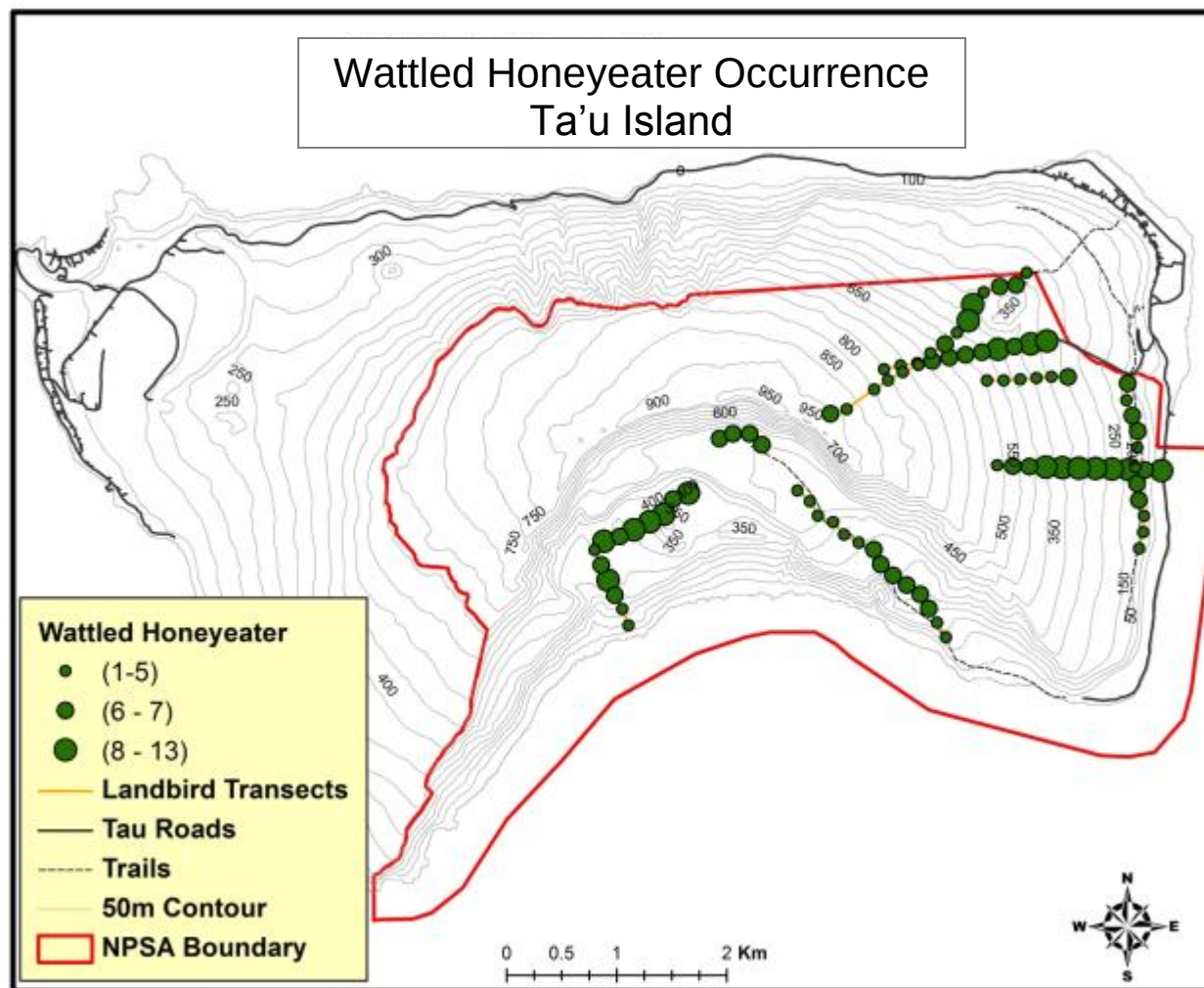
Appendix C—Figure 22. Samoan Starling occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



