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Population Density, Distribution, and Trends of Landbirds in the National Park of American Samoa, Ta‘ū and Tutuila Units (2011–2018)

Natural Resource Report NPS/PACN/NRR—2021/2222



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ON THE COVER
Pacific Kingfisher (Ti‘otala, *Todiramphus sacer*)
Courtesy of the National Park of American Samoa

Population Density, Distribution, and Trends of Landbirds in the National Park of American Samoa, Ta‘ū and Tutuila Units (2011–2018)

Natural Resource Report NPS/PACN/NRR—2021/2222

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Abstract

The National Park of American Samoa (NPSA) was surveyed for landbirds from June through July, 2018. Surveys were conducted using point-transect distance sampling methods to estimate bird densities. This information provides the second datum in the time-series of landbird monitoring for long-term trends in landbird distribution, density, and abundance within NPSA. The Taʻū Unit and Tutuila Unit, each on separate islands, were first surveyed in 2011 and we tested for changes in densities between each survey year.

A total of 1,766 birds was detected of 14 species in both units. All species were either endemic or indigenous to the islands of American Samoa. Sufficient detections were made of seven species, allowing for density estimation. Birds per station (BPS) and percent occurrence were calculated for the remaining species. The Polynesian Wattled Honeyeater (*Foulehaio carunculatus*) was the most widely distributed and abundant species, with an estimated 50,794 ± 11,149 SE birds in the 2,229 ha Taʻū Unit and 18,147 ± 3,230 birds in the 1,021 ha Tutuila Unit. The Samoan Starling (*Aplonis atrifusca*) occurred at an estimated abundance of 12,801 ± 3,596 birds in the Taʻū Unit. We observed a significant decline in Samoan Starling densities in the Tutuila Unit–our abundance estimate of 4,994 ± 597 birds was approximately 54% of the 2011 estimate. The Polynesian Starling (*Aplonis tabuensis*) also occurred broadly in both units–we estimated an abundance of 9,153 ± 1,943 birds in the Taʻū Unit and 3,707 ± 805 birds in the Tutuila Unit. The Pacific Imperial Pigeon (*Ducula pacifica*) occurred at an abundance of 654 ± 303 birds in the Taʻū Unit and 1,050 ± 362 birds in the Tutuila Unit. The Crimson-crowned Fruit Dove (*Ptilinopus porphyraceus*) occurred in a relatively low abundance in both units, with an estimated 815 ± 386 birds in the Taʻū Unit and 484 ± 187 birds in the Tutuila Unit. Estimated abundance of the Pacific Kingfisher (*Todirhamphus sacer*) was 280 ± 87 birds in the Taʻū Unit and 202 ± 62 birds in the Tutuila Unit. The Blue-crowned Lorikeet (*Vini australis*) in the Taʻū Unit declined significantly from 2011 estimates to an abundance of 2,686 ± 1,007 birds. The Cardinal Myzomela (*Myzomela cardinalis*) occurred at 31.5% of the stations sampled in the Tutuila Unit, but the species has been historically absent from Taʻū Island. The White-rumped Swiftlet (*Aerodramus spodiopygius*) occurred at 35.4% and 45.2% of stations sampled in the Taʻū Unit and Tutuila Unit, respectively. The remaining species detected occurred at less than 20% of stations sampled. The Purple Swamphen (*Porphyrio porphyrio*) and Banded Rail (*Gallirallus philippensis*) were most often detected in areas close to villages and agroforestry plantations. The Samoan Shrikebill (*Clytorhynchus powelli powelli*) was limited to one area on the southern portion of the Taʻū 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 tabuensi*), also a species of concern, was incidentally detected at one location in the Taʻū Unit.

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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 fauna. 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, of the sixty-five documented species, five have been introduced (Watling 2001, O’Connor and Rauzon 2004). Seabirds and shorebirds comprise the majority of the avifauna; composing approximately 60% of all bird species. Twenty-one species of landbirds regularly occur in American Samoa, of which eighteen are indigenous breeding species (Watling 2001). However, recent revisions in Samoan landbird taxonomy have resulted in a more diverse and unique avifauna than previously thought. The Samoan Shrikebill (*Clytorhynchus powelli powelli*) was recently split to subspecies from the Fiji Shrikebill (*C. vitiensis*; Pratt 2010). Pratt and Mittermeier (2016) suggest the American Samoa populations of Cardinal Myzomela (*Myzomela cardinalis*), Polynesian Starling (*Aplonis tabuensis*), and Pacific Kingfisher (*Todirhamphus sacer*) be split to distinct Samoan species. Pratt and Mittermeier (2016) also suggest recognizing four other taxa in the Independent State of Samoa (hereafter: Independent Samoa) as “full biological species” and suggest taxonomic re-evaluation of several other birds in the Samoan Archipelago. Landbirds of NPSA represent an important area for conservation efforts because of their diversity in the South Pacific. Furthermore, Samoan landbirds serve a vital function in driving ecological processes, as many species are pollinators and seed dispersers of native plants (Freifeld 1996, 1999, Webb et al. 1999, Craig 2009).

Population declines, scarcity, and extirpation of Samoan avifauna have been historically documented. In 2016, the United States Fish and Wildlife Service (USFWS) listed the Tongan Ground Dove (*Alopecoenas stairi*) and the Mao (*Gymnomyza samoensis*) as federally endangered (USFWS 2016a). The Tongan Ground Dove has a very narrow distribution in American Samoa, only occurring on portions of Ofu and Olosega in the Manu‘a Island Group. The Mao is considered extirpated in American Samoa–the endemic honeycreeper was last seen on Tutuila in 1977 (Pratt et al. 1987, Engbring and Ramsey 1989). Their small and fragmented population in Independent Samoa was estimated as fewer than 1,000 birds (BirdLife International 2019). The Spotless Crake (*Porzana tabuensis*) was a candidate for listing as threatened or endangered under the Endangered Species Act in 1994, but the petition was deemed “not warranted” and removed as a candidate in 2016 (USFWS 2016b). The species has a broad distribution in the South Pacific (BirdLife International 2016), but only occurs on Ta‘ū Island in American Samoa (Rauzon and Fialua 2003, Adler et al. 2010). Primary factors for scarcity and decline of the above species include anthropogenic deforestation and habitat destruction (USFWS 2016a). Subsistence and commercial agriculture, especially at lower elevations, greatly reduced suitable habitat for Samoan landbirds (Whistler 1994, Mueller-Dombois and Fosberg 1998, USFWS 2016a). However, because of the extreme topography in many areas of American Samoa, habitat degradation alone cannot explain the scarcity of some species. Predation by introduced mammals, such as rats and feral cats, have 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).

In many cases, localized pressures on landbirds can be exacerbated by landscape level disturbance. The Samoan Archipelago is susceptible to devastating episodic hurricanes and cyclones, at least two per decade have occurred over the last 40 years (Ulafala 1990, Craig 2009, Kuleshov et al. 2014). In 1990, Hurricane Ofa severely damaged Tutuila and then just a year later, Hurricane Val ravaged the island. The destruction caused a decline in bird abundance, and the Pacific Imperial Pigeon (*Ducula pacifica*) and Many-colored Fruit Dove (*Ptilinopus perousii*) were nearly driven to extinction (Craig et al. 1994). Both species were popular game birds, and after forests were denuded of vegetation, the birds were extremely vulnerable to hunting pressures. A strict hunting ban was immediately enacted and may have saved the birds from extinction (Craig et al. 1994). Similarly, many species may be vulnerable to depredation after hurricane events, especially flightless species such as the Spotless Crake. In 2005, Hurricane Olaf destroyed lowland habitat vital to the Tongan Ground Dove, which reduced the already small population, further illustrating that natural disturbance can exacerbate the effect of anthropogenic disturbance (USFWS 2016a). Some species are naturally slow to recover, such as the Mao, which lays only one egg and has a prolonged nesting period (Stirnemann et al. 2016). These life history traits, in combination with numerous threats, likely contributed to its extirpation in American Samoa. The Many-colored Fruit Dove is strongly associated with *Ficus* spp. (Engbring and Ramsey 1989), and thus may be particularly vulnerable to hurricanes if trees are denuded of fruits and vegetation. In February of 2018, Tropical Cyclone Gita, which originated in the Southern Hemisphere, devastated parts of Tonga and the Samoan Archipelago, bringing strong winds and heavy rain (Radio New Zealand 2018 a, b, c). The storm posed the most recent and severe risk to landbirds in NPSA and the Samoan Archipelago.

Repeated surveys identify temporal changes of populations (Skalski 1990) allowing National Park Service (NPS) managers to monitor population changes, as well as document changes related 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 landbird 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 as well as 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 I&M Pacific Island Network (PACN) is to collect, organize, and make available natural resource data and contribute to institutional knowledge by facilitating the transformation of data into information through analysis, synthesis, and modeling (Fancy et al. 2009).

PACN established transects for long-term monitoring of landbird trends in distribution, density, and abundance in two units of NPSA, including several transects surveyed by Engbring and Ramsey (1989). Surveys were conducted from June through August of 2011, which provided the first data in the time-series (Judge et al. 2013). During the initial survey, a total of 2,516 birds from 13 species were detected in the Ta‘ū and Tutuila Units (Judge et al. 2013). There were sufficient detections made of seven species to allow for estimating densities (birds/ha). Estimates for those species were encouraging, as they were similar or higher than previous island-wide surveys on both Tutuila and

Ta‘ū (Amerson et al. 1982b, Engbring and Ramsey 1989, Freifeld 1999). The remaining species were detected at less than 20% of stations sampled. There was a notable lack of detections of the Many-colored Fruit Dove, just 17 were detected in 2011 (Judge et al. 2013). Engbring and Ramsey (1989) estimated a population of only 85 individuals. Surveyors did not detect the very shy and cryptic Spotless Crake, a species for which there is a paucity of information in American Samoa.

In 2018, we conducted point-transect distance sampling repeating the 2011 survey to provide current distribution and occurrence of landbirds in NPSA. For species with sufficient detections, we provide density estimates specific to the Ta‘ū Unit and Tutuila Unit. To assess trends, we used a two-sample *z*-test to check for differences in density between the 2011 and 2018 surveys. Ultimately, this information will help to inform and implement management actions for bird conservation.

Surveyors also sampled for a number of habitat variables including canopy height, cover, and predominant understory species. Habitat conditions can influence food availability, which may affect bird population densities in the area (Fretz 2002). If future changes in bird populations are detected, having long-term habitat information may help identify potential reasons. Furthermore, the information gathered from the habitat surveys serves as an overview and provides general descriptions of habitat conditions at our study plots. Over time, park managers and researchers may use the information to characterize habitat changes in areas critical for landbirds.

Methods

The landbird vital sign monitoring protocol conducted by the PACN I&M Program surveys three parks on a rotating basis: NPSA, Hawai‘i Volcanoes National Park, and Haleakalā National Park. Each park and units therein are surveyed once every five years to determine landbird status and trends (Camp et al. 2011). NPSA is composed of three units on three islands in American Samoa: the main island of Tutuila, and the islands Ofu and Ta‘ū of the Manu‘a Island Group (115 km east of Tutuila; Figure 1). The Protocol was first implemented in 2011 at NPSA and repeated here in 2018– in both the Ta‘ū and Tutuila Units. Surveys are not conducted on the small and primarily coastal Ofu Unit.

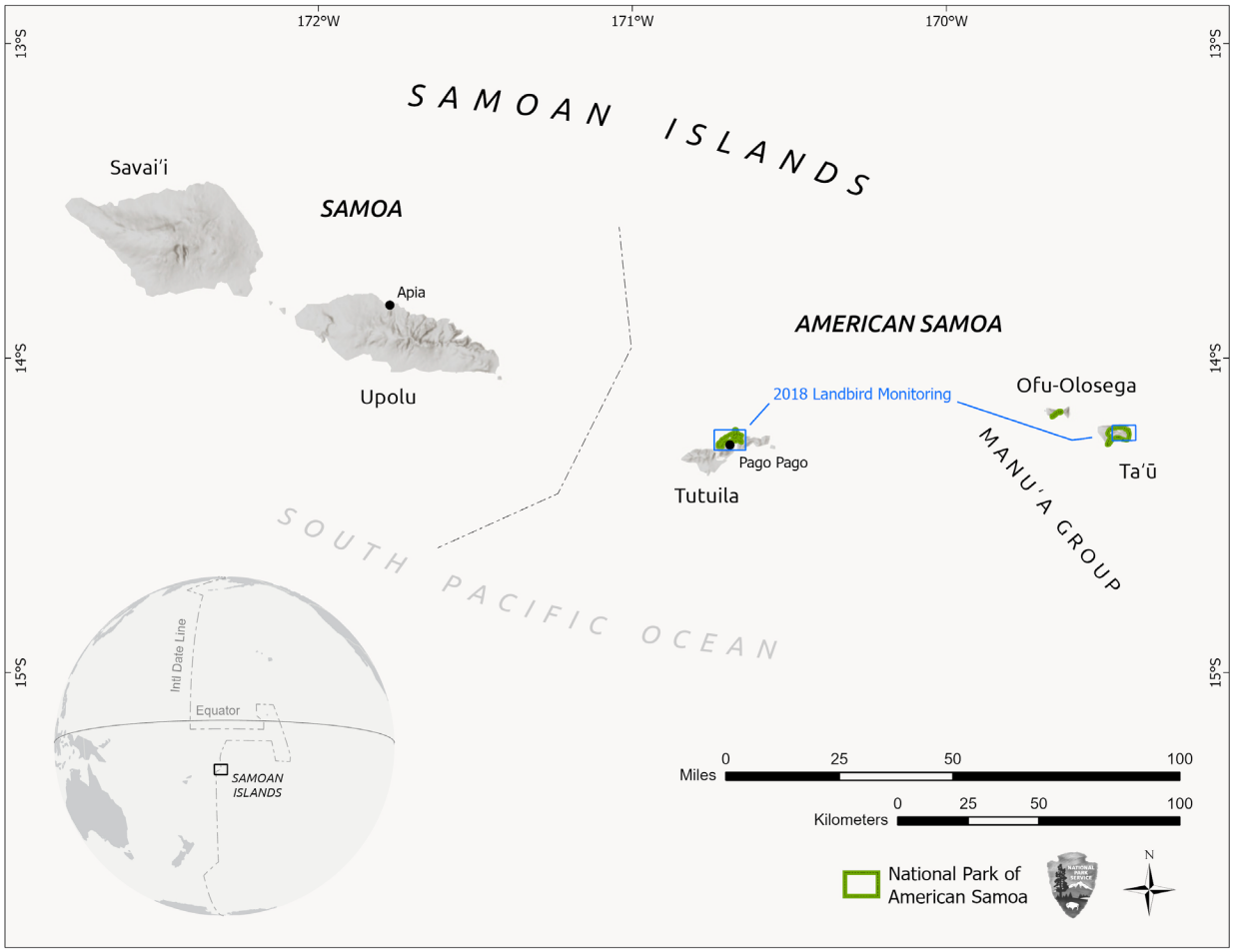


Figure 1. The Samoan Archipelago and the National Park of American Samoa. Base map from World Geodetic System 1984.

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). 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. 1982a, Whistler 1992, 1995, Freifeld 1996). The most invasive tree species in American Samoa are *Falcataria moluccana*, *Adenanthera pavonina*, and *Syzygium samarangense* (Monello 2004). The most serious non-tree invasive species are *Clidemia hirta* and *Mikania micrantha*, both of which occur along disturbed areas; however, *C. hirta* has become established throughout NPSA (Monello 2004, Judge et al. 2013). In 2011, Judge et al. (2013) described predominant vegetation classes at landbird monitoring stations as Rain Forest, Rhus Secondary Forest, Secondary Scrub, and Summit Scrub (Whistler 2002, Liu et al. 2011). In 2015, PACN and partners published a comprehensive vegetation inventory of NPSA (Green et al. 2015). Their results produced high-quality maps of land-cover and vegetation classes of each unit in the park (Table 1). Green et al. (2015) described 23 vegetated map classes and three unvegetated map classes. In 2018, we used the newer classifications to describe both units.

Ta‘ū Unit

Ta‘ū 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, temperatures average 27ºC and rainfall averages 2,400 mm/year (Whistler 2002). The Ta‘ū Unit (2,229 ha) is more than half the entire island (Figure 1). The community of Ta‘ū Village occupies the northwest portion of the island (Figure 2). Most of the field effort was based out of Fitiuta Village, which is closer to the NPSA boundary (Figure 2). 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 (Figure 2).

The vegetation community is dominated by 1,077 ha of *Syzygium samoense* - *Weinmannia affinis* Forest (Table 1), with a canopy of low stature *Syzygium samoense*, *Weinmannia affinis,* and *Astronidium pickeringii*, and *Dicranopteris linearis* the most abundant herbaceous cover. Epiphytic species cover is high and includes *Freycinetia* spp., *Asplenium nidus*, and *Lomagramma cordipinna* (Green et al. 2015). The next largest vegetation community is 310 ha of *Dysoxylum* spp. - *Rhus* - *Alphitonia* Forest where the canopy is comprised of *Dysoxylum* spp., *Rhus* spp., *Alphitonia* spp., *Ficus tinctorial*, and *F. scabra* (Green et al. 2015). Shrub species cover in this community is low and the herbaceous layer is diverse with *Tectaria dissecta* dominating most of the remaining cover; as well as vines such as *Piper graeffei*, *Faradya amicorum*, *Mikania micrantha*, and *Alyxia bracteolosa* (Green et al. 2015). 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, and *Tectaria dissecta* dominating stands of woody species (Green et al. 2015). Remaining vegetation communities include smaller portions (<150 ha) of steep cliff scrub communities: *Syzygium inophylloides* - *Calophylum* spp. Forest, *Alphitonia zizyphoides* and *Rhus* spp. Forest, and others (Table 1; Green et al. 2015).

Table 1. Vegetation community and map classes of the Taʻū Unit designated by Green et al. (2015). Common names were standardized by NPSA staff and often follow Samoan plant nomenclature described by Wagner et al. (1999) and Whistler (2004). Map class names were adapted from the U.S. National Vegetation Classification system (Grossman et al. 1998, FGDC 2008), but have several classes specific to NPSA (Green et al. 2015). Note that area total area described by Green et al. (2015) does not add up to the total terrestrial area of the unit (2,229 ha) because they didn't include some portions of the park in their analysis.

