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Status of Landbirds in the National Park of American Samoa[1]

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Abstract: The National Park of American Samoa (NPSA) was surveyed in 2011 and 2018 using point-transect distance sampling to estimate trends in landbird distribution, composition, population density, and abundance. Surveys were conducted within the Ta'ū Unit and Tutuila Unit, each on separate islands of American Samoa. We detected a total of 14 species during surveys and there were sufficient detections of seven species to allow for density estimation and abundance within each unit. We assessed differences in density between surveys with a two-sample *z*-test and found significant declines of Blue-crowned Lorikeets (*Vini australis*) in the Ta'ū Unit, and of Samoan Starlings (*Aplonis atrifusca*) in the Tutuila Unit. Density estimates of the Crimson-crowned Fruit Dove (*Ptilinopus porphyraceus*), Pacific Kingfisher (*Todiramphus sacer*), Polynesian Wattled Honeyeater (*Foulehaio carunculatus*), and Samoan Starling (in the Ta'ū Unit) were also lower in 2018 than 2011, but differences were inconclusive because of relatively large variance estimates. Densities of the Polynesian Starling (*Aplonis tabuensis*) and Pacific Imperial Pigeon (*Ducula pacifica*) in the Ta'ū Unit were higher in 2018 than 2011, but differences were similarly inconclusive. Lower 2018 densities could be due to Tropical Cyclone Gita that struck the islands just four months before the surveys. We provide indices of relative occurrence and abundance for the remaining seven species detected, which include the Many-colored Fruit Dove (*Ptilinopus perousii*) and the rarely detected Spotless Crake (*Zapornia tabuensis*)—both of which are species of concern in American Samoa.

Keywords: landbird trends, population estimates, American Samoa, distance sampling, conservation

The National Park of American Samoa (NPSA) encompasses the only paleotropical rainforest in the U.S. National Park system. The park is distributed across portions of three islands: Tutuila, Ofu, and Ta'ū, each having among the best representations of tropical rainforest in the South Pacific (Webb et al. 1999). The avifauna of American Samoa is primarily indigenous, with seabirds and shorebirds comprising approximately 65% of the 65 documented species (Watling 2001, O'Connor and Rauzon 2004). Twenty-one species of landbirds regularly occur and breed in American Samoa, of which five were introduced by humans (Watling 2001). None of the American Samoa landbirds were considered endemic until findings from a recent taxonomic re-evaluation suggested otherwise (Pratt 2010, Pratt and Mittermeier 2016). We use the International Ornithological Committee (IOC) World Bird List as the taxonomic authority for bird names (Gill et al. 2021). Pratt and Mittermeier (2016) identified differences in vocalizations and morphology of the Samoan Myzomela (*Myzomela cardinalis*

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nigriventris) and recommended a full split from *M. rubrata*, its conspecific in Micronesia. The IOC has not adopted the split yet, but it has been recognized as *M. nigriventris* by other taxonomic authorities (Higgins et al. 2020*a*). The IOC recognizes 12 subspecies of Fiji Shrikebill (*Clytorhynchus vitiensis*) in Melanesia and Western Polynesia, including the Manuʻa Shrikebill (*Clytorhynchus vitiensis powelli*), which only occurs in American Samoa's Manuʻa Island group of Ofu, Olosega, and Taʻū (Gill et al. 2021). Taxonomists proposed the Manuʻa Shrikebill be considered a full species (*C. powelli*) because of geographic isolation and morphological differences (Pratt 2010, Pratt and Mittermeier 2016), but this suggestion has not been adopted by the IOC yet. Pratt and Mittermeier (2016) also suggested taxonomic revisions among several other species of birds, including the American Samoa populations of Polynesian Starling (*Aplonis tabuensis*), Pacific Kingfisher (*Todiramphus sacer*), and four other taxa in the Independent State of Samoa.

Historical population declines, scarcity, and extirpation of American Samoan avifauna have been documented. In 2016, the U.S. Fish and Wildlife Service (USFWS) listed the American Samoa population of the Tongan (also known as Shy or Friendly) Ground Dove (*Pampusana stairi*) and the Mao (*Gymnomyza samoensis*) as federally endangered (USFWS 2016*a*). The Tongan Ground Dove has a narrow distribution in American Samoa, only occurring on portions of Ofu and Olosega. The Mao is considered extirpated in American Samoa—this honeyeater, endemic to the Samoan archipelago, was last seen on Tutuila in 1977 (Pratt et al. 1987, Engbring and Ramsey 1989). However, because of scant records of sightings, it is uncertain if a thriving Mao population ever persisted in American Samoa (Higgins et al. 2020*b*). Their small and fragmented population in Independent Samoa was estimated as fewer than 1,000 birds in 2016 (BirdLife International 2020). The Spotless Crake (*Zapornia tabuensis*) was a candidate for listing as threatened or endangered under the U.S. Endangered Species Act in 1994, but listing the species was deemed "not warranted," and it was removed as a candidate in 2016 (USFWS 2016*b*). The species has a broad distribution in the South Pacific (BirdLife International 2021), but in American Samoa occurs only on Taʻū Island (Rauzon and Fialua 2003, Adler et al. 2010). Primary factors for scarcity and decline of those species include anthropogenic deforestation and habitat destruction (USFWS 2016*a*). Subsistence and commercial agriculture, especially at lower elevations, has greatly reduced suitable habitat for Samoan landbirds (Whistler 1994, Mueller-Dombois and Fosberg 1998, USFWS 2016*a*). However, agriculture and development are infeasible in much of American Samoa because of the steep terrain, thus habitat degradation alone cannot explain the rarity of some species. Predation by introduced mammals such as rats (*Rattus* spp.) and feral cats (*Felis catus*) has also had profound negative effects on many species of island birds (Atkinson 1977, Butler and Stirnemann 2013, O'Donnell et al. 2017, Banko et al. 2019).