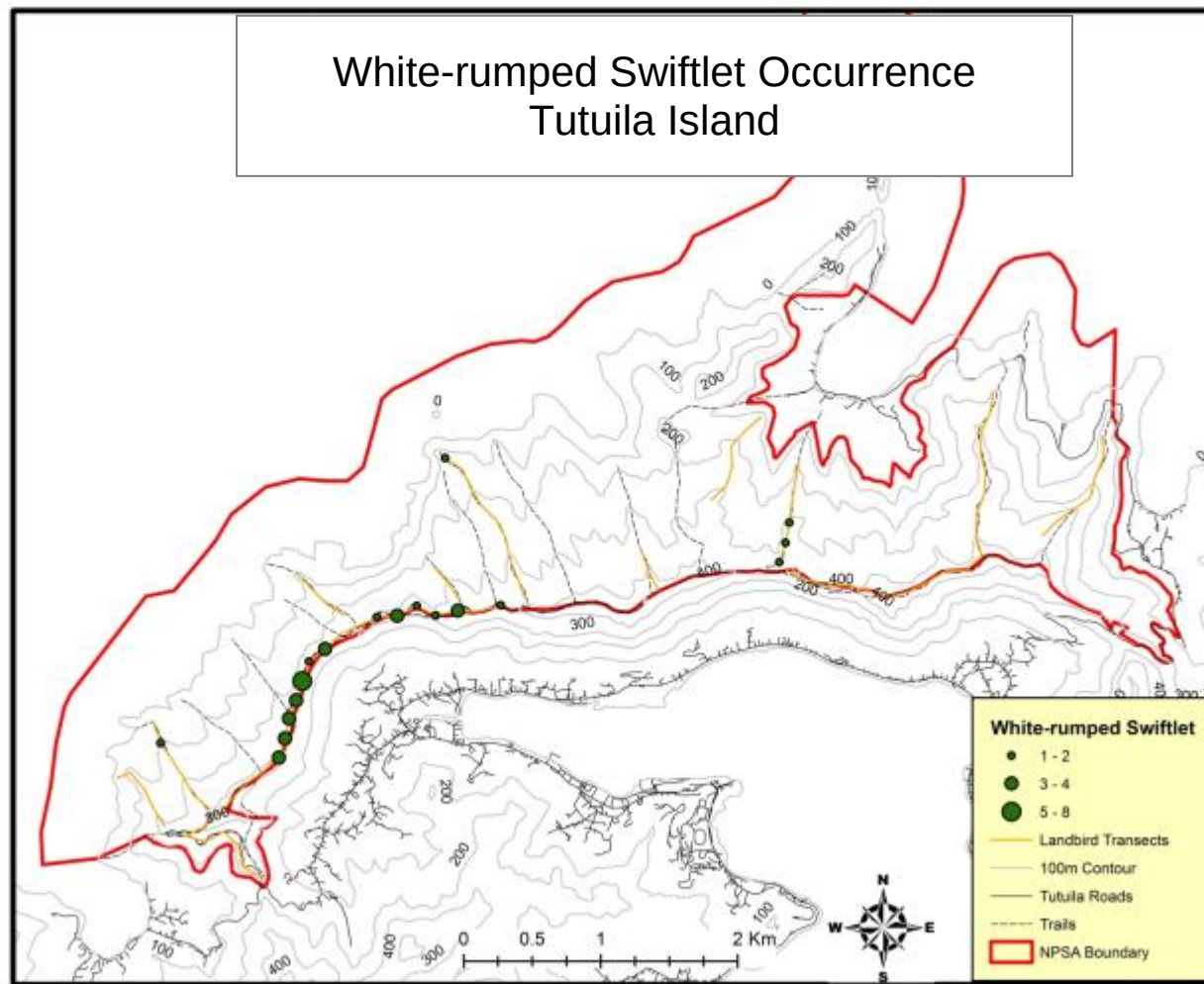
Appendix C—Figure 23. Samoa Starling occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