Map Class- Description	**Common Name**	**Area (ha)**
Dysoxylum samoense and *Dysoxylum maota* Forest	Mamala - Maota Forest	236.4
Syzygium inophylloides - Calophylum spp. Forest	Asi - Tamanu Forest	149.8
Wedelia biflora - Scaevola taccada Shrubland	Ateate-Toʻitoʻi Shrubland	5.0
Cliff Scrub- Inaccessible cliff faces described by Whistler (2009)	Cliff Scrub	149.2
Crater Marsh- Inaccessible marshes described by Whistler (2009)	Crater Marsh	1.0
Pandanus tectorius Littoral Forest	Fala Littoral Forest	0.2
Hibiscus tiliaceus Forest	Fau Forest	67.3
Syzygium samoense - Weinmannia affinis Forest	Fena Vao - Weinmannia Forest	1,077.1
Merremia peltata - Mikania micrantha Semi-natural Vine Scrub	Fue lautelele - Fue saina Vine Scrub	22.8
Barringtonia asiatica Littoral Forest	Futu Littoral Forest	6.5
Dysoxylum spp. – *Rhus taitensis - Alphitonia zyzyphoides* Forest	Mamala- Maota -Tavai-Toi Forest	310.3
Cocos nucifera Southern Polynesian Forest	Niu Southern Polynesian Forest	2.2
Pisonia grandis Littoral Forest	Puʻa Vai Littoral Forest	7.7
Pometia pinnata Forest	Tava Forest	0.8
Alphitonia zizyphoides and Rhus spp. Forest	Toi - Tavai Forest	98.4
Unvegetated	Unvegetated	25.7
Grand Total	–	2,160

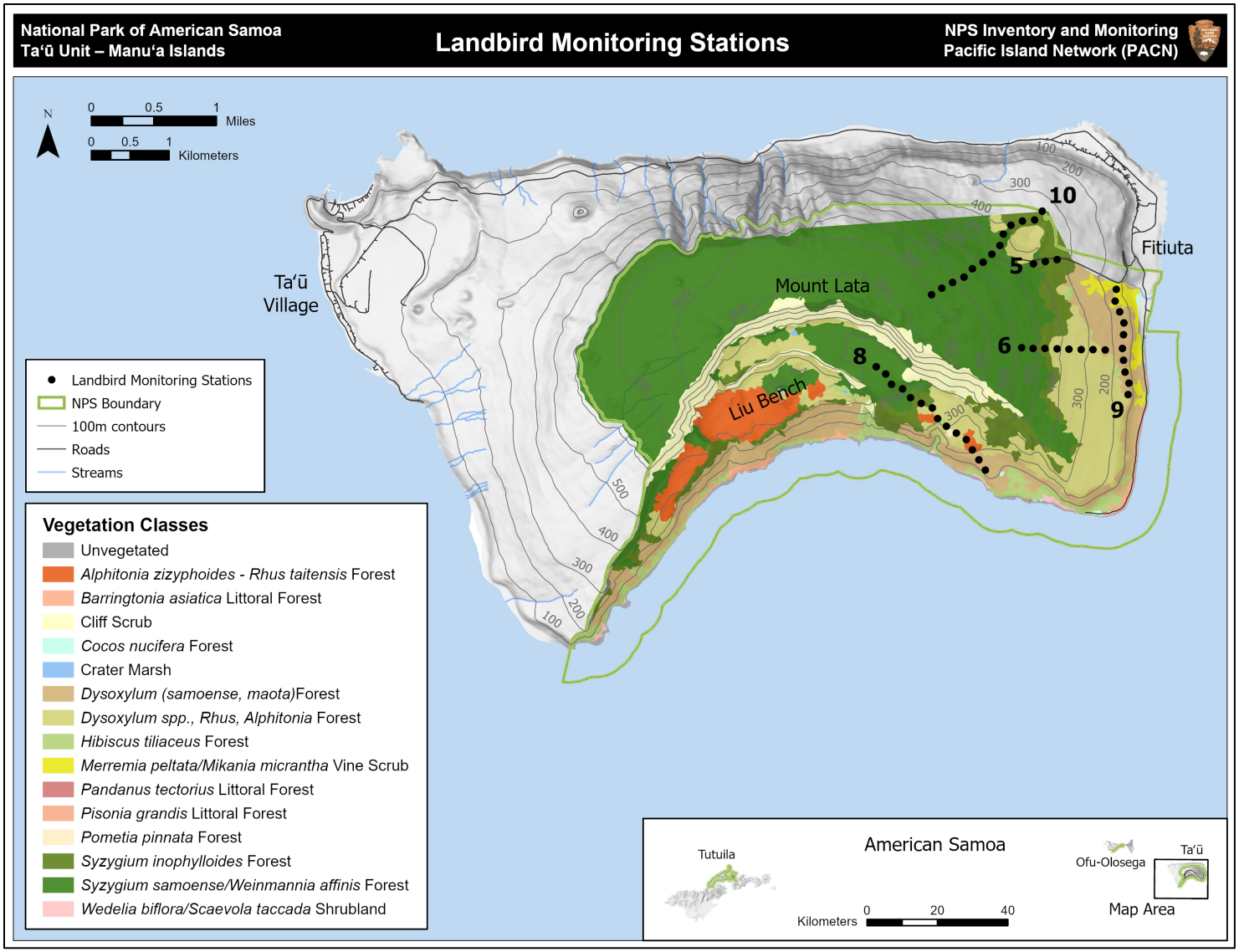


Figure 2. Ta'ū Unit landbird monitoring transects and stations surveyed in 2018. Transects are labeled numerically in black.

Tutuila Unit

Tutuila 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). Dense forested ridges stretch towards the ocean from the summit of Mt. Alava (491 m; Figure 3). The villages of Vatia, Afono, and Fagasa border the eastern and western boundaries of the unit, separated by a steep and rocky coastline (Figure 3). 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 Tutuila Unit is predominately a diverse combination of *Dysoyxylum* spp., *Rhus taitensis*, *Alphitonia zizyphoides*, *Myristica inutilis* and *Canarium* spp. Forest, which comprises 680 ha of the unit (Table 2; Figure 2). More than 40 other tree species are common, including *Barringtonia asiatica*, *Planchonella samoensis*, and *Buchanania merrilli* (Green et al. 2015). Vines are abundant and diverse in the understory including species such as *Alyxia bracteolosa, Epipremnum pinnatum, Faradaya amicorum, Freycinetia* spp., *Hoya australis*, and *Piper graeffei*. Epiphytes such as *Asplenium nidus, Lomagramma cordipinna*, and *Davallia solida* are often present (Green et al. 2015). The herbaceous cover is typically composed of tree seedlings and ferns such as *Angiopteris evecta, Asplenium acuminatum, Christella harveyi*, as well as *Heliconia laufao, Tectaria dissecta*, and *Zingiber zerumbet* (Green et al. 2015). 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 interspersed among the *Myristica inutilis* and *Canarium* spp. Forest community (Figure 2). Less predominant tree species include *Barringtonia asiatica, Buchanania merrillii, Calophyllum neo-ebudicum, Glochidion ramiflorum, Hibiscus tiliaceus, Planchonella garberi, Myristica inutilis, Canarium mafoa, Canarium vitiense, Cyathea* spp., *Diospyros samoensis, Elaeocarpus ulianus. Psychotria insularum, Rhus taitensis*, or *Syzygium clusiifolium*. Understory shrubs include *Mapania macrocephala* and the invasive *Clidemia hirta*. Vine cover can be high with *Alyxia bracteolosa* or *Erythrospermum acuminatissimum* and herbaceous species have low cover and may include *Tectaria dissecta*, *Zingiber zerumbet*, and *Angiopteris evecta* (Green et al. 2015). Several other smaller communities are interspersed in the unit, many of which don't overlap with landbird monitoring stations (Table 2; Figure 3).

Table 2. Vegetation community and map classes of the Tutuila Unit designated by Green et al. (2015). Common names were standardized by NPSA staff and often follow Samoan plant nomenclature described by Wagner et al. (1999) and Whistler (2004). Map class names were adapted from the U.S. National Vegetation Classification system (Grossman et al. 1998, FGDC 2008), but have several classes specific to NPSA (Green et al. 2015). Green et al. (2015) mapped approximately 2 ha of area outside the boundary of the 1,021-ha area of NPSA.

Map Class- Description	**Common Name**	**Area (ha)**
Agriculture- *Musa* spp., *Artocarpus altilis*, etc.	Agriculture	3.4
Syzygium inophylloides - Calophylum spp. Forest	Asi - Tamanu Forest	177.4
Wedelia biflora - Scaevola taccada Shrubland	Ateate -To‘ito‘i Shrubland	0.1
Built-up- Urban structure	Built-up	0.7
Hibiscus tiliaceus Forest	Fau Forest	54.5
Syzygium samoense - (Crossostylis biflora) Forest	Fena Vao - (Saitamu) Forest	14.4
Merremia peltata - Mikania micrantha Semi-natural Vine Scrub	Fue lautelele - Fue saina Vine Scrub	14.5
Barringtonia asiatica Littoral Forest	Futu Littoral Forest	13.5
Mangifera indica Forest	Mago Forest	1.6
Dysoxylum spp*., Rhus taitensis., Alphitonia zyzyphoides* Forest	Mamala, Maota - Tavai– Toi	680.5
Metrosideros spp. Forest	Metrosideros Forest	0.2
Montane Scrub- Inaccessible cliff faces described by Whistler (2009)	Montane Scrub	6.7
Cocos nucifera Southern Polynesian Forest	Niu Southern Polynesian Forest	5.2
Pisonia grandis Littoral Forest	Pu‘a Vai Littoral Forest	8.0
Rhus taitensis Forest	Tavai Forest	19.1
Alphitonia zizyphoides and *Rhus taitensis* Forest	Toi - Tavai Forest	2.2
Unvegetated- beach, bare soil, large rocks	Unvegetated	21.1
Grand Total	–	1,023

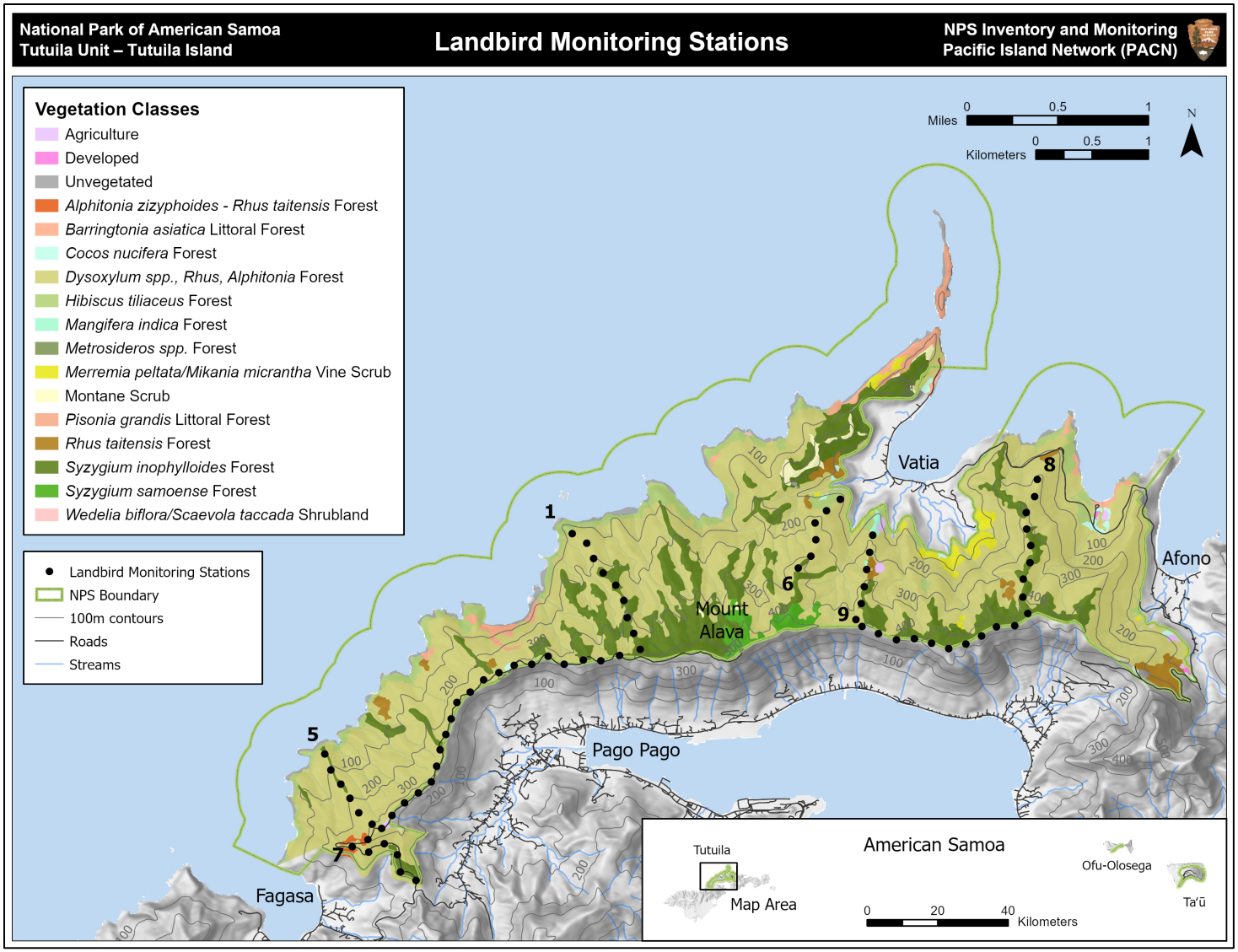


Figure 3. Tutuila Unit landbird monitoring transects and stations surveyed in 2018. Transects are labeled numerically in black.

Landbird Sampling

We sampled for landbirds in the forested portions of the Ta‘ū and Tutuila Units. On Tutuila, from June 12 to June 21, 2018, we sampled landbirds at 73 stations on six transects. On Ta‘ū, from July 10 to July 23, 2018, we sampled 48 stations on five transects. 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 distance 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 estimator precision. Appendix B summarizes the field methods and survey effort, and details of landbird 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 were calculated for seven species–Blue-crowned Lorikeet, Pacific Kingfisher, Pacific Imperial Pigeon, Crimson-crowned Fruit Dove, Polynesian Starling, Samoan Starling, and Polynesian Wattled Honeyeater–that had sufficient detections to adequately characterize detectability (Buckland et al. 2015) 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). 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. 2015; Appendix B). Data were truncated at a distance where the detection probability (using a preliminary detection function model) was about 0.1. 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.

Habitat Sampling

Landbird habitat data were also collected at each of the point-transect sampling stations following the methods described in Camp et al. (2011). A 50-m radius plot was established at each station. At each plot, the canopy species composition, canopy height and cover, and understory species composition were described. Because of the diverse canopy in most areas of NPSA–canopy and understory traits were lumped into classes, such as native trees, introduced trees, native shrubs, etc. Each class was recorded in order of dominance, sub-dominance, or co-dominance. Similarly, canopy height was classified into three classes: 1 (2–5 m tall), 2 (6–10 m tall), and 3 (>10 m tall). Canopy cover was classified into four classes: very scattered (<5% cover), scattered (5–25% cover), open (25–60% cover, and closed (>60% cover). Habitat surveys were collected after completing bird counts (either after completing the station count, or after completing the daily counts). In addition to habitat characteristics, station locations were overlaid on vegetation map classes described by Green et al. (2015) using program ArcMap GIS. Number of stations within each vegetation map class and percent of total stations surveyed were calculated to determine distribution of habitat surveyed and use detailed accounts provided by Green et al. (2015) to describe landbird habitat.

Bird detections and habitat data are available at URL https://irma.nps.gov/DataStore/Reference/Profile/2266886.

Results

Landbird Results

A total of 1,766 birds of 14 landbird species was detected during the survey (Tables 3 and 4). All species detected were either indigenous or endemic to the Samoa Archipelago, except for two detections of Red Junglefowl (*Gallus gallus*). Indices of bird occurrence and relative abundance were calculated for all species detected (Table 4). There were sufficient detections of seven species to determine densities. We provide those estimates and abundance per unit for both 2011 and 2018 in Tables 5 and 6. We then provide a brief narrative summary for each species detected, describing distribution in each unit and measures of occurrence and abundance where appropriate. Occurrence maps displaying extent and number of detections of each species are presented in Appendix C.

Table 3. List of species detected during the 2018 landbird survey in NPSA. Abbreviated species code (Pyle and DeSante 2017) and origin (E=endemic to Samoan Archipelago, I=indigenous, NN=non-native) of birds are presented. Taxonomy and names follow Gill and Donsker (2019) except the Samoan Shrikebill, which was split from Fiji Shrikebill (*C. vitensis*) following Pratt (2010).

Species Name	Samoan Name	Scientific Name	Species Code	Origin
Banded Rail	Ve‘a	*Gallirallus philippensis*	BARA	I
Blue-crowned Lorikeet	Sega	*Vini australis*	BCLO	I
Cardinal Myzomela	Segasegamau'u	*Myzomela cardinalis*	CAMY	I
Crimson-crowned Fruit Dove	Manutagi	*Ptilinopus porphyraceus*	CCFD	I
Many-colored Fruit Dove	Manuma	*Ptilinopus perousii*	MCFD	I
Pacific Imperial Pigeon	Lupe	*Ducula pacifica*	PIPI	I
Pacific Kingfisher	Ti‘otala	*Todiramphus sacer*	PAKI	I
Polynesian Starling	Miti vao	*Aplonis tabuensis*	POST	I
Polynesian Wattled Honeyeater	Iao	*Foulehaio carunculatus*	POWH	I
Red Junglefowl	Moa	*Gallus gallus*	RJFO	NN
Samoan Shrikebill	Sega ‘olevau	*Clytorhynchus powelli powelli*	SASH	E
Samoan Starling	Fuia	*Aplonis atrifusca*	SAST	E
Spotless Crake	Vai	*Porzana tabuensis*	SPCR	I
White-rumped Swiftlet	Pe‘ape‘a	*Aerodramus spodiopygius*	WRSW	I

Table 4. Number of birds detected, indices of bird occurrence (% occurrence), and relative abundance (BPS) by NPSA Unit in 2018.