Localized pressures on landbird communities can be exacerbated by landscape level disturbance. The Samoan Archipelago is susceptible to devastating episodic tropical cyclones; at least two per decade have occurred over the last 40 years (Ulafala 1990, Craig 2009, Kuleshov et al. 2014). The storms affect birds directly through nest destruction and egg and nestling mortality (Plentovich et al. 2005). Indirect effects include damage to food supplies (Lynch 1991) and increased competition for resources (Hulme 2005). On Tutuila, the Pacific Imperial Pigeon (*Ducula pacifica*) and Many-colored Fruit Dove (*Ptilinopus perousii*) were nearly extirpated after Tropical Cyclones Ofa (1990) and Val (1991) severely damaged forests. Both species were popular game birds and were extremely vulnerable to hunting pressures after forests were denuded of vegetation (Craig et al. 1994). A strict hunting ban was immediately enacted and may have saved the birds from extirpation (Craig et al. 1994). In 2005, Tropical Cyclone Olaf struck the Manuʻa Island Group and destroyed lowland habitat vital to the Tongan Ground Dove, which reduced the already small population, further illustrating that natural disturbance can exacerbate the adverse effects of anthropogenic disturbance (USFWS 2016*a*). The Many-colored Fruit Dove is strongly associated with *Ficus* spp. (Engbring and Ramsey 1989) and may be particularly vulnerable to cyclones if trees are denuded of fruits and vegetation. In February of 2018, Tropical Cyclone Gita devastated parts of Tonga and the Samoan Archipelago, bringing strong winds and heavy rain (Radio New Zealand 2018*a*, *b*), and occurred a mere four months before our 2018 survey.

Repeated surveys may identify temporal changes in populations (Skalski 1990) allowing National Park Service (NPS) managers to monitor population changes, as well as document response to management (Camp et al. 2011). Landbird inventories by Amerson et al. (1982a, b), Engbring and Ramsey (1989), and the American Samoa Department of Marine and Wildlife Resources (DMWR 1994, 1996) provided detailed information describing Samoa's forest bird composition, distribution, and abundance. Surveys by Engbring and Ramsey (1989) in 1986 established baseline population data in American Samoa, which included NPSA, and their work along with the Hawai'i Forest Bird Survey by Scott et al. (1986) helped establish protocols for long-term monitoring (Camp et al. 2011). NPS created the Inventory and Monitoring (I&M) Program following the National Park Omnibus Management Act of 1998. The role of the NPS Pacific Island Inventory and Monitoring Network (PACN) is to collect, organize, and make available natural resource data and contribute to institutional knowledge through analysis, synthesis, and modeling (Fancy et al. 2009).

In 2011 and 2018, PACN conducted point-transect distance sampling to estimate trends in landbird composition, distribution, density, and abundance in the Taʻū and Tutuila Units of NPSA. We provide indices of relative occurrence and abundance for every landbird species detected. For species with sufficient detections (>75–100 detections; Buckland et al. 2015), we provide density estimates (birds/ha) and abundance within each unit. To assess trends, we used a two-sample *z*-test to check for differences in density between the 2011 and 2018 surveys. This information can help to inform and implement management actions for the conservation of these species.

MATERIALS AND METHODS

PACN surveys for landbirds in three national parks (NPSA, Hawaiʻi Volcanoes National Park, and Haleakalā National Park) on a rotating basis. Each park and units therein are surveyed once every five years to determine status and trends of landbird populations following a standardized sampling and monitoring protocol (Protocol; Camp et al. 2011). NPSA is composed of three units on three islands in American Samoa: Tutuila and the islands Ofu and Taʻū (115 km east of Tutuila; Figure 1). The Protocol was first implemented in 2011 at NPSA and surveys were repeated in 2018 in both the Taʻū and Tutuila Units. Surveys are not conducted on the small and primarily coastal Ofu Unit.

Unit Descriptions

The flora of the Samoan Archipelago is diverse, consisting of approximately 225 ferns and 550 flowering plants, of which 250 are tree species (Whistler 2004). Approximately 92% of NPSA is forested: 49% is lowland forest, 45% is montane rain forest, and 6% is coastal forest (Green et al. 2015). Flowering and fruiting stands of *Syzygium inophylloides*, *Diospyros samoensis*, *Myristica inutilis*, and *Dysoxylum maota* offer foraging opportunities for landbirds (Amerson et al. 1982*a*, Whistler 1992, 1995, Trail 1994). Descriptions of invasive plants specific to NPSA are provided in Monello (2004). We use a comprehensive vegetation inventory of NPSA produced and maintained by Green et al. (2015) to describe survey areas according to 23 vegetated map classes and three unvegetated map classes.

Taʻū Unit

Taʻū Island is an approximately 300K year-old shield volcano and is the youngest high island in the Samoan Archipelago (Nunn 1998). Warm and humid, temperatures average

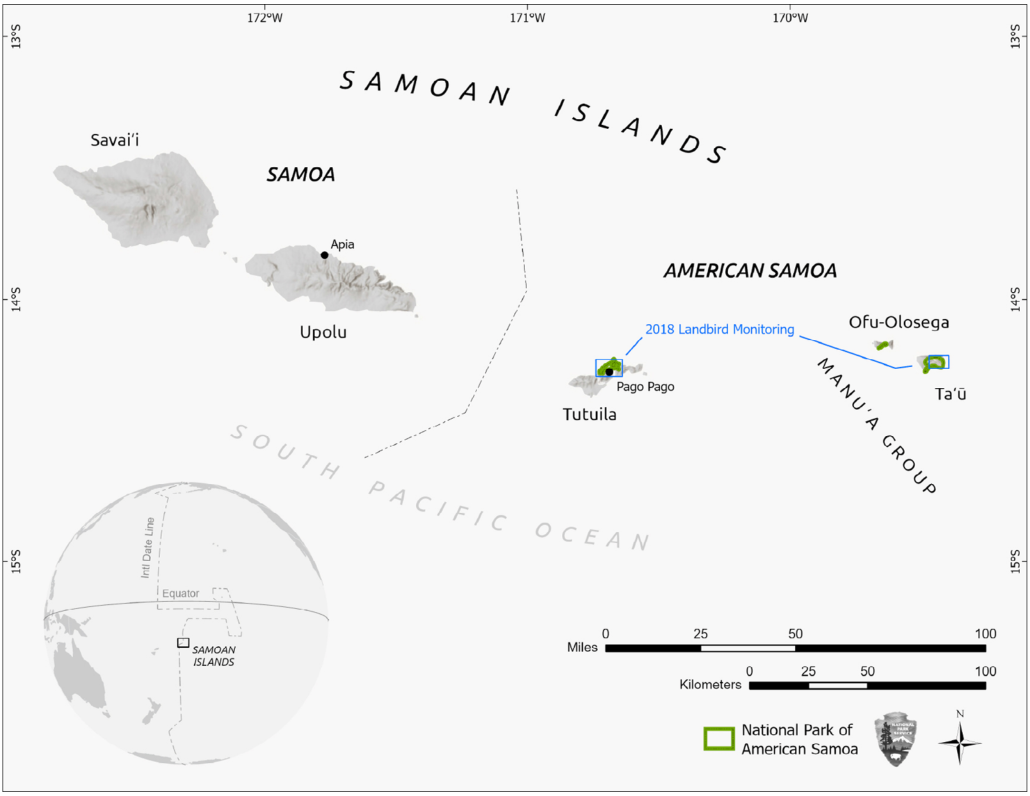

FIGURE 1. The Samoan Archipelago and the National Park of American Samoa. Base map from World Geodetic System 1984.