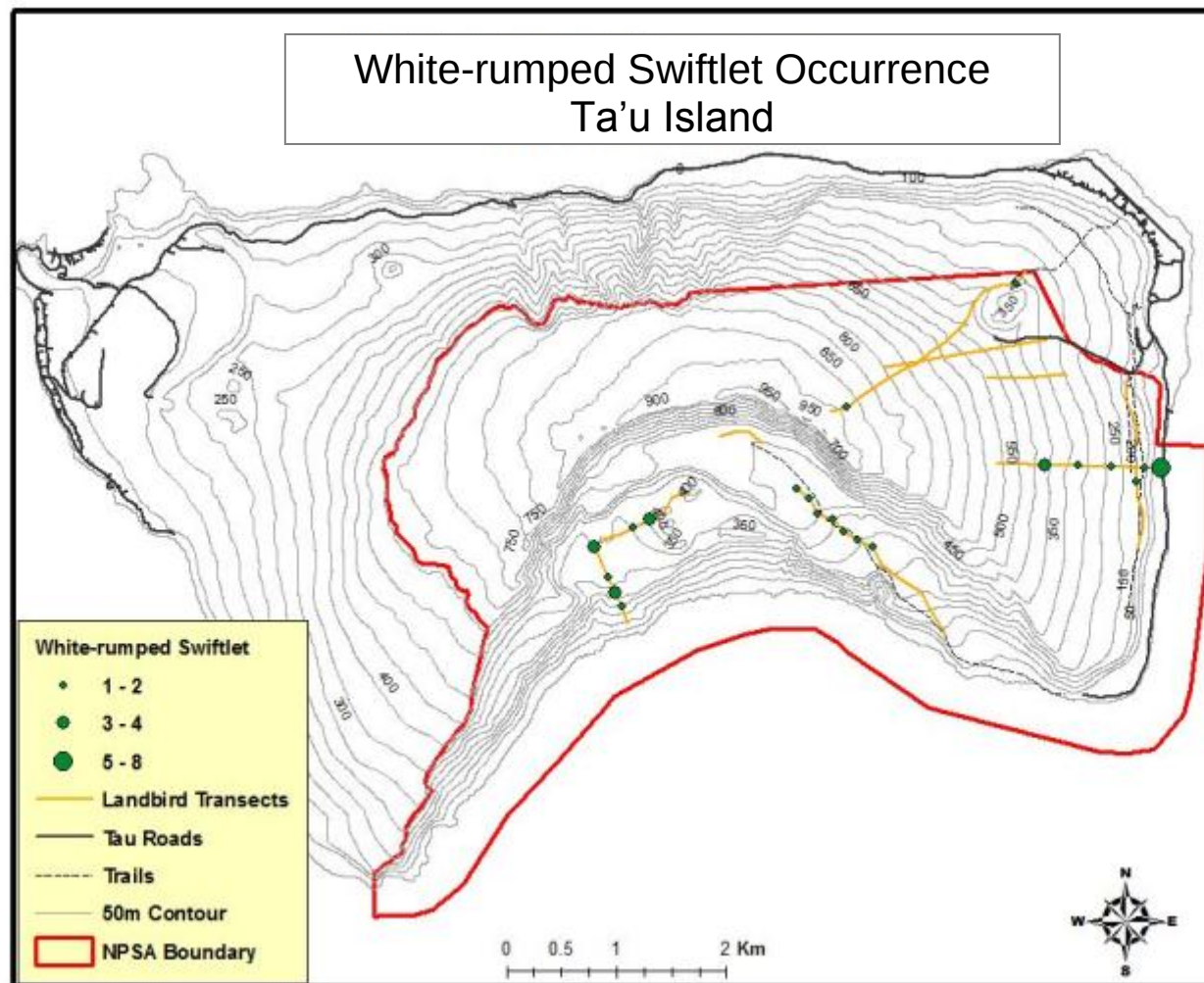
Appendix C—Figure 24. Wattled Honeyeater occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



Appendix C—Figure 25. Wattled Honeyeater occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



Appendix C—Figure 26. White-rumped Swiftlet occurrence in the Tutuila unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.



Appendix C—Figure 27. White-rumped Swiftlet occurrence in the Ta'u unit during the 2011 NPSA landbird survey. Graduated symbols display the abundance of individuals detected at each station.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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