		Ta‘ū				Tutuila			
Species Name	**Total Detections**	**Birds Detected**	**Stations Occupied**	**% Occurrence**	**BPS**	**Birds Detected**	**Stations Occupied**	**% Occurrence**	**BPS**
Banded Rail	8	3	3	6.3%	0.06	5	5	6.8%	0.07
Blue-Crowned Lorikeet	19	19	11	22.9%	0.40	0	0	0	0
Cardinal Myzomela	36	0	0	0	0	36	23	31.5%	0.49
Crimson-crowned Fruit Dove	174	49	27	56.3%	1.02	125	62	84.9%	1.71
Many-Colored Fruit Dove	19	3	3	6.3%	0.06	16	11	15.1%	0.22
Pacific Imperial Pigeon	134	28	18	37.5%	0.58	106	57	78.1%	1.45
Pacific Kingfisher	31	6	5	10.4%	0.13	25	22	30.1%	0.34
Polynesian Starling	130	44	25	52.1%	0.92	86	50	68.5%	1.18
Polynesian Wattled Honeyeater	756	283	48	100%	5.90	473	73	100%	6.48
Red Junglefowl	2	2	1	2.1%	0.04	0	0	0	0
Samoan Shrikebill	10	10	8	16.7%	0.21	0	0	0	0
Samoan Starling	326	112	42	87.5%	2.33	214	72	98.6%	2.93
Spotless Crake	3	3	1	2.1%	0.06	0	0	0	0
White-rumped Swiftlet	118	30	17	35.4%	0.63	88	33	45.2%	1.21

Table 5. Densities (birds/ha) and abundances (birds/unit) of landbirds within the Ta‘ū Unit in 2011 and 2018. 95% confidence intervals are presented in parentheses. Total abundance was calculated as mean density weighted by unit area (2,229 ha).

Species	Year	Density: birds/ha ± SE (95%CI)	Abundance: birds/2,229 ha ± SE (95%CI)
Blue-crowned Lorikeet	2011	4.15 ± 1.21 (1.87–6.72)	9,247 ± 2,703 (4,178–14,972)
	2018	1.20 ± 0.45 (0.33–2.18)	2,686 ± 1,007 (733–4,870)
Crimson-crowned Fruit Dove	2011	0.59 ± 0.22 (0.26–1.13)	1,326 ± 489 (590–2,512)
	2018	0.37 ± 0.17 (0.09–0.73)	815 ± 386 (209–1,629)
Pacific Imperial Pigeon	2011	0.29 ± 0.14 (0.06–0.58)	654 ± 303 (127–1299)
	2018	0.55 ± 0.26 (0.12–1.08)	1,232 ± 571 (275–2,409)
Pacific Kingfisher	2011	0.13 ± 0.04 (0.07–0.22)	280 ± 87 (149–492)
	2018	0.09 ± 0.04 (0.03–0.17)	200 ± 81 (64–386)
Polynesian Starling	2011	3.19 ± 1.58 (1.27–7.31)	6,839 ± 3,396 (2,717–15,688)
	2018	4.27 ± 0.91 (3.01–6.61)	9,153 ± 1,943 (6,458–14,180)
Polynesian Wattled Honeyeater	2011	36.68 ± 11.63 (19.09–57.70)	81,757 ± 25,917 (42,561–128,602)
	2018	22.79 ± 5.00 (15.36–35.47)	50,794 ± 11,149 (34,246–79,072)
Samoan Starling	2011	6.67 ± 1.10 (4.50–8.87)	14,871 ± 2,460 (10,021–19,778)
	2018	5.74 ± 1.61 (3.36–9.33)	12,801 ± 3,596 (7,485–20,791)

Table 6. Densities (birds/ha) and abundances (birds/unit) of landbirds within the Tutuila Unit in 2011 and 2018. 95% confidence intervals are presented in parentheses. Total abundance was calculated as mean density of unit estimates weighted by unit area (1,021 ha)

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 (0.61–1.61)	1,035 ± 267 (627–1,647)
	2018	0.47 ± 0.18 (0.26–0.95)	484.04 ± 187 (262–972)
Pacific Imperial Pigeon	2011	1.31 ± 0.28 (0.85–1.97)	1,338 ± 287 (871–2,008)
	2018	1.03 ± 0.35 (0.52–1.89)	1,050 ± 362 (532–1,928)
Pacific Kingfisher	2011	0.35 ± 0.09 (0.21–0.56)	362 ± 94 (215–575)
	2018	0.20 ± 0.06 (0.09–0.32)	202 ± 62 (88–330)
Polynesian Starling	2011	5.36 ± 1.08 (3.64–7.87)	5,473 ± 1,102 (3,714–8,032)
	2018	3.63 ± 0.79 (2.34–5.45)	3,707 ± 805 (2,388–5,561)
Polynesian Wattled Honeyeater	2011	32.9 ± 10.95 (17.44–56.09)	33,595 ± 11,184 (17,802–57,269)
	2018	17.77 ± 3.16 (13.06–25.22)	18,147 ± 3,230 (13,339–25,745)
Samoan Starling	2011	9.11 ± 1.02 7.22–11.29	9,303 ± 1,038 (7,376–11,525)
	2018	4.89 ± 0.58 4.06–6.29	4,994 ± 597 (4,143–6,419)

Trends of Landbirds Between 2011 and 2018 Surveys

For the seven species with sufficient detections to estimate densities, we assessed differences between population densities using end-point comparisons with a two-sample *z*-test in an equivalency framework. We compared the 2018 densities in both units to estimates from 2011. Many comparisons were inconclusive due to relatively small differences and large uncertainties in the density estimates (Table 7). Variances were very large for some species with coefficient of variation about 100% or larger; however, we detected a downward trend for Blue-crowned Lorikeets in the Ta‘ū Unit, with a reduction of 2.94 birds/ha in 2018 (Tables 5 and 7). There was a similar downward trend of Samoan Starlings in the Tutuila Unit, with a reduction of 4.22 birds/ha between survey years (Tables 6 and 7).

Table 7. Differences and short-term trends in bird densities in the Ta‘ū Unit and Tutuila Unit. The null hypothesis that 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. Trends were interpreted as upward, downward, stable, or inconclusive.

Species	Unit and Years	Difference	SE	LCL	UCL	z-test p	LEL	UEL	LELp	UELp	Result
Blue-crowned Lorikeet	Ta‘ū (2011 vs 2018)	-2.94	1.29	-5.06	-0.82	0.02	2.21	-2.32	0.99	0.01	Downward
Crimson-crowned Fruit Dove	Ta‘ū (2011 vs 2018)	-0.23	0.28	-0.69	0.23	0.41	0.52	-1.05	0.70	0.15	Inconclusive
	Tutuila (2011 vs 2018)	-0.54	0.32	-1.07	-0.01	0.09	1.43	-1.89	0.92	0.03	Inconclusive
Pacific Imperial Pigeon	Ta‘ū (2011 vs 2018)	0.26	0.29	-0.22	0.74	0.37	-1.18	0.67	0.12	0.75	Inconclusive
	Tutuila (2011 vs 2018)	-0.28	0.45	-1.03	0.46	0.53	0.44	-0.77	0.67	0.22	Inconclusive
Pacific Kingfisher	Ta‘ū (2011 vs 2018)	-0.04	0.05	-0.12	0.05	0.50	-0.89	-1.9	0.19	0.03	Inconclusive
	Tutuila (2011 vs 2018)	-0.16	0.11	-0.34	0.02	0.16	0.67	-2.01	0.75	0.02	Inconclusive
Polynesian Starling	Ta‘ū (2011 vs 2018)	1.08	1.82	-1.91	4.07	0.55	-0.64	0.56	0.26	0.71	Inconclusive
	Tutuila (2011 vs 2018)	-1.73	1.34	-3.93	0.47	0.20	1.23	-1.34	0.89	0.09	Inconclusive
Polynesian Wattled Honeyeater	Ta‘ū (2011 vs 2018)	-13.89	12.66	-34.71	6.93	0.27	1.09	-1.1	0.86	0.14	Inconclusive
	Tutuila (2011 vs 2018)	-15.13	11.40	-33.89	3.63	0.18	1.32	-1.33	0.91	0.09	Inconclusive
Samoan Starling	Ta‘ū (2011 vs 2018)	-0.93	1.95	-4.14	2.29	0.63	0.43	-0.51	0.67	0.31	Inconclusive
	Tutuila (2011 vs 2018)	-4.22	1.17	-6.15	-2.29	0	3.53	-3.65	1	<0.01	Downward

Species Summaries

Below we provide a brief summary for each species detected in the 2018 NPSA landbird survey. We reference the tables above for species with 2018 density estimates and trends compared to the 2011 NPSA landbird survey. For all other species we provide a brief comparison in distribution and BPS to the 2011 findings. Occurrence maps in Appendix C display detections of each species on both the Ta‘ū and Tutuila Units.

Banded Rail

Banded Rails (*Rallus philippensis*) were detected in low numbers in the Ta‘ū Unit and Tutuila Unit (3 and 5, respectively; Table 4). All detections on Ta‘ū were near coastal areas (Appendix C–Figure 1). 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 habitat (Appendix C–Figure 2). Banded Rails were also seen incidentally near the forest edge in disturbed areas and low elevation agroforest plots on both islands. Detections were consistent with 2011 results when a total of 14 birds were detected, also at low elevation (Judge et al. 2013).

Blue-crowned Lorikeet

Absent on Tutuila Island, Blue-crowned Lorikeets (*Vini australis*) were common in the Manu‘a Island Group. In the Ta‘ū Unit, the species occupied 22.9% of stations surveyed at 0.4 BPS. We report a 2018 density of 1.2 ± 0.5 birds/ha and an abundance 2,686 ± 1,007 individuals (Table 5). Trends were downward compared to 2011 estimates, with a reduction of -2.94 birds/ha between survey years (Table 7). Detections were distributed broadly across the survey area (Appendix C–Figure 3), and there were incidental detections of the species on Mt. Lata summit as well as most coastal and residential areas outside NPSA.

Cardinal Myzomela

The Cardinal Myzomela (*Myzomela cardinalis*) does not occur in the Manu‘a Island Group. There was a total of 36 detections on Tutuila at 31.5% of the stations surveyed (Table 4; Appendix C–Figure 4). 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. Occurrence and BPS indices in 2018 were higher than reported in 2011, when there were 17 total detections (Judge et al. 2013).

Crimson-crowned Fruit Dove

The Crimson-crowned Fruit Dove (*Ptilinopus porphyraceus*) was widely distributed in both units, occurring at 56.3% of stations on Ta‘ū and 84.9% of stations surveyed on Tutuila (Table 4; Appendix C–Figure 5; Appendix C–Figure 6). We estimated a density of 0.37 ± 0.17 birds/ha on Ta‘ū and 0.47 ± 0.18 birds/ha on Tutuila, which resulted in abundances of 815 ± 386 birds and 484 ± 187 birds, respectively. Trends were inconclusive in both units, but densities were lower in both units with a -0.23 birds/ha decrease in density on Ta‘ū and -0.54 birds/ha decrease on Tutuila (Table 7).

Many-colored Fruit Dove

Detected in very low numbers, the Many-colored Fruit Dove (*Ptilinopus perousii*) appeared to be rare in NPSA. Just three individuals were detected in *Dysoxylum* spp. Forest in the Southern Liu Bench area of the Ta‘ū Unit (Table 4; Appendix C–Figure 7). In the Tutuila Unit, there were 16

detections in the central and western areas of *Syzygium* spp. Forest (Appendix C–Figure 8). In 2011, there were similar results reported with a total of three detections on Ta‘ū and 11 detections on Tutuila (Judge et al. 2013).

Pacific Imperial Pigeon

The Pacific Imperial Pigeon (*Ducula pacifica*) was detected at 37.5% of stations surveyed on the Ta‘ū Unit and 78.1% of stations on the Tutuila Unit. On Ta‘ū, occurrence was highest in isolated *Syzygium samoense* - *Weinmannia affinis* Forest and *Dysoxylum* spp. - *Rhus* - *Alphitonia* Forest Forest of the Liu Bench (Appendix C–Figure 9). Detections on Tutuila were widespread throughout the unit (Table 4; Appendix C–Figure 10). We estimated densities of 0.55 ± 0.26 birds/ha on Ta‘ū with an abundance of 654 ± 303 birds (Table 5). On Tutuila, we estimated a density of 1.03 ± 0.35 birds/ha and an abundance of 1,050 ± 362 birds (Table 6). Trends were inconclusive when compared to 2011 estimates, with a 0.26 birds/ha increase in density on Ta‘ū and -0.28 birds/ha decrease on Tutuila (Table 7).

Pacific Kingfisher

The Pacific Kingfisher (*Todiramphus sacer*) occurred at 10.4% of stations surveyed on Ta‘ū and 30.1% of stations on Tutuila (Table 4). Most detections on Ta‘ū were at elevations between 20 m and 200 m in *Alphitonia zyzyphoides-Rhus taitensis* Forest and *Dysoxylum* (*samonese, maota*) Forest (Appendix C–Figure 11). On Tutuila, detections were broadly distributed at all elevations (Appendix C–Figure 12). We estimated a density of 0.09 ± 0.04 birds/ha on Ta‘ū with an abundance of 200 ± 81 birds/unit (Table 5). On Tutuila, we estimated 0.20 ± 0.06 birds/ha for an abundance of 202 ± 62 birds (Table 6). Trends were inconclusive compared to 2011 estimates, but with a reduction of -0.04 birds/ha and -0.16 birds/ha on Ta‘ū and Tutuila, respectively (Table 7).

Polynesian Starling

The Polynesian Starling was broadly distributed in both units, occurring at 52.1% of stations surveyed on Ta‘ū and 68.5% of stations on Tutuila (Appendix C–Figure 13 and Appendix C–Figure 14). Density in the Ta‘ū Unit was 4.27 ± 0.91 birds/ha for an estimated abundance of 9,153 ± 1,943 birds/unit (Table 5). In the Tutuila Unit, density was 3.63 ± 0.79 with an abundance of 3,707 ± 805 birds (Table 6). Trends were inconclusive in both units; 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 7).

Polynesian Wattled Honeyeater

The Polynesian Wattled Honeyeater (*Foulehaio carunculatus*) was the most ubiquitous and abundant species detected during the survey. Honeyeaters were detected at every survey station in both units (Appendix C–Figure 15 and Appendix C–Figure 16). In the Ta‘ū Unit, we estimated a density of 22.79 ± 5.0 birds/ha for an abundance of 50,794 ± 11,149 birds/unit (Table 5). In the Tutuila Unit, we estimated a density 17.77 ± 3.16 birds/ha for an abundance of 18,147 ± 3,230 birds (Table 6). Trends in both units were inconclusive because of a high uncertainty in density estimates (coefficient of variation ≥ 75%), but it’s notable there was reduction of -13.89 birds/ha and -15.13 birds/ha on Ta‘ū and Tutuila, respectively (Table 7).

Red Junglefowl

Red Junglefowl, or feral chickens, were detected near 340 m elevation in the Ta‘ū Unit (Appendix C–Figure 17). Far from habitations in Fitiuta Village, the birds were assumed to be a feral and self-sustaining population. There were no detections of Red Junglefowl during survey efforts in 2011 (Judge et al. 2013).

Samoan Shrikebill

A subspecies endemic to the Manu‘a Island Group, the Samoan Shrikebill (*Clytorhynchus powelli powelli*) was detected only in *Syzygium* spp. Forest and *Dysoxylum* spp. Forest on the Liu Bench area in low numbers with only 10 individuals detected (Table 4; Appendix C–Figure 18). Indices were consistent with 2011 findings, when there were 15 detections in the same southern portion of the park (Judge et al. 2013). However, in 2011 the species was detected on a southwest transect that was deemed too dangerous to survey in 2018 (see Appendix B).

Samoan Starling

Endemic to the Samoan Archipelago, the Samoan Starling (*Aplonis atrifusca*) was widely distributed (Appendix C–Figure 19 and Appendix C–Figure 20) and occurred in relatively high densities. In the Ta‘ū Unit, we estimated a density of 5.74 ± 1.61 birds/ha and an abundance of 12,801 ± 3,596 birds (Table 5). Density on Tutuila was 4.89 ± 0.58 birds/ha for an abundance of 4,994 ± 597 birds (Table 6). Trends were inconclusive on the Ta‘ū Unit, with a -0.93 birds/ha reduction in estimated density (Table 7). There was a downward trend on the Tutuila Unit, with a -4.22 birds/ha reduction in density (Table 7).

Spotless Crake

The Spotless Crake (*Porzana tabuensi*) was detected incidentally on Transect 10 near station 14 in low stature *Dysoxylum* (*samoense, maota*) Forest and dense montane scrub dominated by *Freycinetia storkii* and *Cyrtandra* spp. on the Ta‘ū Unit (Appendix C–Figure 21). The species’ cryptic nature, small size, dark plumage, and rarely heard calls have made it difficult to determine its distribution and status on Ta‘ū Island. Rauzon and Fiaula (2003) describe their calls as “churring” and “bup bup bup bup,” and Engbring and Ramsey (1989) described the calls as “mechanical clicking to a low crooning, including chirping whistles”. In 2018, surveyors had recordings on hand to confirm vocalizations because the birds were not seen in the dense understory. The species was not detected during surveys or incidentally in 2011 (Judge et al. 2013). See discussion for a detailed account of detection history.

White-rumped Swiftlet

White-rumped Swiftlets (*Aerodramus spodiopygius*) were detected in modest numbers in the Ta‘ū and Tutuila Units (30 and 88, respectively; Table 4). On Ta‘ū, the species was detected at 35.4% of stations sampled, mostly at lower elevations (Appendix C–Figure 22). On Tutuila, the species was detected at 45.2% of stations sampled, where it was observed flying along the jeep trail to Mt. Alava summit and near high ridges where it forages for insects during flight (Appendix C–Figure 23). 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 surveyors detected 41 and 43 birds on the Ta‘ū and Tutuila Units, respectively (Judge et al. 2013).

Undetected Landbird Species

Australasian Swamphen

The Australasian Swamphen (*Porphyrio melanotus samoensis*) was only detected incidentally in coastal and low elevation rainforests in the Ta‘ū and Tutuila Units, primarily along roadsides and in agroforest habitats. Previously referred to as the Purple Swamphen, or “Western Swamphen” (*Porphyrio porphyrio*), the species was identified as a closer relative to the Australasian Swamphen and identified to sub-species in Samoa as recommended by Sangster (1998) and Garcia-R and Trewick (2015) and recognized by the International Ornithologists’ Union (Gill and Donsker 2019).

Pacific Long-tailed Cuckoo

In 2011, an individual Pacific Long-tailed Cuckoo (*Urodynamis taitensis*) was incidentally seen and heard on Ta‘ū Island, just outside the NPSA boundary on the trail near Judd’s Crater (Judge et al. 2013). In 2018, the species was not detected incidentally or during surveys. This migratory species breeds in New Zealand and migrates north to spend winter months in Polynesia. Shy and secretive, the species was considered an uncommon migrant and population estimates have not been determined in American Samoa (Amerson et al. 1982b, Engbring and Ramsey 1989).