27 °C and rainfall averages 2,400 mm/year (Whistler 2002). The Ta'ū Unit (2,229 ha) is more than half the entire island (Figure 2). The village of Ta'ū occupies the northwest portion of the island. Most of the field effort was based out of the village of Fitiuta, which is closer to the NPSA boundary. The Ta'ū 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 to the dramatic Liu Bench area.

The vegetation community is dominated by 1,077 ha of *Syzygium samoense–Weinmannia affinis* Forest, with a canopy of low stature native trees, high epiphytic species cover, and an abundant herbaceous cover (Figure 2; Green et al. 2015). The next largest vegetation community is 310 ha of *Dysoxylum* spp.–*Rhus–Alphitonia* Forest, with low shrub species cover and a diverse herbaceous layer with well-established vines. Lowland areas of southern Ta'ū Island, in the Liu Bench area, are dominated by *Dysoxylum samoense* and *Dysoxylum maota* Forest, with low shrub cover and a diverse herbaceous layer. Remaining vegetation communities include smaller portions (<150 ha) of steep cliff scrub communities.

Tutuila Unit

Tutuila Island is the largest (145 km^2) and most populated island in American Samoa. The island is dominated by 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 (Figure 3). Densely forested ridges stretch towards the ocean from the summit of

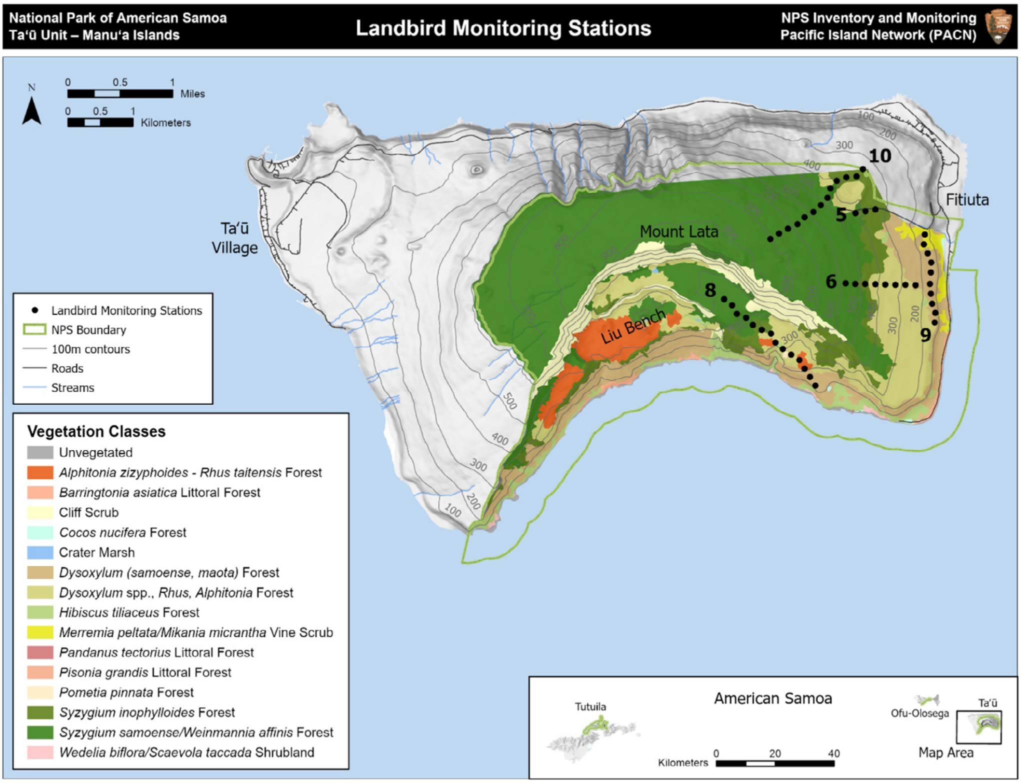

FIGURE 2. Ta'ūUnit landbird monitoring transects and stations surveyed in 2018. Transects are labeled numerically in black.

Mt. Alava (491 m). The villages of Vatia, Afono, and Fagasa border the eastern and western boundaries of the unit, separated by a steep and rocky coastline. Mean monthly temperatures are warm, ranging from 20 °C to 37 °C, and monthly rainfall is highly variable, ranging between 60 mm to 1,700 mm (Western Regional Climate Center 2020).

The Tutuila Unit is predominately a diverse combination of *Dysoyxylum* spp., *Rhus taitensis*, *Alphitonia zizyphoides* Forest, which comprises 680 ha of the unit (Figure 3; Green et al. 2015). More than 40 tree species are common, vines are abundant, and epiphytes are often present. The herbaceous cover is typically composed of tree seedlings and ferns. The *Syzygium inophylloides–Calophylum* spp. Forest community is less predominant, comprising 177 ha of the higher reaches of the unit (49–386 m elevation), often on ridgetops, where understory shrubs are dominated by *Mapania macrocephala* and the invasive *Clidemia hirta*. Vine cover can be high when the herbaceous cover is low. Several other smaller communities are interspersed in the unit, many of which do not overlap with landbird monitoring stations.

Landbird Sampling

We sampled for birds in the forested portions of the Ta'ū and Tutuila Units. In 2011, from June 17 to June 30, we sampled landbirds at 99 stations on 11 transects in the Tutuila Unit. In the Ta'u Unit, we sampled 86 stations on nine transects from July 26 to August 8, 2011. In 2018, from June 12 to June 21, we sampled 73 stations on six transects in the Tutuila Unit (Figure 3). In the Ta'u Unit, we sampled 48 stations on five transects from July 10 to July