Tongan Ground Dove

In 2011, a single individual Tongan Ground Dove (*Alopecoenas stairi*) was incidentally heard near the middle of Legacy Transect 8 in the Ta‘ū Unit (Figure 2; Judge et al. 2013); however, the individual was not visually confirmed. In 2018, the species was not detected incidentally or during surveys. The species was listed as Endangered in 2016 (USFWS 2016a). A range expansion and establishment of a population on Ta‘ū would be beneficial for this vulnerable species (IUCN red list 2011). Further surveys are needed, and implementation of a Rare Bird Search (RBS), as prescribed in the Protocol (Camp et al. 2011), would be useful to confirm its presence and colonization on Ta‘ū. Additional management to facilitate its success on Ta‘ū may be warranted.

Non-native Birds

Three species of introduced birds were common in non-native lowland habitats in American Samoa. The Common Myna and Jungle Myna (*Acridotheres tristis* and *A. fuscus*, respectively), and the Red-vented Bulbul (*Pycnonotus cafer*) were readily observed in and close to villages and plantations. They were especially common on the Tafuna Plain on Tutuila Island where they forage in agricultural fields and ornamental vegetation. In 2018, there were no detections of these species in the predominately native forests surveyed in either NPSA unit. Similar observations were reported in 2011 (Judge et al. 2013).

Seabird Observations

Ta‘ū Unit

On Ta‘ū, observations of seabirds included Great Frigatebirds (*Fregata minor*), White Terns (*Gygis alba*), White-tailed Tropicbirds *(Phaethon lepturus)*, and Brown Noddies (*Anous stolidus*). Most

notably, there appeared to be several thousand Black Noddies (*Anous minutus*) foraging, nesting, and resting in coastal forests of NPSA. Apparent densities were highest in southern coastal areas but were also observed in mid-elevation *Dysoxylum* 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. Tahiti Petrels (*Pseudobulweria rostrata*) and Audubon's Shearwaters (*Puffinus lherminieri*) may be detected from December–May when birds nest (O'Connor and Rauzon 2003).

Tutuila Unit

Several species of seabirds were observed incidentally and during the 2018 landbird survey effort. However, we made no attempt to estimate abundances (see O'Connor and Rauzon 2004 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 of the Tutuila Unit, and several late-stage chicks were seen resting in nests during landbird surveys in July. White Terns (*Gygis alba*) and White-tailed Tropicbirds were commonly observed resting and flying over steep ridgelines and coastal areas of NPSA. Brown Noddies and Black Noddies 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.

Habitat Composition

Ta‘ū Unit

We sampled 48 stations for habitat characteristics in the Ta‘ū Unit. Stations were distributed unevenly among five vegetation classes (Table 8). The majority of the stations surveyed (33.3%) occurred in *Syzygium samoense* - *Weinmannia affines* Forest (Green et al. 2015). This community occurred at the highest elevations of Mt. Lata (350–970 m) and was dominated by lower-statured trees (4–6 m) of *Astronidium pickeringii*, *Syzgium samoense*, *Fagreae berteroan*a, *Weinmannia affines*, and *Reynoldsia lanutoensis* (Green et al. 2015). Understory was dominated by native epihytes: *Freycinetia* spp., *Asplenium nidus*, *Lomagramma cordipinna*, and *Dendrobium* spp. There was nearly an equal representation of the next three vegetation classes at stations surveyed in 2018 (Table 8). *Dysoxylum samoense* and *Dysoxylum maota* Forest, *Dysoxylum* spp. - *Rhus taitensis* - *Alphitonia zyzyphoides* Forest, and *Syzygium inophylloides* - *Calophylum* spp. Forest accounted for 25.0%, 20.8%, and 18.8% of stations surveyed, respectively (Table 8). *Dysoxylum samoense* and *D. maota* Forest was dominated by the species of its namesake, with an understory of *Tectaria dissecta* and a high occurrence of epiphytic species such as *Lomagramma cordipinna* (Green et al. 2015). Elevation of this community ranged from 15–330 m. The diverse *Dysoxylum* spp. - *Rhus taitensis*- *Alphitonia zyzyphoides* Forest is a combination of several associations and is described in unit descriptions (see methods) and further in Green et al (2015). The *Syzygium inophylloides* - *Calophylum* spp. Forest was a combination of open and closed canopy dominated by the species of the class’ namesake; as well as *Intsia bijuga*, *Barringtonia asiatica*, *Hibiscus tiliaceus*, *Myristica inutilis* and other species. Understory included *Mapania macrocephala* and the invasive *Clidemia hirta* (Green et al. 2015). Only one station was surveyed in the *Merremia peltata* - *Mikania micrantha* Semi-natural Vine Scrub map class which was a mix of native and non-native trees covered by the native and non-native vines. Order of dominant canopy and understory classes recorded at the stations are provided in Appendix D–Table 1. The class of native trees dominant with native ferns being subdominant was recorded at 37.5% of the stations surveyed. An understory dominated by bare ground was recorded at 29.2% of stations surveyed and the class of native ferns dominant with native shrubs codominant was recorded at 14.6% of stations surveyed (Appendix D–Table 2). A closed canopy was recorded at 79.2% of stations surveyed and trees in plots were recorded as >10 m at 75.0% of stations surveyed (Appendix D–Table 3).

Table 8. Forest communities surveyed within the Ta‘ū Unit during the 2018 landbird survey.

Habitat Class (Green et al. 2015)	# of Landbird Stations	%
Syzygium samoense - *Weinmannia affinis* Forest	16	33.3%
Dysoxylum samoense and *Dysoxylum maota* Forest	12	25.0%
Dysoxylum spp., *Rhus taitensis*, *Alphitonia zyzyphoides* Forest	10	20.8%
Syzygium inophylloides - *Calophylum* spp. Forest	9	18.8%
Merremia peltata - *Mikania micrantha* Semi-natural Vine Scrub	1	2.1%

Tutuila Unit

We sampled 73 stations for canopy and understory composition in the Tutuila Unit. The *Dysoxylum* spp. - *Rhus taitensis* - *Alphitonia zyzyphoides* Forest and *Syzygium inophylloides* - *Calophylum* spp. Forest predominated the survey area, accounting for 53.4% and 39.7% of stations surveyed, respectively (Table 9). Both communities formed a diverse combination of map classes that are often indistinguishable from one another (Green et al. 2015). These forests comprise the highest reaches of Mount Alava (330–490 m), where stations were surveyed. Canopy was recorded closed at 61.1% of stations surveyed and 67.1% of plots were dominated by trees >10 m tall (Appendix D–Table 6). Understory cover was variable with shrubs and ferns having low constancy and cover with no one species dominating areas surveyed (Appendix D–Table 5). Stations surveyed at the lower elevations were mixed with *Hibiscus tiliaceus*, Agriculture, and *Mangifera indica* which account for a much smaller area of NPSA on Tutuila (Table 2).

Table 9. Forest communities surveyed within the Tutuila Unit during the 2018 landbird survey.

Habitat Class (Green et al. 2015)	# of Landbird Stations	%
Dysoxylum spp., *Rhus taitensis*, *Alphitonia zyzyphoides* Forest	39	53.4%
Syzygium inophylloides - *Calophylum* spp. Forest	29	39.7%
Hibiscus tiliaceus Forest	2	2.7%
Agriculture- *Musa* spp., *Artocarpus altilis*, etc.	1	1.4%
Mangifera indica Forest	1	1.4%
Cocos nucifera Southern Polynesian Forest	1	1.4%

Discussion

Landbirds

The 2018 landbird survey effort produced density estimates for seven species on two units of NPSA, yielding 13 unique abundances that we were able to index and compare to 2011 estimates. Density estimates in 2018 were lower for nearly every species than in 2011. Because of relatively large variance in estimates, most trends were inconclusive; but we did detect a significant reduction in densities of the Samoan Starling in the Tutuila Unit and of Blue-crowned Lorikeets in the Ta‘ū Unit. The Samoan Starling was still abundant and broadly distributed, occurring at about 99% of stations surveyed on Tutuila and nearly 90% of stations on Ta‘ū. The Blue-crowned Lorikeet however exhibited a marked decline in both distribution and abundance. Like the Samoan Starling, 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 estimates within the NPSA Units, possibly a result from NPS protection. The Polynesian Starling, Pacific Kingfisher, Pacific Imperial Pigeon, and Crimson-crowned Fruit Dove also occurred in a similar distribution to 2011 but at a lower density in most cases. Freifeld et al. (2004) documented temporal variation in abundance of the Crimson-crown Fruit Dove and Wattled Honeyeater, which the authors attributed to seasonal patterns; possibly because of variability in vocalizations and concentration of birds near foraging resources, which could be the case for Blue-crowned Lorikeets. However, it’s likely that lower densities of nearly every species can be attributed to Tropical Cyclone Gita, which struck the islands in February 2018, only four months before sampling began in June 2018.

For rarer species that lacked enough detections to determine density, a landscape level disturbance such as a hurricane is very concerning. In both 2011 and 2018, surveyors detected less than 20 Many-colored Fruit Doves. Previous estimates have been historically low for the species throughout American Samoa (Amerson et al. 1982b, Engbring and Ramsey 1989, DMWR 1996). Declines have been due to subsistence harvest (Craig et al. 1994), hurricanes, and the loss of key tree food resources due to deforestation (DMWR 1996). There was a slow increase in Many-colored Fruit Dove distribution because of the ban on hunting (DMWR 1996), but Hurricanes Heta (in January 2004) and Olaf (in February 2005) likely drove numbers down again. The species was patchily distributed because of its association to *Ficus* spp. and availability of fruits (Amerson et al. 1982b, Engbring and Ramsey 1989). Thus, assessing the population status in American Samoa may require a coordinated effort that conducts distance sampling across large areas of the islands and incorporates a banding and tracking component to better assess the species’ movements and habitat associations. In response to the species’ imperiled status–DMWR, Pacific Bird Conservation (PBC), the Honolulu Zoo, and the Toledo Zoo have collaborated in a captive breeding program to safeguard against extinction (PBC 2019). The more generalist sister species–the Crimson-crowned Fruit Dove–occurred broadly in both the Ta‘ū and Tutuila Units, which is encouraging because the species plays an important role in seed dispersal (Steadman and Freifeld 1999).

The Banded Rail occurred in low numbers in the Ta‘ū and Tutuila Units (3 and 5 detections, respectively). The Australasian Swamphen was not detected during surveys but seen incidentally in low elevation areas within NPSA and close to developed areas outside the park. Both species, which travel 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 impact 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 impacts on landbirds and seabirds in the Pacific (Atkinson 1985, Steadman 1989, Banko et al. 2019). Determining the impact of depredation on Banded Rails, as well as other birds, could be used to evaluate if threat mitigation would increase rail productivity and survival.

The Samoan Shrikebill subspecies is unique to the Manu‘a Island group following recommendations by Pratt (2010), who suggested a taxonomic split from the Fiji Shrikebill (*C. vitiensis*). In both 2011 and 2018, the species 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 explain the Samoan Shrikebill’s limited distribution. Engbring and Ramsey (1989) estimated a density of 1.1 birds/ha for an abundance of 4,695 birds on the entirety of Ta‘ū Island; and they estimated a much smaller abundance of 232 and 28 birds on the islands of Olosega and Ofu, respectively. This flycatcher is one of the rarest landbirds in American Samoa and we couldn’t update current population densities due to the limited number of detections.

The Spotless Crake detections on Ta‘ū were an exciting 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, they found a dead specimen on a road near Ta‘ū Village and had seen or heard at least three more individuals. Rauzon and Fiaula (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 for approximately 15 years. Engbring and Engilis (1988) observed the species on low elevation dirt roads, while all of the recent detections have been in dense montane scrub dominated by *Freycinetia storkii* and *Cyrtandra* spp.

Pacific Imperial Pigeons 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 hurricanes when the species was more visible (Craig et al. 1994). We estimated 1,187 ± 550 birds in the Ta‘ū Unit and 1,050 ± 362 birds in the much smaller Tutuila Unit. Lower densities on Ta‘ū may be due to a combination of slow recovery after hurricanes, and a lack of mature native trees on which the species relies; such as *Bischoffia*, *Dysoxylum*, *Elaeocarpus*, *Ficus*, *Guettarda*, *Myristica*, *Rhus*, and *Syzygium* (Steadman and Freifeld 1999, Freifeld 1999, Watling 2001).

Habitats

Canopy and understory composition in NPSA were predominantly a diverse mix of native vegetation. However, the invasive *Clidemia hirta* was recorded at approximately 40% of stations surveyed in both units. The shrub is a serious noxious weed that can invade native forests on many tropical islands (PIER 2007, Englberger 2009). The weed has completely replaced native vegetation at an alarming rate in forests of Independent Samoa, Fiji, and the Hawaiian Islands (PIER 2007). *Clidemia hirta* is shade tolerant but also thrives in full sunlight; therefore, with an event such as a landslide or hurricane the species can irrupt in open disturbed areas (PIER 2007). The small sticky seeds are easily spread by mammals; thus, emphasizing the importance of controlling non-native ungulates such as feral pigs (Conant 2009).

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Appendix A: Bird Modeling

Bird density estimate models for each species are presented below (Appendix A–Table 1 through Appendix A–Table 6).

Appendix A–Table 1. Blue-crowned Lorikeet density estimate models.

Model	Series adjustment	Covariate	Num params	-LogL	AICc	Delta AICc	AIC weights	Weights	Notes
HR	Key	None	2	182.72	169.56	0	1.00000	1	–
HN	Key	None	1	185.18	372.40	202.84	0.00000	8.99E-45	–
HR	Key	MinSS	3	183.25	372.72	203.16	0.00000	7.66E-45	–
HR	Key	Obs	3	183.25	372.72	203.16	0.00000	7.66E-45	–
HR	Key	Yr	3	183.25	372.72	203.16	0.00000	7.66E-45	–
HR	Key	Rain	3	183.25	372.72	203.16	0.00000	7.66E-45	–
HR	Key	Panel	3	183.25	372.72	203.16	0.00000	7.66E-45	–
HR	Key	Wind	5	183.25	377.06	207.50	0.00000	8.75E-46	–
HN	Cos	None	–	–	–	–	–	–	Convergence issues
HN	H-poly	None	–	–	–	–	–	–	Convergence issues
HR	Cos	None	–	–	–	–	–	–	Convergence issues
HR	S-poly	None	–	–	–	–	–	–	Convergence issues
HR	Key	Cloud	–	–	–	–	–	–	Convergence issues
HR	Key	Gust	–	–	–	–	–	–	Convergence issues

Appendix A–Table 2. Crimson-crowned Fruit Dove density estimate models.

Model	Series adjustment	Covariate	Num params	-LogL	AICc	Delta AICc	AIC weights	Weights	Notes
HR	Key	Obs	3	1895.19	3796.45	0	0.95096	1	–
HR	Key	Gust	6	1895.09	3802.38	5.93	0.04903	0.05156	–
HR	Key	Yr	3	1906.86	3819.78	23.33	0.00001	8.59E-06	–
HR	Key	Wind	5	1915.49	3841.13	44.68	0.00000	1.99E-10	–
HR	Key	None	2	1922.09	3848.21	51.76	0.00000	5.76E-12	–
HR	Key	Panel	3	1922.08	3850.21	53.76	0.00000	2.12E-12	–
HR	Key	MinSS	3	1922.08	3850.22	53.77	0.00000	2.11E-12	–
HR	Key	Cloud	12	1913.17	3851.08	54.63	0.00000	1.37E-12	–
HN	Key	None	1	1926.00	3854.00	57.55	0.00000	3.19E-13	–
HN	Cos	None	–	–	–	–	–	–	Convergence issues
HN	H-poly	None	–	–	–	–	–	–	Convergence issues
HR	Cos	None	–	–	–	–	–	–	Convergence issues
HR	S-poly	None	–	–	–	–	–	–	Convergence issues
HR	Key	Rain	–	–	–	–	–	–	Convergence issues

Appendix A–Table 3. Pacific Imperial Pigeon density estimate models.

Model	Series adjustment	Covariate	Num params	-LogL	AICc	Delta AICc	AIC weights	Weights	Notes
HR	Key	Cloud	12	1180.41	2386.00	0	0.37108	1	–
HR	Key	Gust	6	1187.00	2386.31	0.31	0.31780	0.856415	–
HR	Key	None	2	1191.80	2387.64	1.64	0.16343	0.440432	–
HR	Key	Rain	4	1190.82	2389.79	3.79	0.05578	0.150318	–
HR	Key	Panel	3	1192.83	2391.75	5.75	0.02093	0.056416	–
HR	Key	MinSS	3	1192.83	2391.75	5.75	0.02093	0.056416	–
HR	Key	Obs	3	1192.83	2391.75	5.75	0.02093	0.056416	–
HR	Key	Yr	3	1192.83	2391.75	5.75	0.02093	0.056416	–
HR	Key	Wind	4	1192.83	2393.81	7.81	0.00747	0.020141	–
HN	Key	None	1	1198.27	2398.55	12.55	0.00070	0.001883	–
HN	Cos	None	–	–	–	–	–	–	Convergence issues
HN	H-poly	None	–	–	–	–	–	–	Convergence issues
HR	Cos	None	–	–	–	–	–	–	Convergence issues
HR	S-poly	None	–	–	–	–	–	–	Convergence issues

Appendix A–Table 4. Polynesian Starling density estimate models.

Model	Series adjustment	Covariate	Num params	-LogL	AICc	Delta AICc	AIC weights	Weights	Notes
HN	Key	None	1	866.50	1735.02	0	0.70022	1	–
HR	Key	None	2	866.88	1737.81	2.79	0.17354	0.247833	–
HR	Key	Obs	3	867.53	1741.16	6.14	0.03251	0.046421	–
HR	Key	Yr	3	867.61	1741.31	6.29	0.03016	0.043067	–
HR	Key	Panel	3	867.70	1741.49	6.47	0.02756	0.03936	–
HR	Key	MinSS	3	867.70	1741.50	6.48	0.02742	0.039164	–
HR	Key	Wind	5	867.42	1745.08	10.06	0.00458	0.006539	–
HR	Key	Rain	3	867.67	1745.59	10.57	0.00355	0.005067	–
HR	Key	Cloud	12	862.16	1749.64	14.62	0.00047	0.000669	–
HN	Cos	None	–	–	–	–	–	–	Key model selected
HN	H-poly	None	–	–	–	–	–	–	Key model selected
HR	Cos	None	–	–	–	–	–	–	Key model selected
HR	S-poly	None	–	–	–	–	–	–	Key model selected
HR	Key	Gust	–	–	–	–	–	–	Convergence issues

Appendix A–Table 5. Polynesian Wattled Honeyeater density estimate models.

Model	Series adjustment	Covariate	Num params	-LogL	AICc	Delta AICc	AIC weights	Weights	Notes
HR	Key	Yr	3	6250.79	12507.60	0	0.90827	1	–
HR	Key	Gust	6	6250.21	12512.48	4.88	0.07917	0.087161	–
HR	Key	None	2	6256.15	12516.32	8.72	0.01161	0.012778	–
HR	Key	Rain	5	6255.72	12521.48	13.88	0.00088	0.000968	–
HR	Key	Cloud	12	6251.43	12527.05	19.45	0.00005	5.98E-05	–
HR	Key	MinSS	3	6261.90	12529.81	22.21	0.00001	1.5E-05	–
HN	Key	None	1	6264.33	12530.67	23.07	0.00001	9.78E-06	–
HR	Key	Panel	3	6263.25	12532.52	24.92	0.00000	3.88E-06	–
HR	Key	Obs	3	6283.40	12572.80	65.20	0.00000	6.95E-15	–
HR	Key	Wind	5	6282.43	12574.90	67.30	0.00000	2.43E-15	–
HN	Cos	None	–	–	–	–	–	–	Convergence issues
HN	H-poly	None	–	–	–	–	–	–	Convergence issues
HR	Cos	None	–	–	–	–	–	–	Convergence issues
HR	S-poly	None	–	–	–	–	–	–	Convergence issues

Appendix A–Table 6. Samoan Starling density estimate models.

Model	Series adjustment	Covariate	Num params	-LogL	AICc	Delta AICc	AIC weights	Weights	Notes
HR	Key	Yr	2	2179.40	4362.81	0	0.99844	1	–
HR	Key	Gust	5	2182.82	4375.74	12.93	0.00155	0.001557	–
HR	Key	Obs	2	2193.90	4391.83	29.02	0.00000	4.99E-07	–
HR	Key	Wind	4	2193.70	4395.47	32.66	0.00000	8.09E-08	–
HR	Key	Cloud	11	2187.03	4396.53	33.72	0.00000	4.76E-08	–
HR	Key	None	2	2196.49	4396.99	34.18	0.00000	3.78E-08	–
HN	Key	None	1	2197.85	4397.72	34.91	0.00000	2.63E-08	–
HR	Key	MinSS	2	2197.14	4398.30	35.49	0.00000	1.97E-08	–
HR	Key	Panel	2	2197.61	4399.25	36.44	0.00000	1.22E-08	–
HN	Cos	None	–	–	–	–	–	–	Key model selected
HN	H-poly	None	–	–	–	–	–	–	Convergence issues
HR	Cos	None	–	–	–	–	–	–	Key model selected
HR	S-poly	None	–	–	–	–	–	–	Key model selected
HR	Key	Rain	–	–	–	–	–	–	Convergence issues

Appendix B: 2018 Landbird Monitoring Field Report

Abstract

This abstract summarizes the field methods and survey effort for the 2018 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 Hawai‘i-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 121 stations on 11 transects was surveyed for landbirds and landbird habitat within the NPSA units on Tutuila and Ta‘ū Islands. Landbird surveys on Tutuila began on June 12 and concluded June 21, 2018. On Ta‘ū, surveys began on July 12 and concluded July 23, 2018. Two primary counters surveyed the 121 stations over 18 survey days. A total of 1,766 birds of 14 species was recorded in both units. Each station sampled for birds was also sampled for landbird habitat characteristics.

Introduction

The PACN Protocol field season of 2018 was conducted in the Tutuila and Ta‘ū 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 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 Hawai‘i at Hilo, served as the project Principal Investigator and assisted with planning, preparations, and reporting. Richard Camp, U.S. Geological Survey, assisted with data analysis and reporting, and issues pertaining to the Protocol. NPSA superintendent Scott Burch provided logistical assistance. Ryan Monello, Program Manager of the PACN Inventory and Monitoring Program, offered further support with project and permitting needs. Invaluable field assistance was provided by NPS biotechnicians, each of whom provided much effort in establishing transects through dense forests.

Field Methods

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 "A guide to the birds of Fiji and Western Polynesia" (2001) were excellent source of images, life histories, and distributions of Samoa's avifauna. Audio recordings of birds were accessed on the free website: https://www.xeno-canto.org/. 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 objects (flagging, trees, etc.). 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 a mock sampling 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 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 et al. (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 and provided invaluable expertise.

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 3 to 6 meters (m) and stations were established 1 to 2 m 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 5 to 20 m apart so that the next or previous flag was always visible. Orange flagging was placed approximately 5 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 ¾ 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 centimeters (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 5 or 10 m was strictly avoided to eliminate "heaping." Unnecessary noise and movement were 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 two deviations from the Protocol. First, random transects were not sampled because of the difficult and dangerous sampling conditions in both units. In some cases, randomly prescribed transects accessed in 2011 or 2018 were converted to legacy transects (see transect descriptions). This deviation from the Protocol could introduce estimator bias and more uncertainty in estimates. Second, species composition was not calculated because secondary counters were not available and primary counters sampled each station only once; as multiple visits are needed to create a detection history for each species at each station (Camp et al. 2011).

Habitat data were 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). Data describing the understory density was not collected.

2018 Survey Effort

The field effort was scheduled according to survey needs, 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 primary surveyor and biotechnician could survey approximately 10 stations per day. Ta‘ū required much more effort to survey stations in most areas (~5 stations per day). Each

transect was isolated from human habitations, and at higher elevations the vegetation was a dense tangle of ferns and vines. Strenuous machete work was required to flag and label stations along transects; thus, establishing some transects on Ta‘ū required 3–5 days.

Both the Tutuila and Ta‘ū Units were surveyed for birds and habitat during the 2018 field season Surveys on Tutuila began on June 12, 2018 and concluded June 21, 2018. Two primary counters surveyed 73 stations over 9 survey days. On Ta‘ū, surveys began on July 10 and concluded July 23, 2018. Two primary counters surveyed 48 stations over 9 survey days there. In total, two primary point counters required 18 survey days to conduct landbird surveys and habitat sampling. A total of 7 transects were sampled, each were permanently established legacy transects and had a variable number of stations, ranging from 4–27 stations, and required variable effort. In total, 121 stations were surveyed for landbirds and habitat characteristics were described for each.

Transect Descriptions

Ta‘ū Unit

Transect 5

Transect 5 was a short hike out of Fitiuta Village (Appendix B—Figure 1). The crew established a connecter 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 meandered in and out of a stream bed up to the first sampling station. The transect was thick with vines and difficult to cut and hike but can be surveyed in three days. The transect connected with Transect 10 and the trail to the summit of Mt. Lata. To cut and flag the transect, surveyors hiked up the trail and worked down the transect.

Transect 6

Transect 6 begins near the road that follows the eastern coastline within the park (Appendix B—Figure 1). Station one was approximately 5 m from the road. Station two was 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 traversed north above station two to find a pathway up through the cliff area, and the path was marked with blue flagging. Foot access to stations two and three was difficult, and we suggest surveyor’s follow Transect 9 above the cliff side. Transect 9 may be accessed from the Transect 5 connector trail. The trail was not maintained and may require flagging and clearing. The transect can be cut and surveyed in four days.

Transect 7

Transect 7 was surveyed in 2011 but not in 2018 (Judge et al. 2013). The transect was very isolated and difficult to access, and in 2011 took five days to complete (three to flag and two to survey). Transect 7 was accessed by a coastal path that meandered in and out of the forest, along the rocky coast, which can be slippery and subject to large waves, and through dense forest; the topography was steep in most areas. There were no streams so camping near the transect would require campers to carry several liters of water. The NPSA superintendent advised the crew not to survey Transect 7 in 2018 because of its isolation and hazardous hiking conditions.

Transect 8

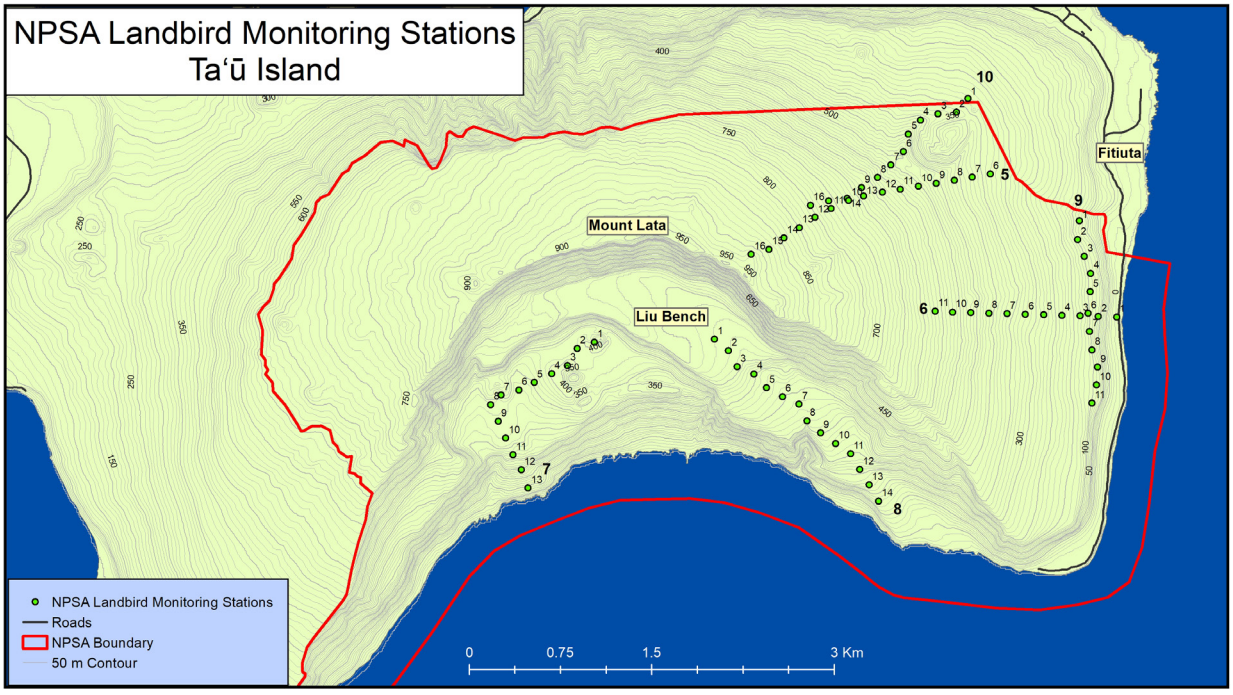
Transect 8 followed a seldom traveled maintenance trail along the Liu Bench and traversed the Laufuti Stream (Appendix B—Figure 1). Stations were marked with pink flagging on trees close to the trail. At 14 stations long, the transect can be surveyed in one or two days. In 2018, two groups of surveyors finished the transect. One group camped in the middle of the transect and the other camped on the beach approximately 20 minutes from Station 14 (Appendix B—Figure 1).

Transect 9

Transect 9 was a newly designated Legacy Transect. The area was surveyed from randomly prescribed transects in 2011 (Judge et al. 2013). Because of surveyor knowledge of the area and ease of access, the transect was permanently established and surveyed in 2018. The transect traversed an old pig snaring trail above a cliffside (Appendix B—Figure 1). The transect was accessed by the same trail above the rock quarry and can be flagged and surveyed in 2–3 days.

Transect 10

Transect 10 was a newly designated Legacy Transect. The transect followed the trail to the Mt. Lata summit area. Because field work is so challenging on Ta‘ū, surveyors took the opportunity to survey areas that are less dangerous and easier to travel. Surveyors established 16 stations with flagging and metal tags in 2018 and were able to survey for landbirds on 13 stations. The last station was near the end of the trail close to the summit area where weather station has been installed.



Appendix B—Figure 1. NPSA landbird monitoring transects (bolded large black numbers) and station numbers (small black numbers) on Ta‘ū Island (2018).

Tutuila Unit

Transect 1

Transect 1 begin approximately 800 m from the summit of Mt. Alava and descended a ridge toward the coast. The transect was accessed from the parking area off Route 005 that leads to Fagasā Village near the southwest boundary of NPSA (Appendix B—Figure 2). A moderately difficult hike on a jeep trail leads to the summit. Surveyors need to start hiking from the parking area before sunrise to reach the transect early enough in time to survey all 9 stations. This transect was surveyed in 2011 and designated as a Legacy Transect in 2018 in order to add more survey stations in the Tutuila Unit.

Transect 5

Transect 5 was accessed from the jeep trail that leads to Mt. Alava Summit (Appendix B—Figure 2). The transect descends a ridge towards Lalofutu Point. NPSA management and monitoring has been conducted in the area; thus, travel was not too difficult. The transect was short, at only 6 stations, and can be finished in one survey day. Like Transect 1, this transect was added as a Legacy Transect in 2018.

Transect 6

Transect 6 was accessed from Vatia Village, on the northeast portion of the Tutuila Unit. The first station was adjacent to private land so care and consideration should be given to landowners. The transect was 6 stations long and difficult to hike but can be finished in one survey day if the weather permits.

Transect 7

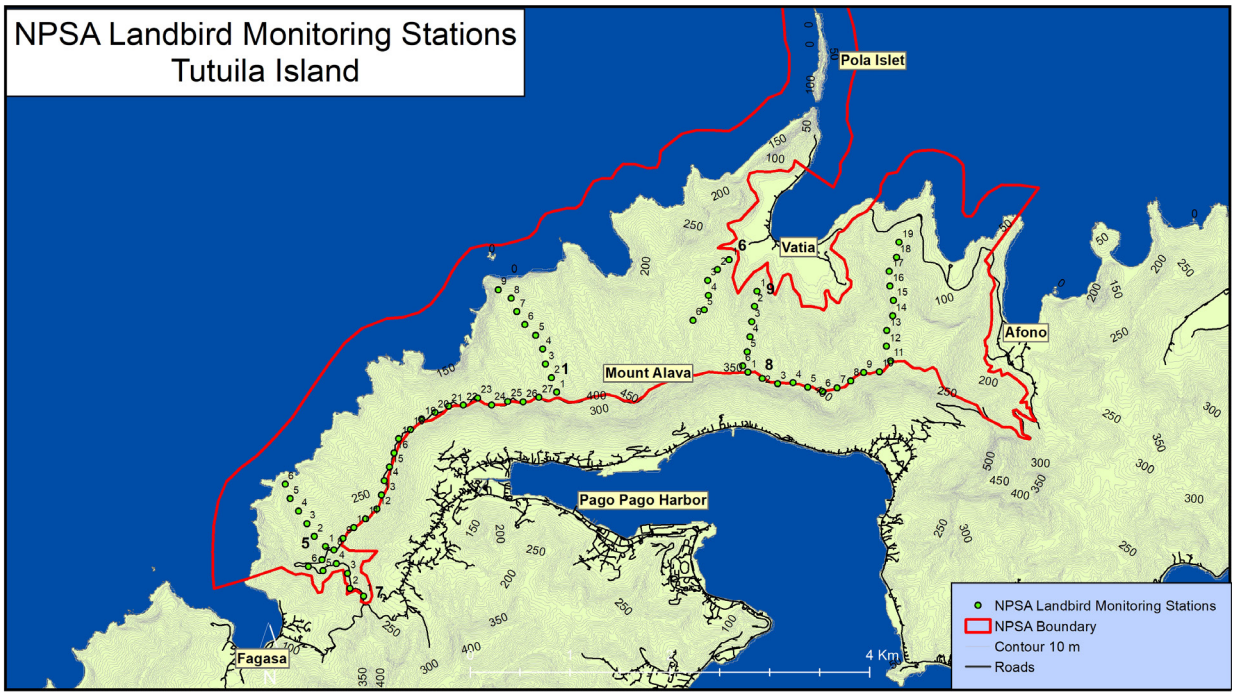
Legacy Transect 7 begin near the western boundary of NPSA and followed the jeep trail that runs along the Maugaloa Ridge and approaches the Mt. Alava Summit (Appendix B—Figure 2). Each survey station was on the roadside and marked on trees with pink flagging and a metal tag. The transect was long at 27 stations, but travel between stations was relatively quick; thus, in good weather the transect can be finished in 2–3 survey days.

Transect 8

Transect 8 begin on the Sauma trail near the eastern boundary of NPSA (Appendix B—Figure 2). Each station was established on the maintained trail and 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.

Transect 9

Transect 9 was a short transect that followed the trail up to Maugaloa Ridge from Vatia Village (Appendix B—Figure 2). Surveyors can park in the village, being considerate of private landowners, and access the trail. The transect can be surveyed in one morning if weather allows.



Appendix B—Figure 2. NPSA landbird monitoring transects (bolded large black numbers) and station numbers (small black numbers) on Tutuila Island (2018).