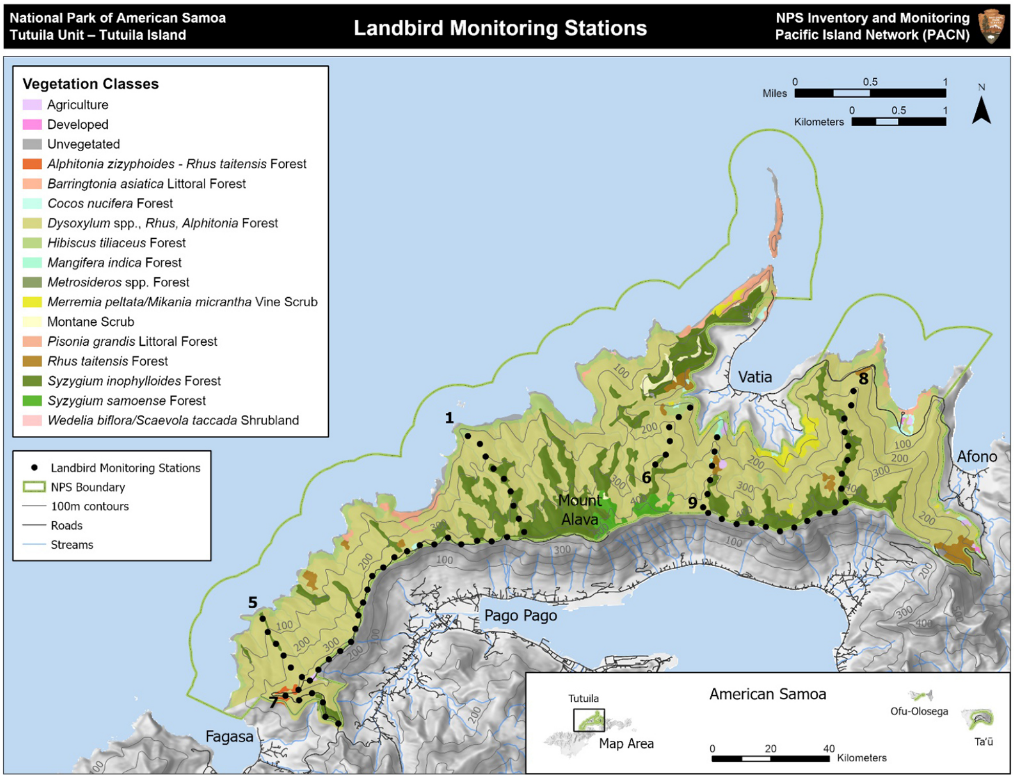

FIGURE 3. Tutuila Unit landbird monitoring transects and stations surveyed in 2018. Transects are labeled numerically in black.

23, 2018 (Figure 2). 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 (Camp et al. 2011). In 2011, transects in the random panel were moved to ridges. The random transect panel was not sampled in 2018 where many areas of the park were deemed too steep to sample and randomly generated transects often traversed canyons too dangerous for foot travel.

Counts began soon after dawn and were concluded by 1100 hours or earlier. Stations, spaced 150 m apart, were surveyed using point-transect distance sampling methods lasting 8 min. 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 important 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 estimator precision. Details of landbird sampling can be found in Camp et al. (2011), and the Pacific Island Network Landbird Monitoring Dataset (2020) is available online (https://irma.nps.gov/DataStore/Reference/Profile/2279288).

Data Analysis

Indices of bird occurrence and abundance were calculated for each species by unit. Percent relative occurrence was calculated as the number of stations occupied by one or more individuals divided by the total number of stations sampled within a unit. 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.

Species-specific density estimates were calculated for seven species—Blue-crowned Lorikeet (*Vini australis*), Pacific Kingfisher, Pacific Imperial Pigeon, Crimson-crowned Fruit Dove (*Ptilinopus porphyraceus*), Polynesian Starling, Samoan Starling (*Aplonis atrifusca*), and Polynesian Wattled Honeyeater (*Foulehaio carunculatus*)—that had sufficient detections to adequately model densities using program DISTANCE, version 7.3, release 1 (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 (Buckland et al. 2015). Covariates included cloud cover, rain, wind, gust, observer, time of detection, canopy cover, canopy height, and unit (Appendix A available here: https://irma.nps.gov/DataStore/Reference/Profile/2288504). All covariates were treated as factors, except time of detection, which was treated as both a factor and a continuous covariate. Assessing time of detection as a continuous covariate allows the detection rate to vary 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) (Appendix A; Buckland et al. 2015). Data were truncated at a distance where the detection probability using a half-normal detection function model was about 0.1 (Appendix A). This procedure facilitates modeling by deleting outliers and reducing the number of parameters needed to modify the detection function (Buckland et al. 2015).

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. For the seven most abundant species, we assessed differences between population densities using end-point comparisons with a two-sample z-test in an equivalency framework following methods detailed in Camp et al. (2008). We compared the 2018 densities in both units to estimates from 2011.

RESULTS

In 2011, a total of 2,516 birds from 13 species were detected in the Ta'ū and Tutuila Units (Table 1). A total of 1,766 birds of 14 landbird species were detected during the 2018 survey (Table 1). All species detected were either indigenous or endemic to the Samoan Archipelago, except for two detections of introduced Red Junglefowl (*Gallus gallus*). We computed indices of bird occurrence (% of survey stations occupied) and relative abundance (# of birds per station) for species detected in both years (Table 1).

Densities and absolute abundances were estimated for seven species in the Ta'ū Unit (Table 2) and six species in the Tutuila Unit (Table 3) for both years. Many statistical comparisons were inconclusive due to relatively small differences and large uncertainties in the density estimates (Table 4). Variances in differences were very large for some species with coefficient of variation (CV) of 100% or more; however, we detected a significant decline at the 5% level of Blue-crowned Lorikeets in the Ta'ū Unit, with a reduction of 2.94 birds/ha in 2018 (Tables 2 and 4). There was a similar decline of Samoan Starlings in the Tutuila Unit, with a reduction of 4.22 birds/ha between survey years (Tables 3 and 4). Although there was a lack of statistical differences between years for most species, it

TABLE 1

Number of Birds Detected, Indices of Bird Occurrence (% Occurrence), and Relative Abundance (BPS) by NPSA Unit in 2011 and 2018