Discussion

The 2018 PACN landbird vital sign monitoring field season by and large was conducted smoothly and efficiently. The weather was good for much 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 are 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‘ū 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‘ū 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‘ū, we noticed that arthropods were chewing the flagging only days after being deployed. The next NPSA surveys are scheduled to occur in 2023 (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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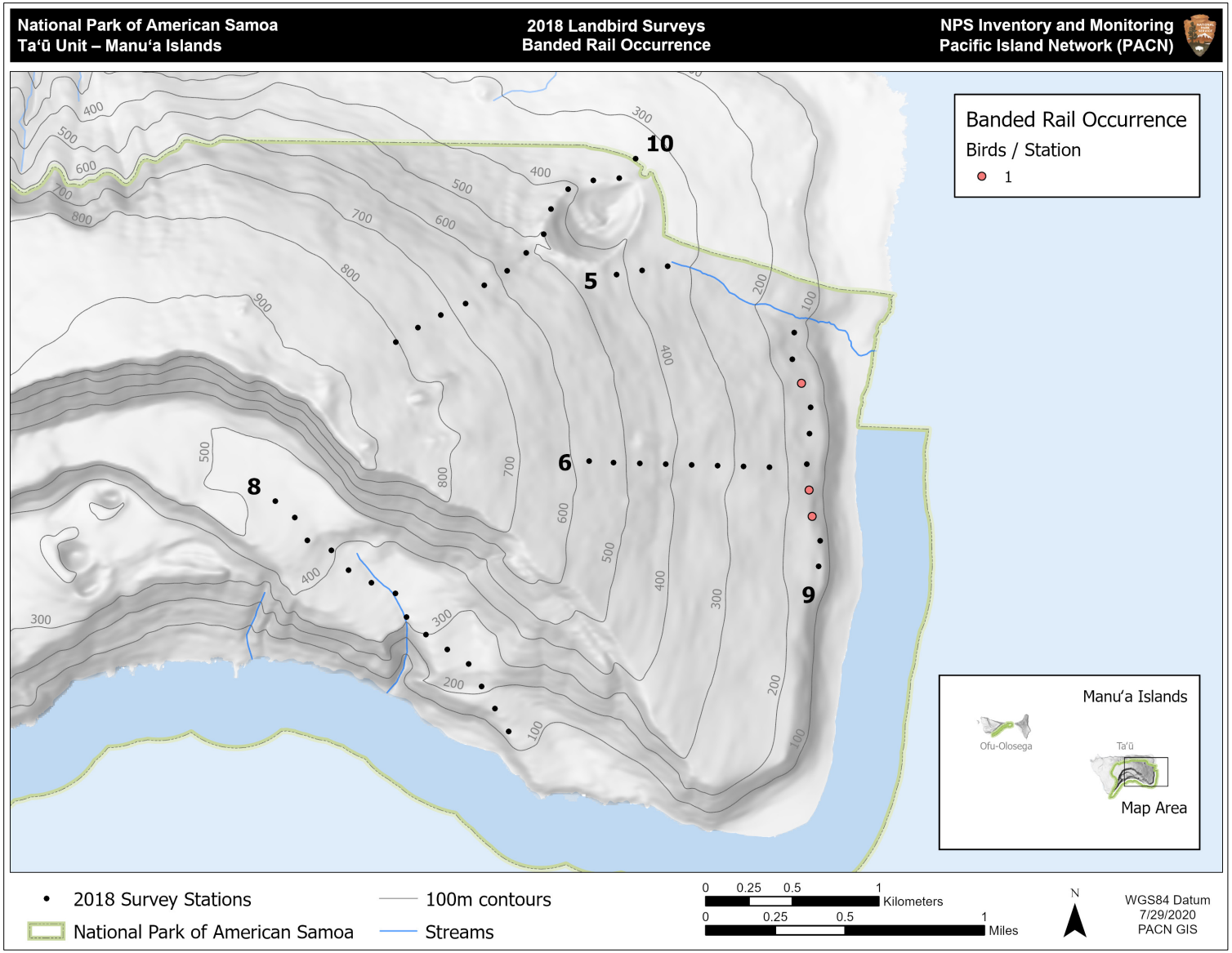