			Taʻū Unit			Tutuila Unit		
Species Name	Year	Total Detections	Birds Detected	% Occurrence	BPS	Birds Detected	% Occurrence	BPS
Blue-Crowned Lorikeet	2011	101	101	47	1.17	0	0	0
	2018	19	19	23	0.4	0	0	0
Buff-banded Rail	2011	13	2	4	0.02	11	11	0.11
	2018	8	3	6	0.06	5	7	0.07
Crimson-crowned Fruit Dove	2011	338	100	56	1.16	238	85	2.4
	2018	174	49	56	1.02	125	85	1.71
Manuʻa Shrikebill	2011	15	15	12	0.17	0	0	0
	2018	10	10	17	0.21	0	0	0
Many-Colored Fruit Dove	2011	16	3	4	0.03	13	11	0.13
	2018	19	3	6	0.06	16	15	0.22
Pacific Imperial Pigeon	2011	197	26	23	0.3	171	75	1.73
	2018	134	28	38	0.58	106	78	1.45
Pacific Kingfisher	2011	73	15	13	0.17	58	42	0.59
	2018	31	6	10	0.13	25	30	0.34
Polynesian Starling	2011	187	51	37	0.59	136	73	1.37
	2018	130	44	52	0.92	86	69	1.18
Polynesian Wattled Honeyeater	2011	1,111	514	99	5.98	597	100	6.02
	2018	756	283	100	5.9	473	100	6.48
Red Junglefowl	2011	0	0	0	0	0	0	0
	2018	2	2	2	0.04	0	0	0
Samoan Myzomela	2011	17	0	0	0	17	10	0.17
	2018	36	0	0	0	36	32	0.49
Samoan Starling	2011	354	117	67	1.36	237	90	2.39
	2018	326	112	88	2.33	214	99	2.93
Spotless Crake	2011	0	0	0	0	0	0	0
	2018	3	3	2	0.06	0	0	0
White-rumped Swiftlet	2011	87	41	24	0.48	46	18	0.46
	2018	118	30	35	0.63	88	45	1.21

is notable that with the exception of the Pacific Imperial Pigeon and Polynesian Starling on Taʻū, every species' estimated density and abundance were lower in 2018 than 2011 (Tables 2 and 3).

Species Summaries

We provide a narrative summary for each species detected during the 2018 survey effort. We describe the 2018 distribution in each unit and provide relative abundance by the percent of stations occupied (% occurrence) and birds per station (BPS). We reference notable differences or consistencies in relative abundance and population densities from the 2011 survey (*see* Judge et al. 2013 for more details).

Blue-crowned Lorikeet

Absent on Tutuila Island, Blue-crowned Lorikeets were common in the Manuʻa Island Group. In the Taʻū Unit, the species occurred at 23% of stations surveyed at 0.4 BPS

TABLE 2

Densities (birds/ha) and Abundances (birds/unit) of Landbirds Within the Ta'ū Unit in 2011 and 2018

Ta'ū Unit: Species	Year	Density (birds/ha ± SE) (95% CI)	Abundance (birds/2,229 ha ± SE) (95% CI)
Blue-crowned Lorikeet	2011	4.15 ± 1.21	9,247 ± 2,703
		1.87–6.72	4,178–14,972
	2018	1.20 ± 0.45	2,686 ± 1,007
		0.33–2.18	733–4,870
Crimson-crowned Fruit Dove	2011	0.59 ± 0.22	1,326 ± 489
		0.26–1.13	590–2,512
	2018	0.37 ± 0.17	815 ± 386
		0.09–0.73	209–1,629
Pacific Imperial Pigeon	2011	0.29 ± 0.14	654 ± 303
		0.06–0.58	127–1,299
	2018	0.55 ± 0.26	1,232 ± 571
		0.12–1.08	275–2,409
Pacific Kingfisher	2011	0.13 ± 0.04	280 ± 87
		0.07–0.22	149–492
	2018	0.09 ± 0.04	200 ± 81
		0.03–0.17	64–386
Polynesian Starling	2011	3.19 ± 1.58	6,839 ± 3,396
		1.27–7.31	2,717–15,688
	2018	4.27 ± 0.91	9,153 ± 1,943
		3.01–6.61	6,458–14,180
Polynesian Wattled Honeyeater	2011	36.68 ± 11.63	81,757 ± 25,917
		19.09–57.70	42,561–128,602
	2018	22.79 ± 5.00	50,794 ± 11,149
		15.36–35.47	34,246–79,072
Samoan Starling	2011	6.67 ± 1.10	14,871 ± 2,460
		4.50–8.87	10,021–19,778
	2018	5.74 ± 1.61	12,801 ± 3,596
		3.36–9.33	7,485–20,791

95% confidence intervals are presented in second row of each year. Total abundance was calculated as mean density weighted by unit area (2,229 ha).

(Table 1). Detections were distributed broadly across the survey area, and there were incidental detections of the species on Mt. Lata summit as well as most coastal and residential areas outside NPSA. Distance sampling models assume there is no movement prior to detection. Most lorikeets were detected in flight, thus computing this species' density and abundance using distance sampling methods should be carefully evaluated. Changes in population densities are reliable as estimator bias are expected to be consistent for both surveys. We estimated a 2018 density of 1.20 ± 0.45 birds/ha and an abundance of 2,686 ± 1,007 birds (Table 2). Densities had decreased significantly by −2.94 birds/ha from estimates in 2011 (Table 4).

Buff-banded Rail

Buff-banded Rails (*Hypotaenidia philippensis goodsoni*) were detected at 6% of the stations surveyed at 0.06 BPS in the Ta'ū Unit (Table 1). In the Tutuila Unit, the species was detected at 7% of stations surveyed at 0.07 BPS (Table 1). Most detections were below 300 m in coastal forests where the species forages for insects in open understory

TABLE 3

Densities (birds/ha) and Abundances (birds/unit) of Landbirds Within the Tutuila Unit in 2011 and 2018

Tutuila Unit: Species	Year	Density (birds/ha ± SE) (95% CI)	Abundance (birds/1,021 ha ± SE) (95% CI)
Crimson-crowned Fruit Dove	2011	1.01 ± 0.26	1,035 ± 267
		0.61–1.61	627–1,647
	2018	0.47 ± 0.18	484 ± 187
		0.26–0.95	262–972
Pacific Imperial Pigeon	2011	1.31 ± 0.28	1,338 ± 287
		0.85–1.97	871–2,008
	2018	1.03 ± 0.35	1,050 ± 362
		0.52–1.89	532–1,928
Pacific Kingfisher	2011	0.35 ± 0.09	362 ± 94
		0.21–0.56	215–575
	2018	0.20 ± 0.06	202 ± 62
		0.09–0.32	88–330
Polynesian Starling	2011	5.36 ± 1.08	5,473 ± 1,102
		3.64–7.87	3,714–8,032
	2018	3.63 ± 0.79	3,707 ± 805
		2.34–5.45	2,388–5,561
Polynesian Wattled Honeyeater	2011	32.9 ± 10.95	33,595 ± 11,184
		17.44–56.09	17,802–57,269
	2018	17.77 ± 3.16	18,147 ± 3,230
		13.06–25.22	13,339–25,745
Samoan Starling	2011	9.11 ± 1.02	9,303 ± 1,038
		7.22–11.29	7,376–11,525
	2018	4.89 ± 0.58	4,994 ± 597
		4.06–6.29	4,143–6,419

95% confidence intervals are presented in second row of each year. Total abundance was calculated as mean density of unit estimates weighted by unit area (1,021 ha).

habitat. Buff-banded Rails were also seen incidentally near the forest edge in disturbed areas and low elevation agroforest plots on both islands. Findings were consistent with 2011 results, when the species was detected at 0.02 BPS and 0.11 BPS in the Ta‘ū Unit and Tutuila Unit, respectively (Table 2; Judge et al. 2013).

Crimson-crowned Fruit Dove

The Crimson-crowned Fruit Dove was widely distributed at all elevations in NPSA. In the Ta‘ū Unit, the species occurred at 56% of stations surveyed at 1.02 BPS (Table 1). We estimated a density of 0.37 ± 0.17 birds/ha and an abundance of 815 ± 386 birds (Table 2). In the Tutuila Unit, the species occurred at 85% of stations surveyed at 1.71 BPS (Table 1). Density was 0.47 ± 0.18 birds/ha and an abundance of 484 ± 187 birds (Table 3). Results of z-tests were inconclusive (coefficient of variation ≥ 59%), but densities were lower in both cases, with a −0.23 birds/ha decrease and −0.54 birds/ha decrease in the Ta‘ū Unit and Tutuila Unit, respectively (Table 4).

Manu‘a Shrikebill

The Manu‘a Shrikebill was detected only in *Syzygium* spp. Forest and *Dysoxylum* spp. Forest in the Southern Liu Bench area of the Ta‘ū Unit. The species occurred at 17% of stations surveyed at 0.21 BPS in 2018 (Table 1). Indices were consistent with 2011 findings, when the species was detected at 0.17

TABLE 4

Differences in 2018 from 2011 Bird Densities (birds/ha) in the Taʻū Unit and Tutuila Unit

Species	Unit	Difference	SE	LCI	UCI	*z*-test *P*	LEL	UEL	LELp	UELp	Result
Blue-crowned Lorikeet	Taʻū	−2.94	1.29	−5.06	−0.82	0.02	2.21	−2.32	0.99	0.01	Decreasing
Crimson-crowned Fruit Dove	Taʻū	−0.23	0.28	−0.69	0.23	0.41	0.52	−1.05	0.7	0.15	Inconclusive
	Tutuila	−0.54	0.32	−1.07	−0.01	0.09	1.43	−1.89	0.92	0.03	Inconclusive
Pacific Imperial Pigeon	Taʻū	0.26	0.29	−0.22	0.74	0.37	−1.18	0.67	0.12	0.75	Inconclusive
	Tutuila	−0.28	0.45	−1.03	0.46	0.53	0.44	−0.77	0.67	0.22	Inconclusive
Pacific Kingfisher	Taʻū	−0.04	0.05	−0.12	0.05	0.5	−0.89	−1.9	0.19	0.03	Inconclusive
	Tutuila	−0.16	0.11	−0.34	0.02	0.16	0.67	−2.01	0.75	0.02	Inconclusive
Polynesian Starling	Taʻū	1.08	1.82	−1.91	4.07	0.55	−0.64	0.56	0.26	0.71	Inconclusive
	Tutuila	−1.73	1.34	−3.93	0.47	0.2	1.23	−1.34	0.89	0.09	Inconclusive
Polynesian Wattled Honeyeater	Taʻū	−13.89	12.66	−34.71	6.93	0.27	1.09	−1.1	0.86	0.14	Inconclusive
	Tutuila	−15.13	11.4	−33.89	3.63	0.18	1.32	−1.33	0.91	0.09	Inconclusive
Samoan Starling	Taʻū	−0.93	1.95	−4.14	2.29	0.63	0.43	−0.51	0.67	0.31	Inconclusive
	Tutuila	−4.22	1.17	−6.15	−2.29	0	3.53	−3.65	1	<0.01	Decreasing

The null hypothesis that the density has not changed over time was tested with a *z*-test. Equivalence tests were used to determine if the difference was within the threshold bounds (−0.0199, 0.0093) of a 25% change in density over 25 years. LCI and UCI = lower and upper 90% confidence intervals; LEL and UEL = lower and upper equivalence levels (*t*-values); LELp and UELp = lower and upper equivalence level *P*-values. Population densities were interpreted as increasing, decreasing, stable, or inconclusive.

BPS in the same southern area of the Taʻū Unit (Table 1).

Many-colored Fruit Dove

Detected in very low numbers, the Many-colored Fruit Dove (*Ptilinopus perousii*) appeared to be rare in NPSA. In the Taʻū Unit, the species was detected at 6% of stations surveyed at 0.06 BPS in 2018 (Table 1). Detections were in *Dysoxylum* spp. Forest in the Southern Liu Bench area. In the Tutuila Unit, the species was detected at 15% of stations surveyed at 0.22 BPS (Table 1), primarily in *Syzygium* spp. Forest within the central and western areas of the unit. Indices were slightly higher than in 2011, when the species was detected in similar areas and habitat cover types in both units (Table 1).

Pacific Imperial Pigeon

The Pacific Imperial Pigeon was detected at 38% of stations surveyed at 0.58 BPS in the Taʻū Unit in 2018 (Table 1). Occurrence was highest in isolated *Syzygium samoense–Weinmannia affinis* Forest and *Dysoxylum* spp.–*Rhus–Alphitonia* Forest of the Liu Bench. We estimated a density of 0.55 ± 0.26 birds/ha for an abundance of 1,232 ± 303 birds (Table 2). Detections in the Tutuila Unit were broadly distributed at all elevations, occurring at 78% of stations surveyed at 1.45 BPS (Table 1). We estimated a density of 1.03 ± 0.35 birds/ha and an abundance of 1,050 ± 362 birds (Table 3). Results of *z*-tests were inconclusive when compared to 2011 estimates (CV ≥ 100%), with a 0.26 birds/ha increase in density in the Taʻū Unit and −0.28 birds/ha decrease in the Tutuila Unit (Table 4).

Pacific Kingfisher

The Pacific Kingfisher was detected at 10% of stations surveyed at 0.13 BPS in the Taʻū Unit in 2018 (Table 1). Most detections were at elevations between 20 m and 200 m in *Alphitonia zyzyphoides–Rhus taitensis* Forest and *Dysoxylum* (*samonese*, *maota*) Forest. We estimated a density of 0.09 ± 0.04 birds/ha with an abundance of 200 ± 81 birds (Table 2). In the Tutuila Unit, the species was broadly distributed at all elevations, occurring at 30% of stations surveyed at 0.34 BPS (Table 1). Density was 0.20 ± 0.06 birds/ha for an abundance of 202 ± 62 birds (Table 3). Results of z-tests were inconclusive compared to 2011 estimates (CV ≥ 70%), but with a reduction of −0.04 birds/ha and −0.16 birds/ha in the Ta‘ū Unit and Tutuila Unit, respectively (Table 4).