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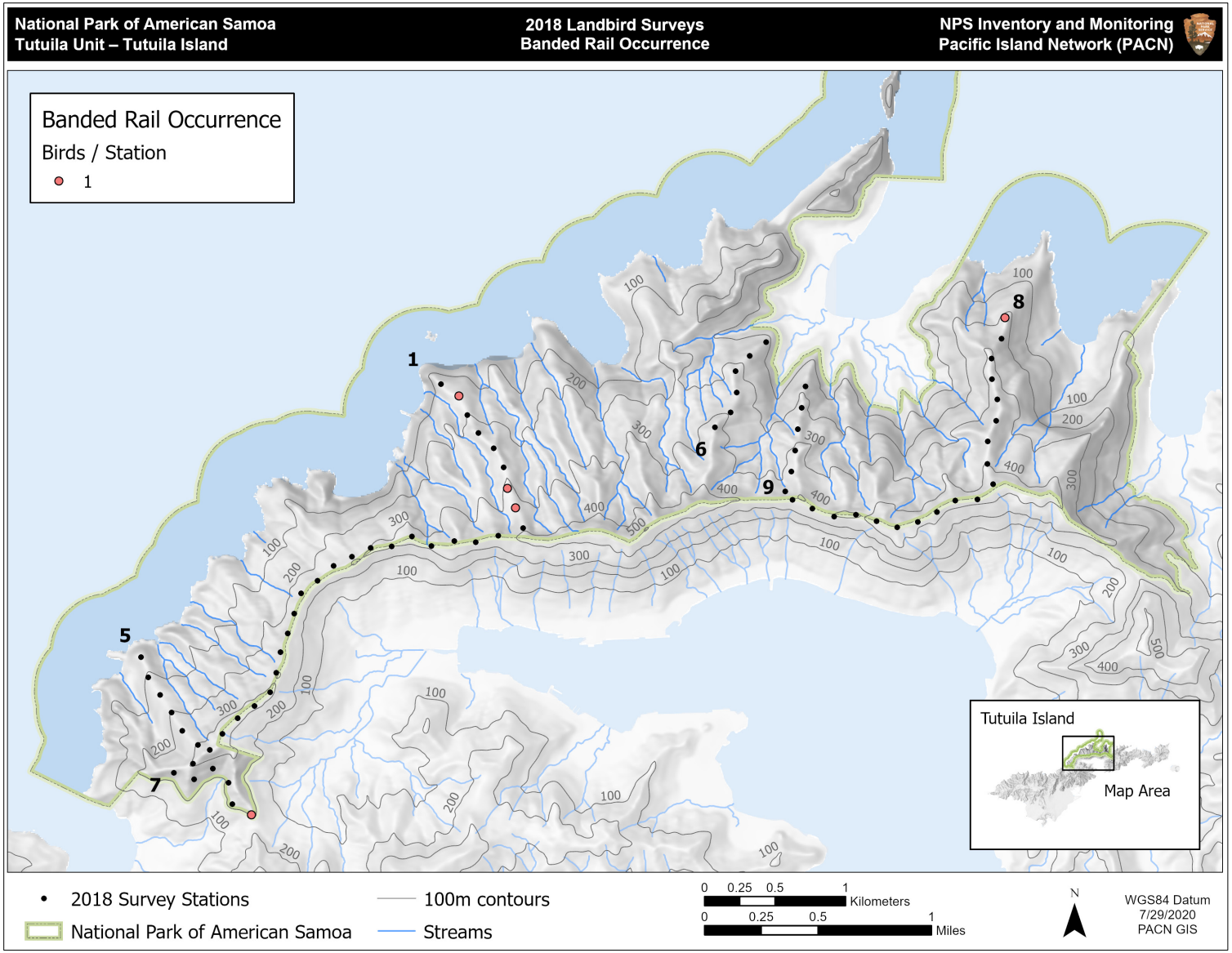
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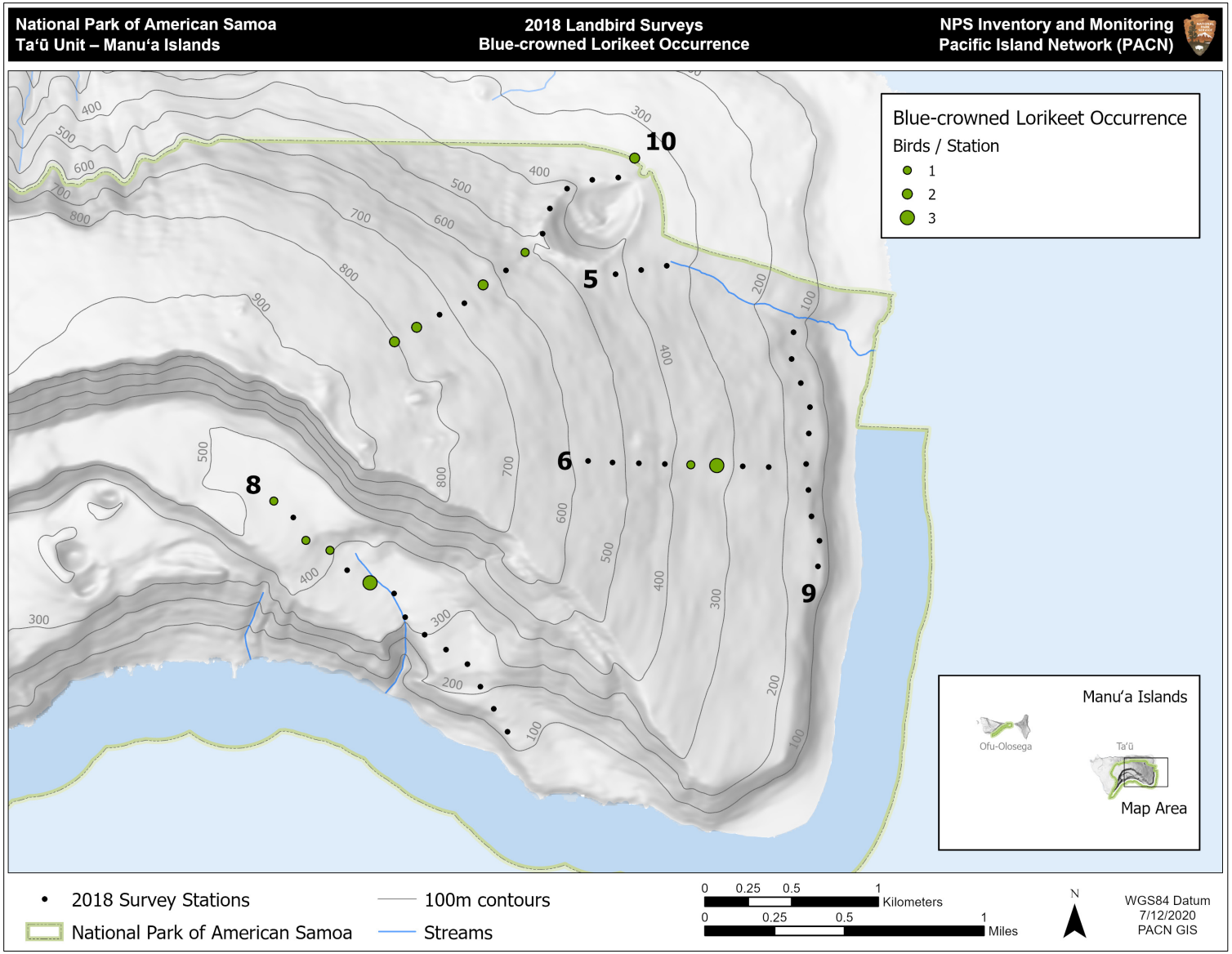
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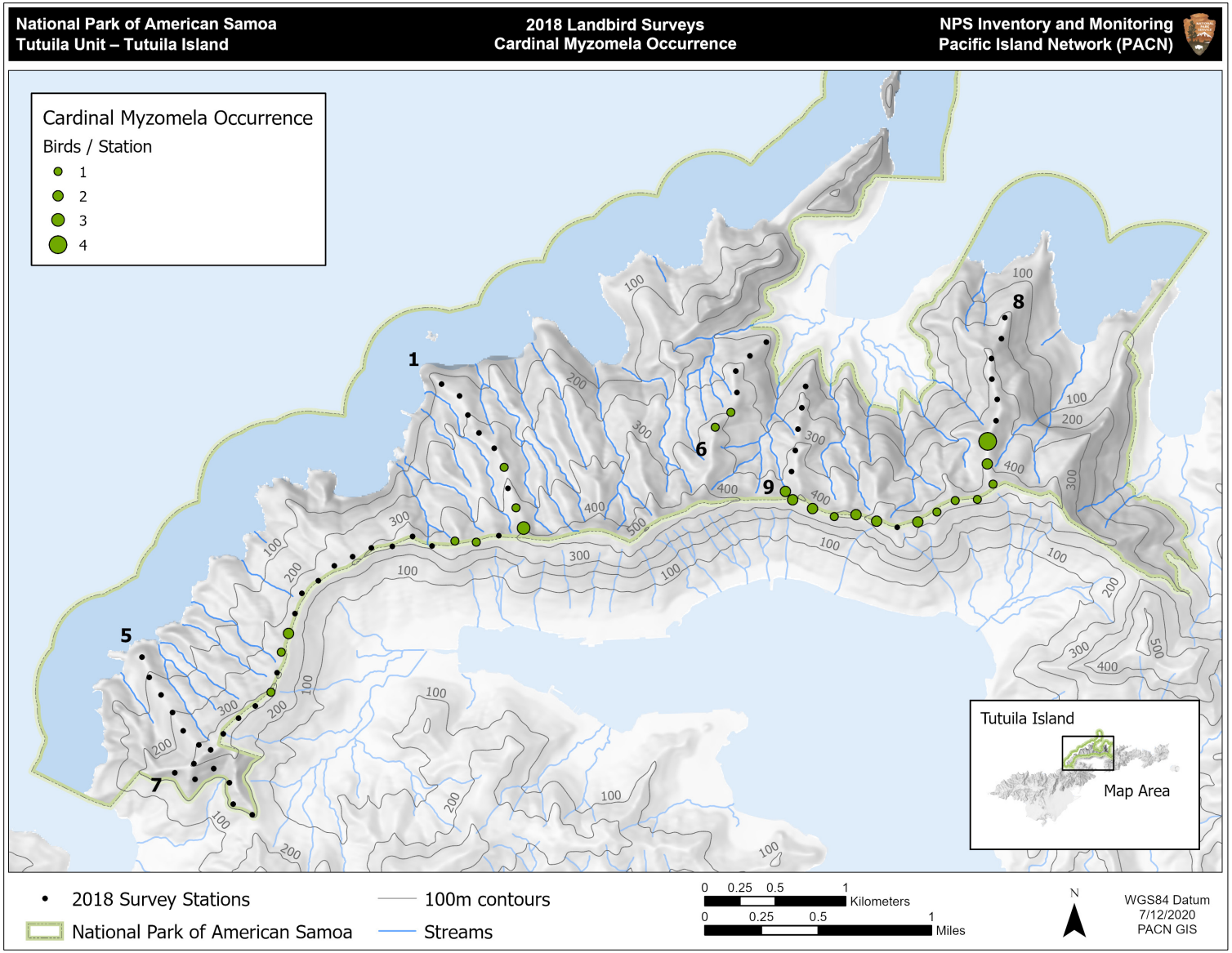
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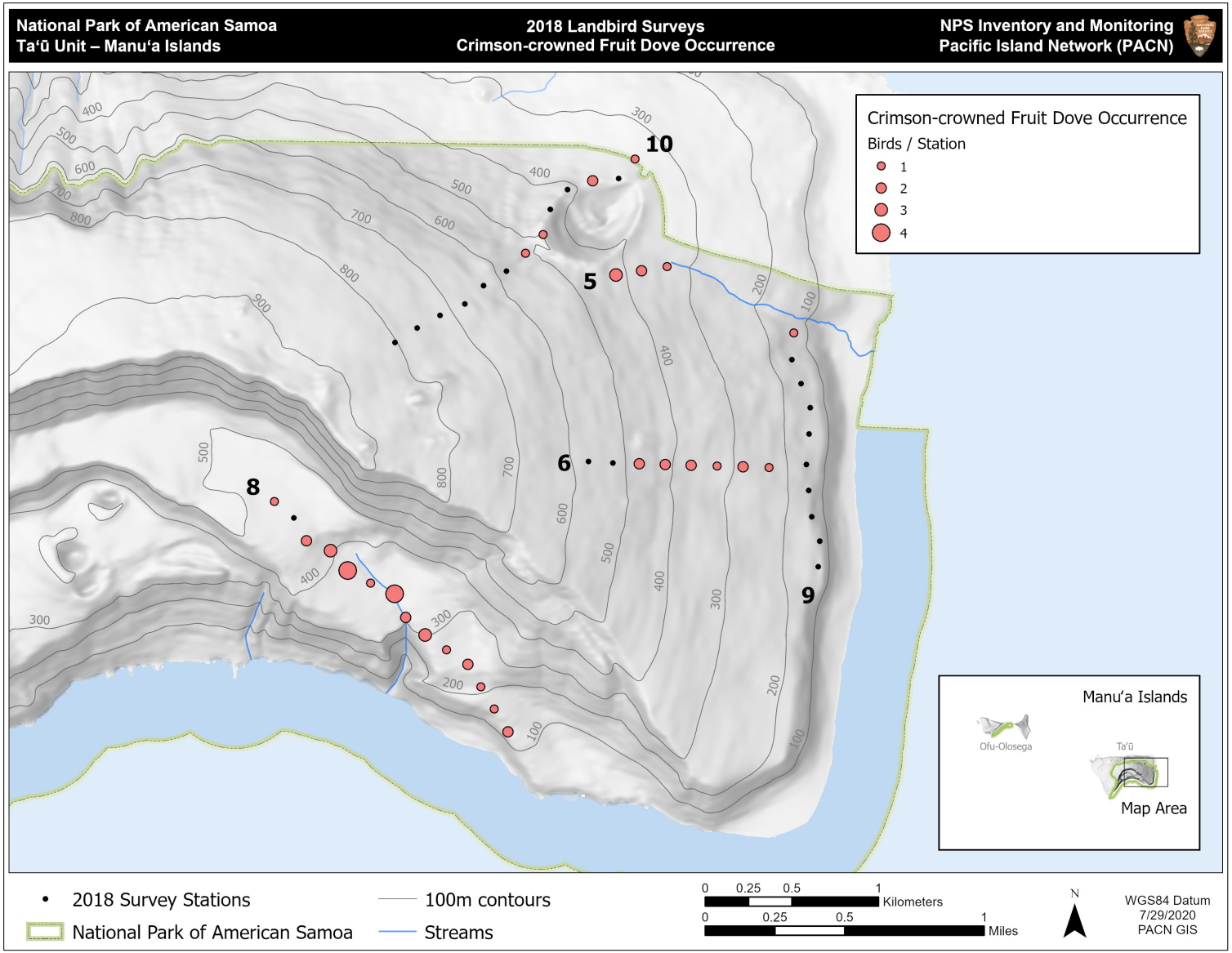
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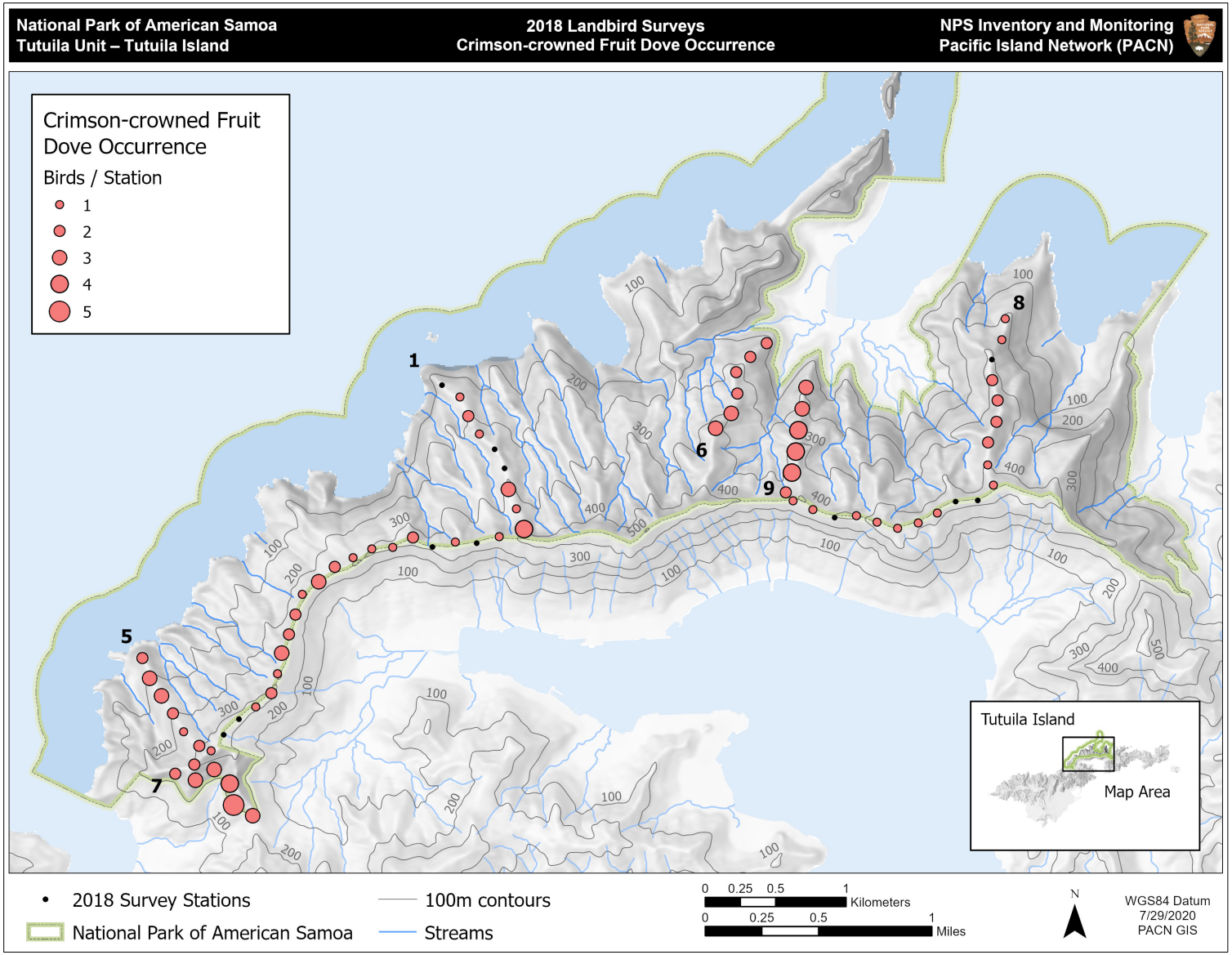
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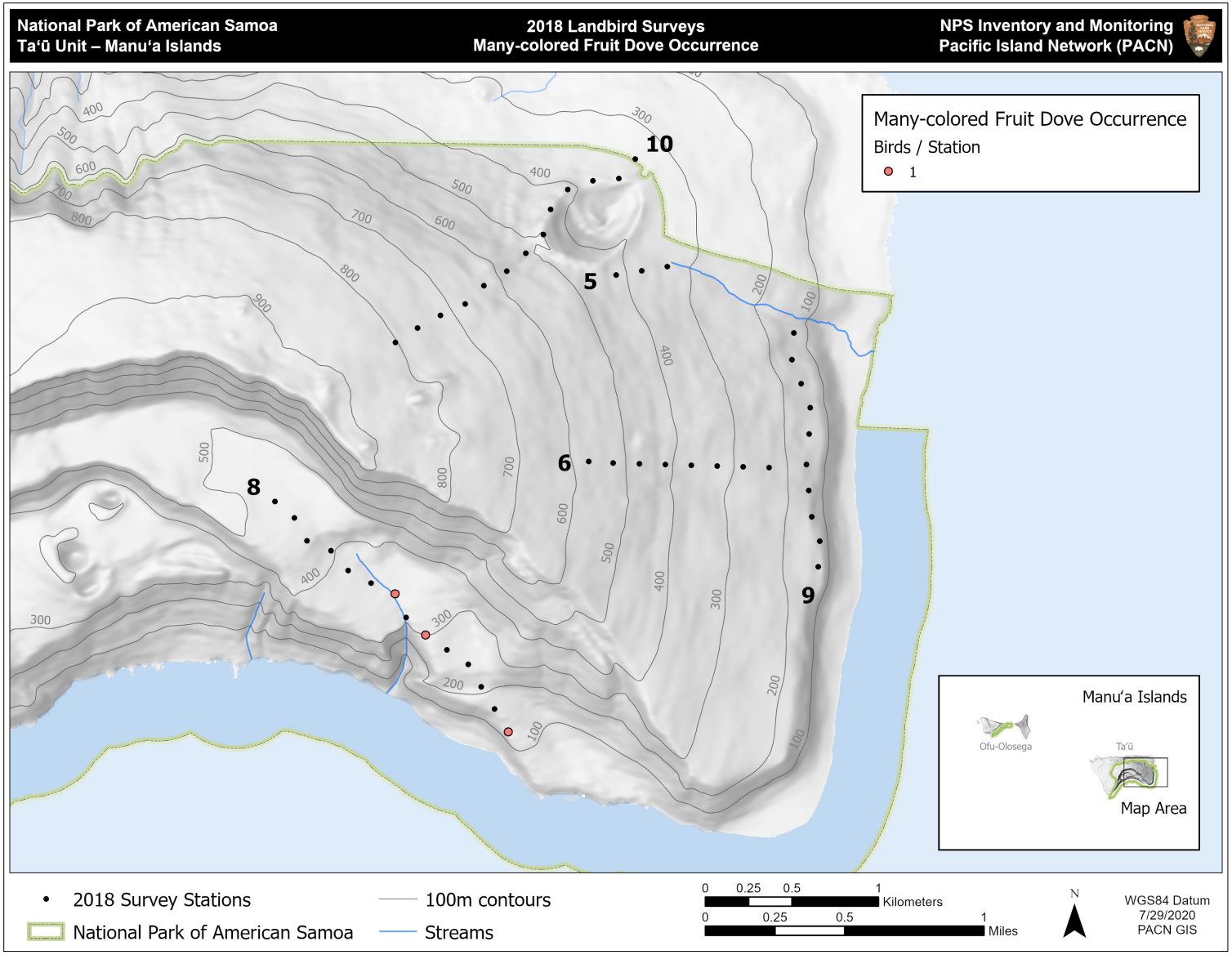
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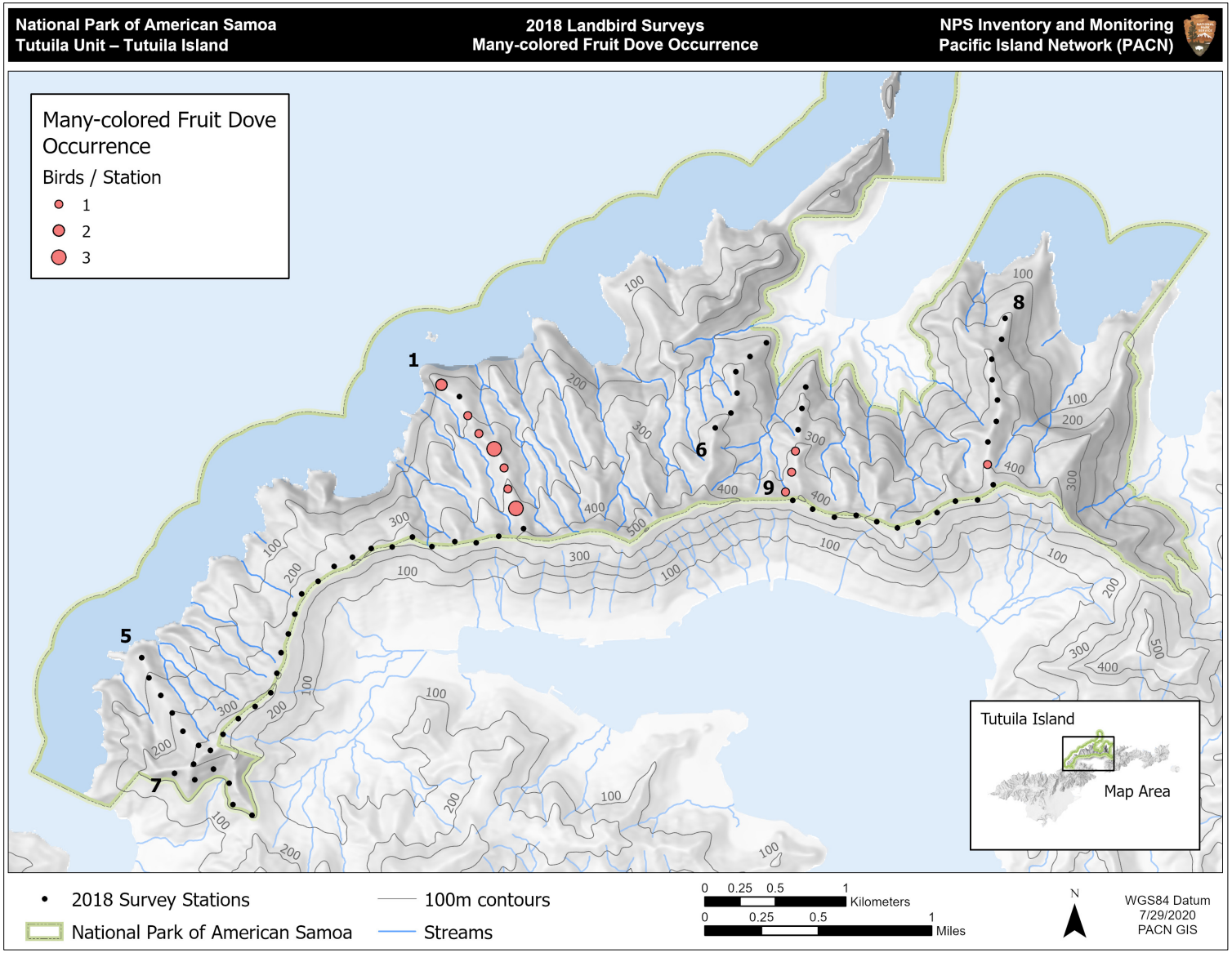