Polynesian Starling

The Polynesian Starling was broadly distributed at all elevations and forest types in both units. The species was detected at 52% of stations surveyed at 0.92 BPS in the Ta‘ū Unit in 2018 (Table 1). We estimated a density of 4.27 ± 0.91 birds/ha for an abundance of 9,153 ± 1,943 birds (Table 2). In the Tutuila Unit, the species was detected at 69% of stations surveyed at 1.18 BPS (Table 1). Density was 3.63 ± 0.79 birds/ha with an abundance of 3,707 ± 805 birds (Table 3). Results of z-tests were inconclusive in both units (CV > 75%); we estimated a 1.08 birds/ha increase on Ta‘ū and a −1.73 birds/ha reduction on Tutuila when compared to 2011 estimates (Table 4).

Polynesian Wattled Honeyeater

The Polynesian Wattled Honeyeater was the most ubiquitous and abundant species detected during the survey. In the Ta‘ū Unit, the species was detected at 100% of stations surveyed at 5.9 BPS in 2018 (Table 1). We estimated a density of 22.79 ± 5.00 birds/ha for an abundance of 50,794 ± 11,149 birds (Table 2). In the Tutuila Unit, the species was detected at 100% of the stations surveyed at 6.48 BPS (Table 1). Density was 17.77 ± 3.16 birds/ha for an abundance of 18,147 ± 3,230 birds (Table 3). Results of z-tests in both units were inconclusive because of a high uncertainty in density estimates (CV ≥ 75%), but it is notable there was reduction between 2011 and 2018 of −13.89 birds/ha and −15.13 birds/ha in the Ta‘ū Unit and Tutuila Unit, respectively (Table 4).

Red Junglefowl

There were two detections of Red Junglefowl near 340 m elevation in *Syzygium samoense*/*Weinmannia affines* Forest within the Ta‘ū Unit in 2018. Far from habitations in the village of Fitiuta, the birds were assumed to be a feral and self-sustaining population. There were no detections of Red Junglefowl during survey efforts in 2011 (Table 1).

Samoan Myzomela

Within American Samoa, the Samoan Myzomela (*Myzomela nigriventris*) occurs only on Tutuila Island. The species was detected on 32% of the stations surveyed at 0.49 BPS in 2018 (Table 1). The majority of the detections were on the eastern half of the Tutuila Unit in *Syzygium* spp. Forest, at elevations ranging between 300 m and 450 m. Indices of occurrence and BPS in 2018 were higher than reported in 2011 (Table 1).

Samoan Starling

The Samoan Starling was broadly distributed in both units, occuring at all elevations and forest types. In the Ta‘ū Unit, the species was detected at 88% of stations surveyed at 2.33 BPS (Table 1). We estimated a density of 5.74 ± 1.61 birds/ha and an abundance of 12,801 ± 3,596 birds (Table 2). In the Tutuila Unit, the species was detected at 99% of stations surveyed at 2.93 BPS (Table 1). Density was 4.89 ± 0.58 birds/ha and an abundance of 4,994 ± 597 birds (Table 3). Results of z-tests were inconclusive on the Ta‘ū Unit (CV > 200%), with a −0.93 birds/ha reduction in estimated density (Table 4). There was a significant difference between 2011 and 2018 on the Tutuila Unit, with a −4.22 birds/ha reduction in density (Table 4).

Spotless Crake

The Spotless Crake was detected incidentally in 2018 on the Ta‘ū Unit at the northeast end of Transect 10 near 800 m elevation (Figure 2), in low stature *Dysoxylum* (*samoense*, *maota*) Forest and dense montane scrub dominated by *Freycinetia storkii* and *Cyrtandra* spp. The species was not detected during surveys or incidentally in 2011 (Table 1).

White-rumped Swiftlet

White-rumped Swiftlets (*Aerodramus spodiopygius*) were detected in modest numbers in both units. In the Ta'ū Unit, the species was detected at 35% of stations surveyed at 0.63 BPS in 2018 (Table 1). In the Tutuila Unit, the species was detected at 45% of stations surveyed at 1.21 BPS (Table 1). Because of the species' biology the assumption of no movement was violated, thus distance sampling was not a reliable method for calculating this species' density and abundance. Results were consistent with 2011 findings, when the species was detected at 0.48 BPS and 0.46 BPS on the Ta'ū Unit and Tutuila Unit, respectively (Table 1).

DISCUSSION

The distribution and species composition of landbirds in NPSA have remained relatively stable while abundances have varied since surveys were first conducted in the 1970s and 1980s (Amerson et al. 1982*b*, Engbring and Ramsey 1989). The protection and management of predominantly native rainforest and the prohibition of hunting have likely maintained populations of native species in American Samoa. In 2018, density estimates and indices were lower for nearly every species than in 2011, but most trends were inconclusive because of relatively large variance estimates. We detected a significant reduction of Samoan Starlings in the Tutuila Unit and of Blue-crowned Lorikeets in the Ta'ū Unit. The Samoan Starling remained abundant and broadly distributed, occurring at nearly all stations in both units. The Blue-crowned Lorikeet, however, exhibited a marked decline in both distribution and abundance. The Polynesian Wattled Honeyeater occurred at every station surveyed in both units, but 2018 estimates were more than 10 birds/ha lower than 2011 estimates. Engbring and Ramsey (1989) reported an island-wide Polynesian Wattled Honeyeater density of 8.68 birds/ha, which was lower than our 2011 and 2018 estimates within NPSA. Distributions of the Polynesian Starling, Pacific Kingfisher, Pacific Imperial Pigeon, and Crimson-crowned Fruit Dove were largely unchanged from 2011 but in most cases densities were lower. Based on year-round monitoring, Freifeld et al. (2004) attributed temporal variation in abundance of the Crimson-crown Fruit Dove and Polynesian Wattled Honeyeater to seasonal patterns, possibly because of variability in vocalizations and concentration of birds near foraging resources. However, it is likely that lower densities of nearly every species in 2018 compared with 2011 can be attributed to Tropical Cyclone Gita, which struck the islands in February 2018, only four months before our sampling periods in June and July.

For rare species, a landscape level disturbance such as a cyclone can be of major conservation concern. For example, in both 2011 and 2018, surveyors detected less than 20 Many-colored Fruit Doves (Table 1). Previous surveys have yielded similarly low numbers for the species throughout American Samoa (Amerson et al. 1982*b*, Engbring and Ramsey 1989, DMWR 1996). Declines have been attributed to subsistence harvest (Craig et al. 1994), cyclones, and the loss of key tree food resources due to deforestation (DMWR 1996). There was a slow increase in Many-colored Fruit Dove distribution after a ban on hunting was implemented (DMWR 1996), but Cyclones Heta (in January 2004) and Olaf (in February 2005) likely drove numbers down again. The species is patchily distributed because of its association with *Ficus* spp. and availability of fruits (Amerson et al. 1982*b*, Engbring and Ramsey 1989), and is detected infrequently, likely due to small population size and secretive behavior, thus rendering the species poorly suited for population estimation using point-transect distance sampling methods (Thompson 2004). Assessing the population status of the Many-colored Fruit Dove and other rare birds in American Samoa may require implementing a rare bird search survey (Camp et al. 2011), which would benefit from a coordinated effort sampling across large areas of the islands and incorporating a banding and tracking component to better assess the species' movements and habitat associations.

The Buff-banded Rail occurred in low numbers during surveys and the Australasian Swamphen (*Porphyrio melanotus*) was only seen incidentally in low elevation areas within NPSA and close to developed areas outside the park. Both species, which inhabit and forage on the forest floor, may be vulnerable to depredation by feral and domestic cats and dogs (Foin and Brenchley-Jackson 1991, Mack et al. 2000, Diamond 2007). Likewise, the effect of the Norway Rat (*Rattus norvegicus*) and Black Rat (*Rattus rattus*) on all bird species in American Samoa is unknown, but there is ample evidence rats can have devastating effects on landbirds and seabirds in the Pacific (Atkinson 1977, Steadman 1989, Banko et al. 2019). Determining the effect of depredation on Buff-banded Rails, as well as other birds, could be used to evaluate if threat mitigation would increase rail productivity and survival.

The Manuʻa Shrikebill subspecies is unique to the Manuʻa Island group (Pratt 2010, Pratt and Mittermeier 2016). On Taʻū, Engbring and Ramsey (1989) detected the species "around the entire island," from 75 m to 600 m elevation, and estimated a density of 1.1 birds/ha with an abundance of 4,695 birds. On the islands of Olosega and Ofu, they estimated a much smaller abundance of 232 and 28 birds, respectively. In both 2011 and 2018, this monarch flycatcher was only detected in the southern Liu Bench area, which is the extinct volcanic crater of Mt. Lata. The steep walls of the crater may offer protection to both birds and habitat during violent storms and thus help explain its limited distribution. We could not update current population densities due to the limited number of detections, but it is apparent that the Manuʻa Shrikebill is one of the rarest landbirds in American Samoa.

The Spotless Crake detections on Taʻū were an unexpected find. The species has been infrequently reported since it was first discovered in 1923 (Murphy 1924). Shy and cryptic, this primarily flightless species was not seen for approximately 60 years after its discovery and was presumed extirpated in American Samoa (Muse and Muse 1982). Engbring and Engilis (1988) rediscovered the species in 1985–1986 when they found a dead specimen on a road near the village of Taʻū and had seen or heard at least three more individuals near the same area. Rauzon and Fialua (2003) heard and saw individuals during several seabird surveys in 2001 and 2002 near the summit of Mt. Lata. The species was again confirmed in 2011 near the summit when it was incidentally captured unharmed in a rat trap (Adler et al. 2010). Badia (2016) also detected Spotless Crakes near the summit of Mt. Lata in 2013. Our detections confirm the species' persistence on Mt. Lata in dense montane scrub dominated by *Freycinetia storkii* and *Cyrtandra* spp., but there have been no detections of the species in low-elevation areas where Engbring and Engilis (1988) found individuals.

Pacific Imperial Pigeons have 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 Island. Take was especially severe after cyclone level winds denuded trees, leaving the birds more visible to hunters (Craig et al. 1994). We estimated 1,232 ± 571 birds in the Taʻū Unit (Table 2) and 1,050 ± 362 birds in the much smaller Tutuila Unit (Table 3). Lower densities on Taʻū may be due to a combination of increased mortality in the four months since Tropical Cyclone Gita, slow recovery after Cyclones Heta and Olaf, and a lack of mature native fruiting trees on which the species relies (Trail 1994, Freifeld 1999, Steadman and Freifeld 1999, Watling 2001). The vegetation inventory of NPSA by Green et al. (2015) provided maps of vegetation communities that include *Ficus prolixa* and *F. obliqua*, both of which provide foraging resources for the Pacific Imperial Pigeon and other Columbiformes. That information may allow managers to evaluate the status of fruiting tree communities and combined with the landbird surveys help track patchily distributed pigeon and dove species dependent on fruiting trees.

Forests of NPSA benefitted from the exhaustive effort to eradicate *Falcataria moluccana*, an invasive tree that negatively influences the composition and function of native Samoan forests (Hughes et al. 2012). A campaign to remove *F. moluccana* in NPSA and surrounding areas began in 2001, and crews removed over 6,000 mature trees over an eight-year period. The control effort allowed native trees to re-establish in disturbed lowland areas and prevent *F. moluccana* ingress into upland native forests (Hughes et al. 2012). A healthy native ecosystem was reflected, in part, by the absence of non-native landbirds in NPSA. The Common Myna (*Acridotheres tristis*), Jungle Myna (*A. fuscus*), and Red-vented Bulbul (*Pycnonotus cafer*) are found predominantly in human-altered areas and neither species were detected during the 2011 or 2018 surveys. Subsequent surveys in NPSA will help identify incursions of those species, as well as weedy plant species, which may allow prompt action from resource management.

Surveys in NPSA are conducted every 5 years (the next in 2023) and efforts are underway to reduce uncertainty in density estimates. The survey design followed here involves sampling a series of stations along transects laid out on a systematic random design, with one panel of 'fixed' transects repeatedly sampled and a second panel of randomly located transects (Camp et al. 2011). The steep topography of NPSA, especially of the Tutuila Unit, precluded the possibility of randomly placing most landbird monitoring transects. Repeat sampling of fixed transects may reduce uncertainty in densities although inference would be limited to the sampled transects. There is a greater opportunity to survey random transects in the Ta'ū Unit, which if sampling were expanded would increase survey coverage, broaden inference from the level of the sample data to the park unit level, and could reduce density uncertainty. Surveying more random transects and repeating surveying fixed transects would reduce uncertainty in density estimates and facilitate detecting changes in population densities.

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