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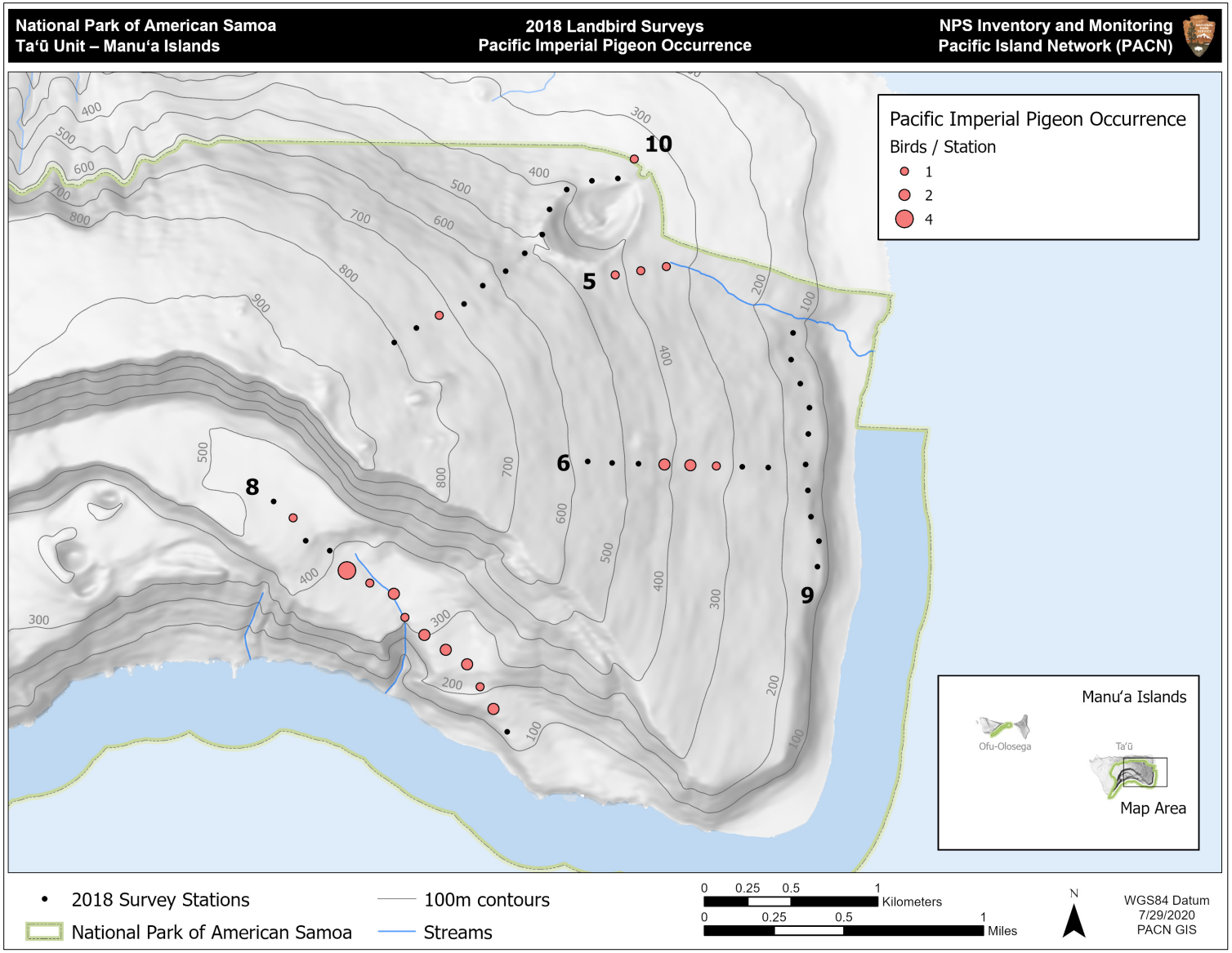
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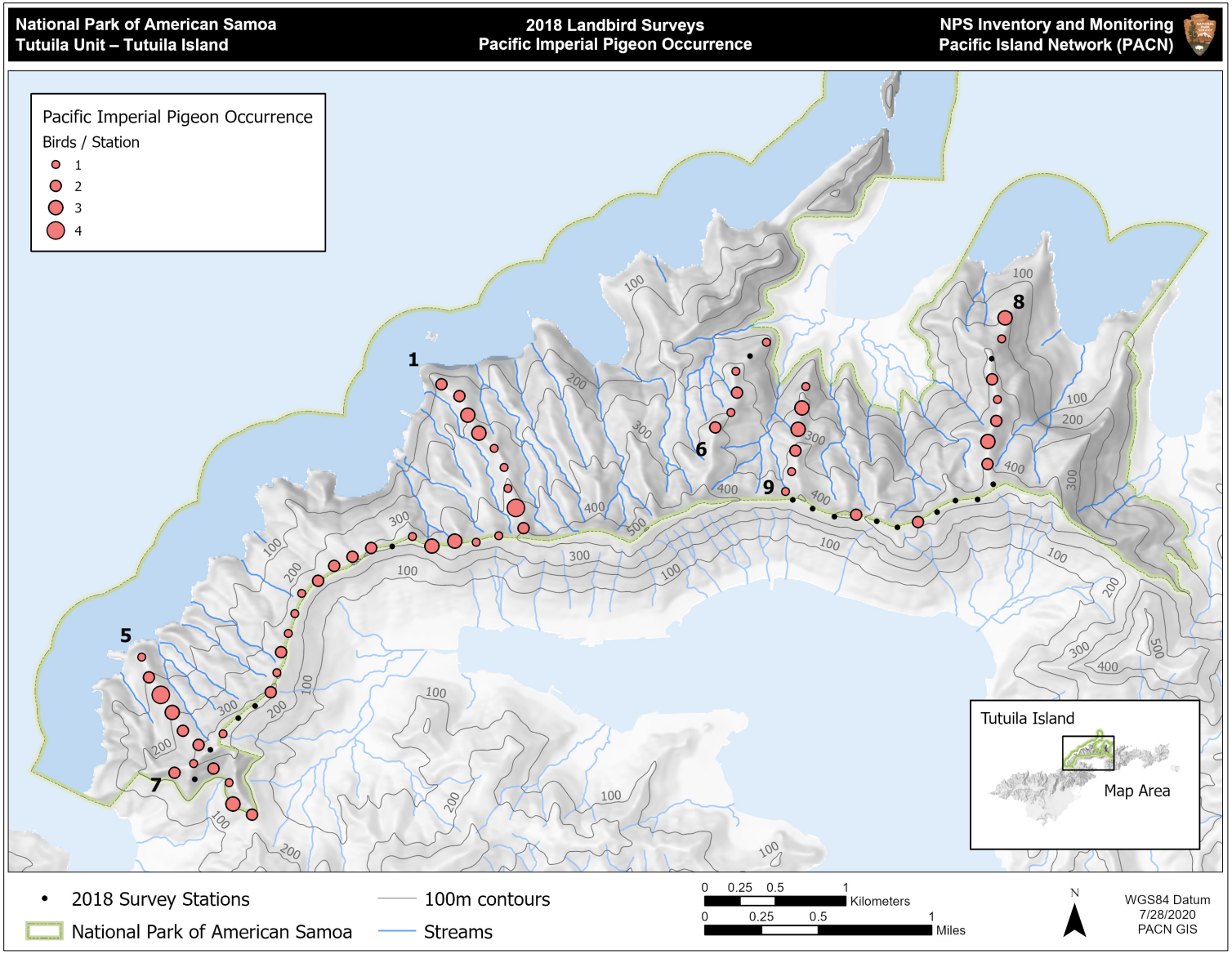
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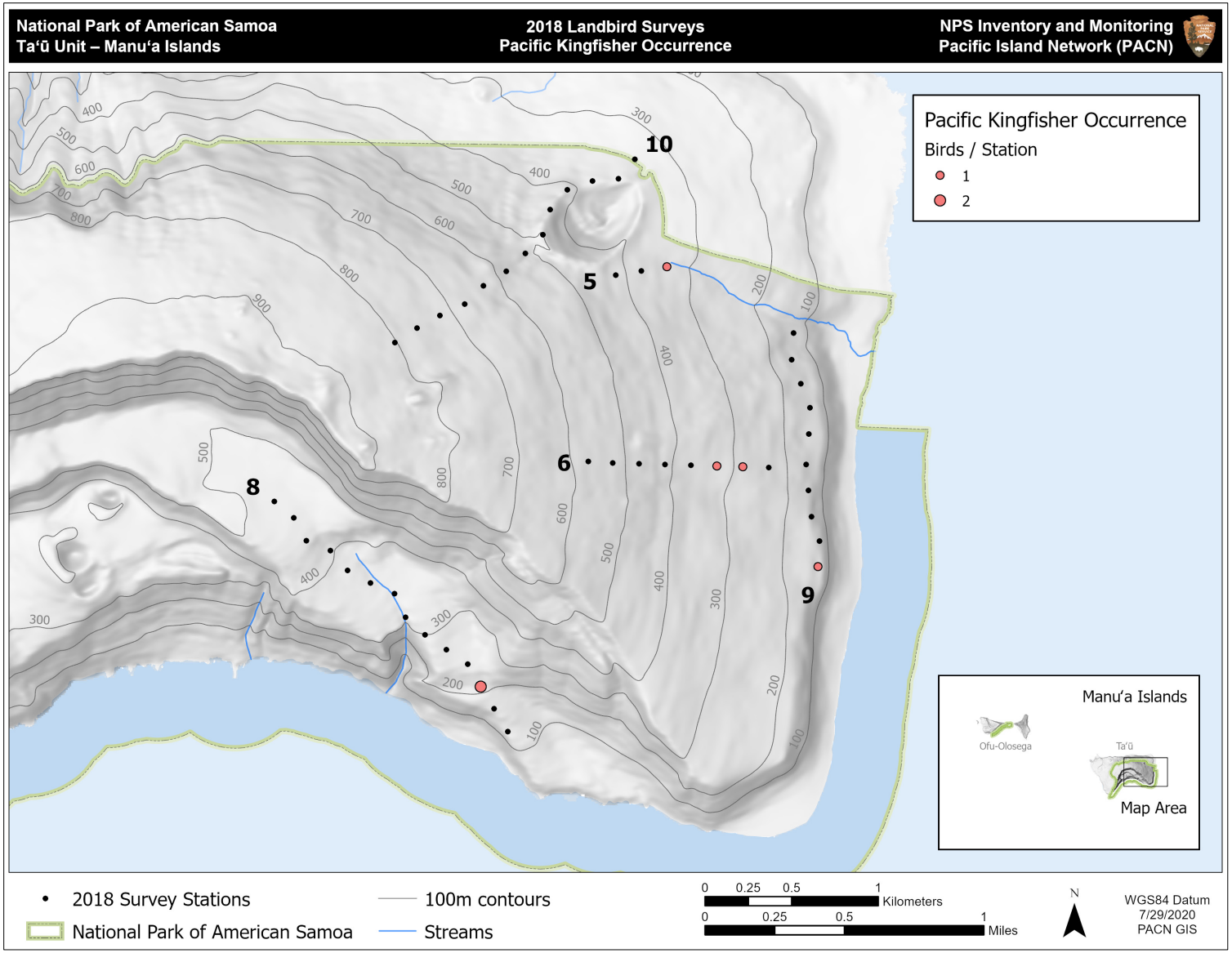
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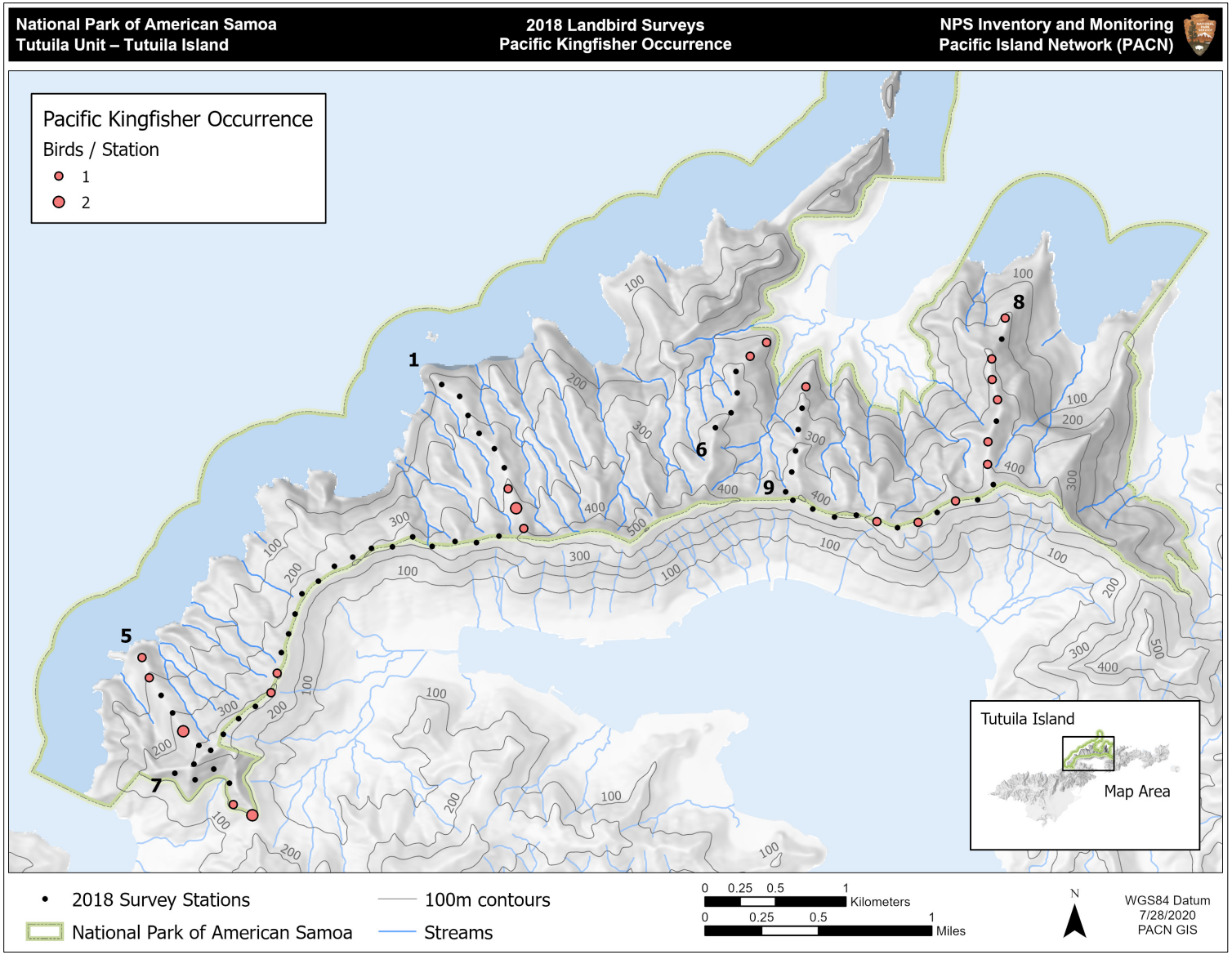
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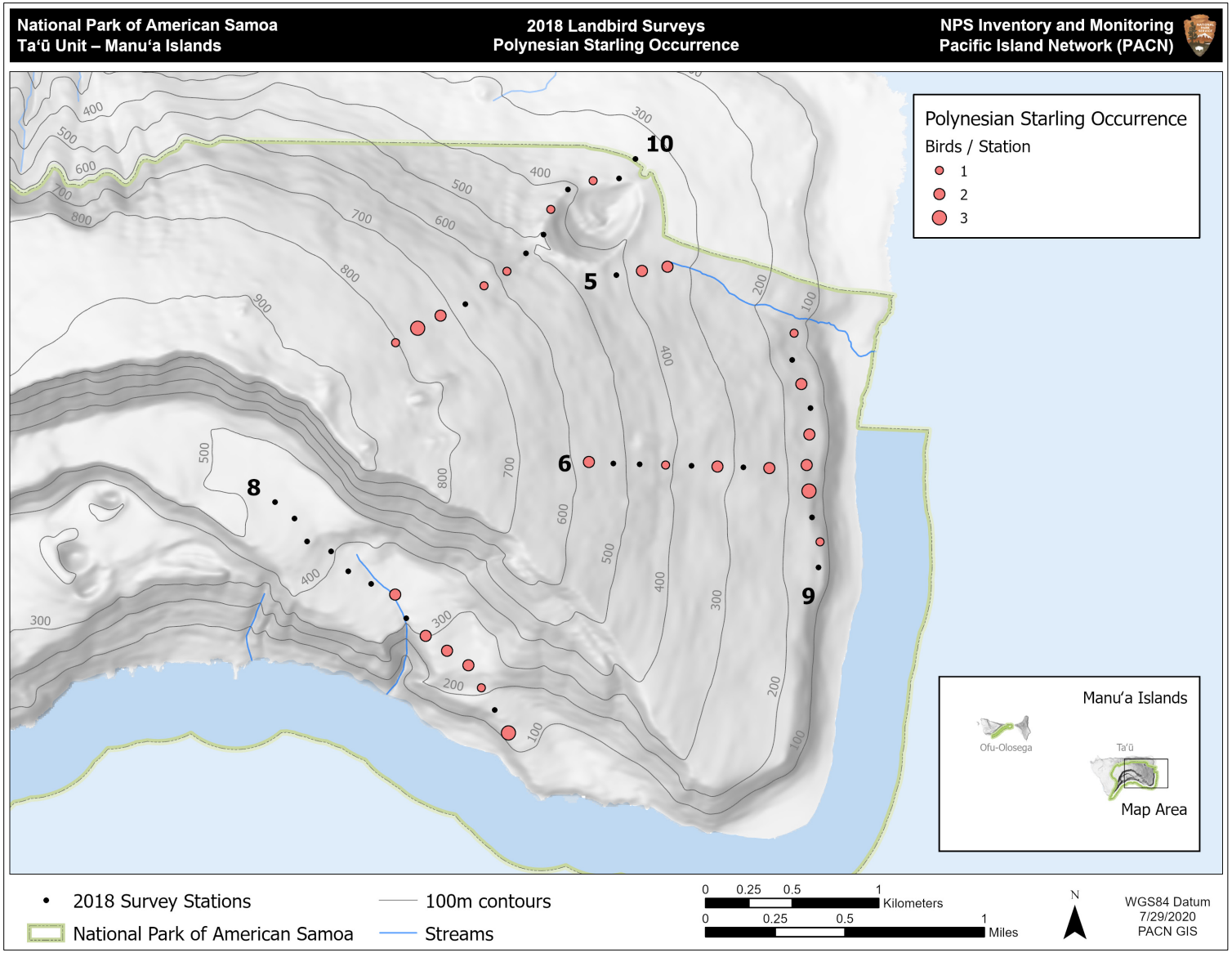
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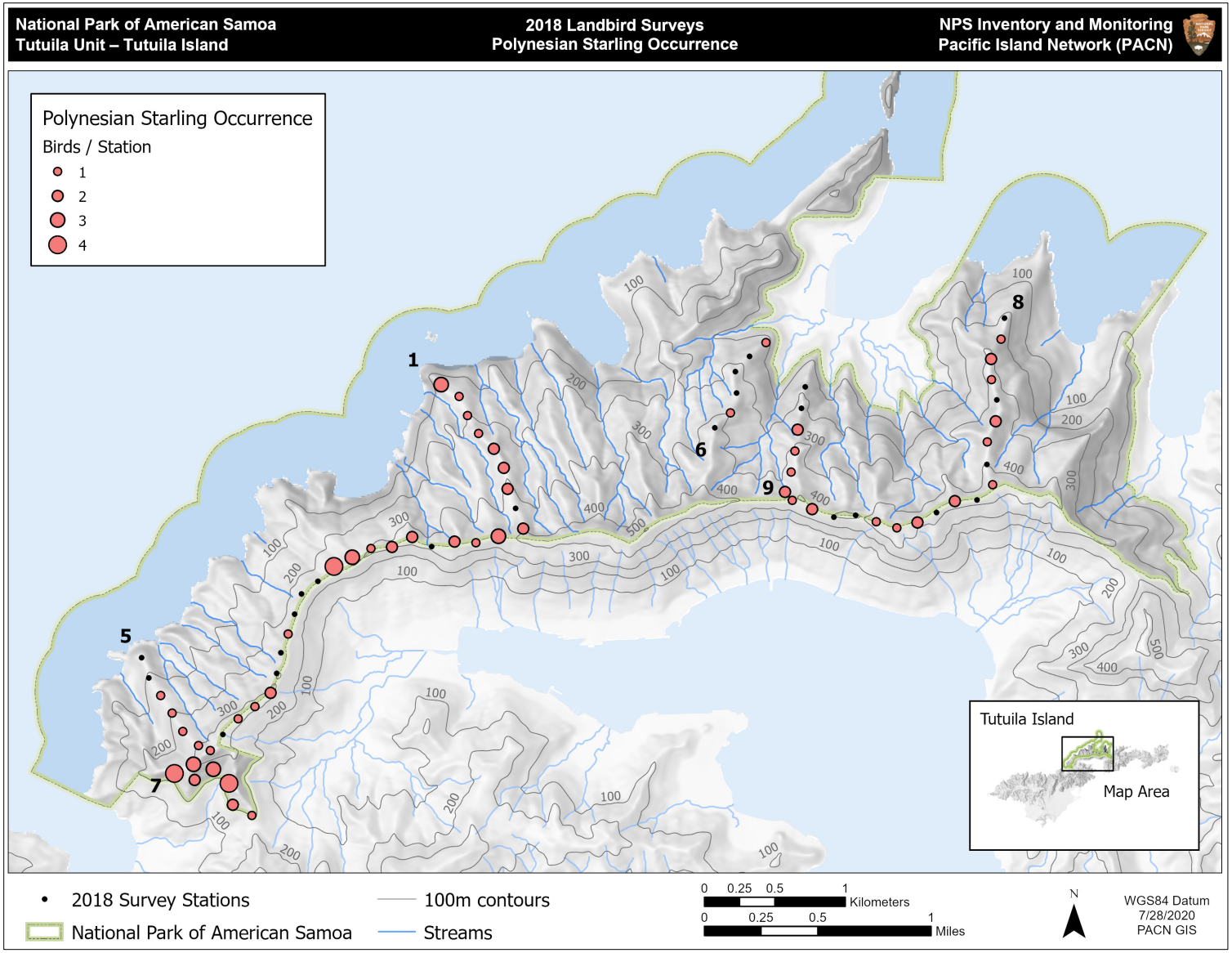
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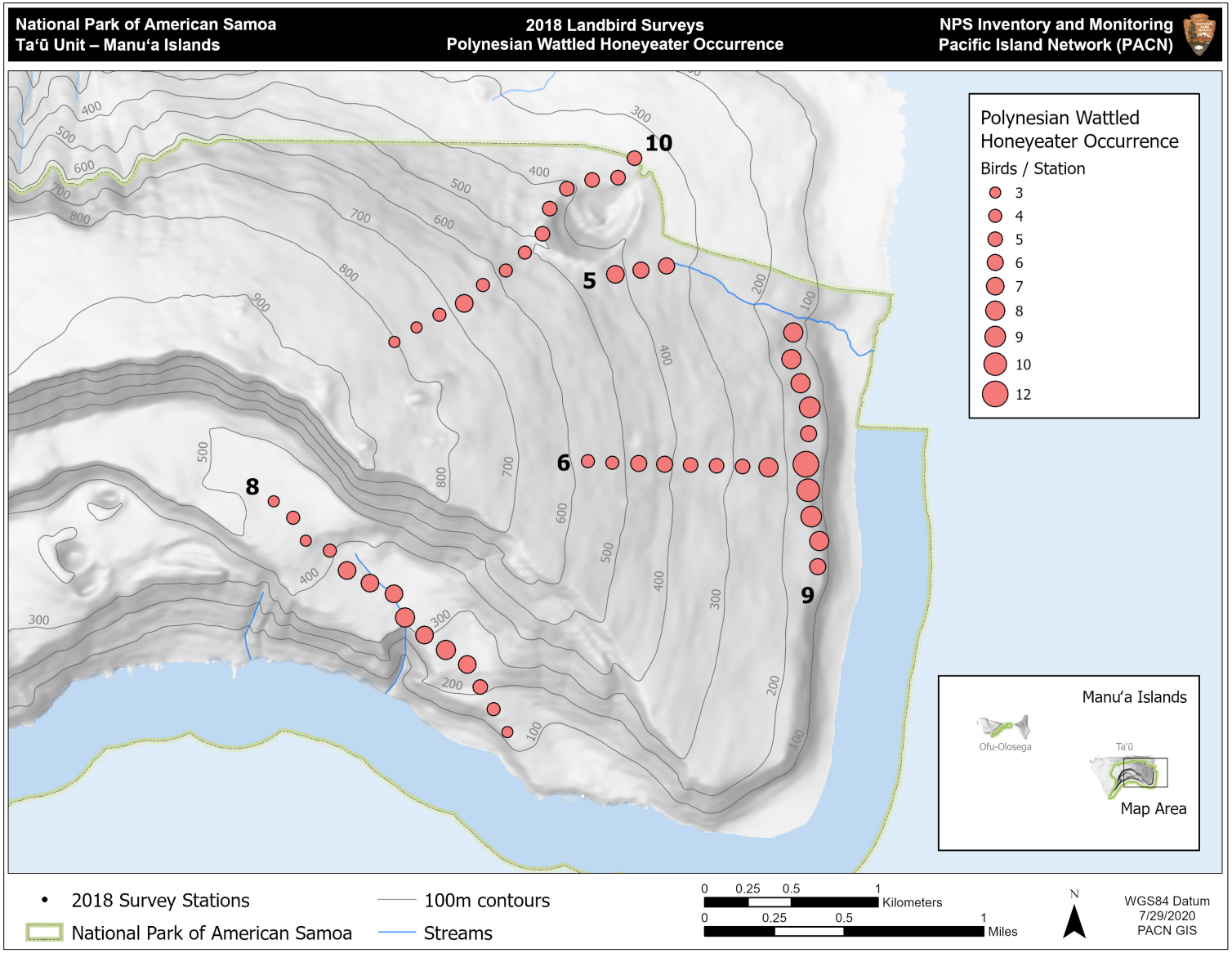
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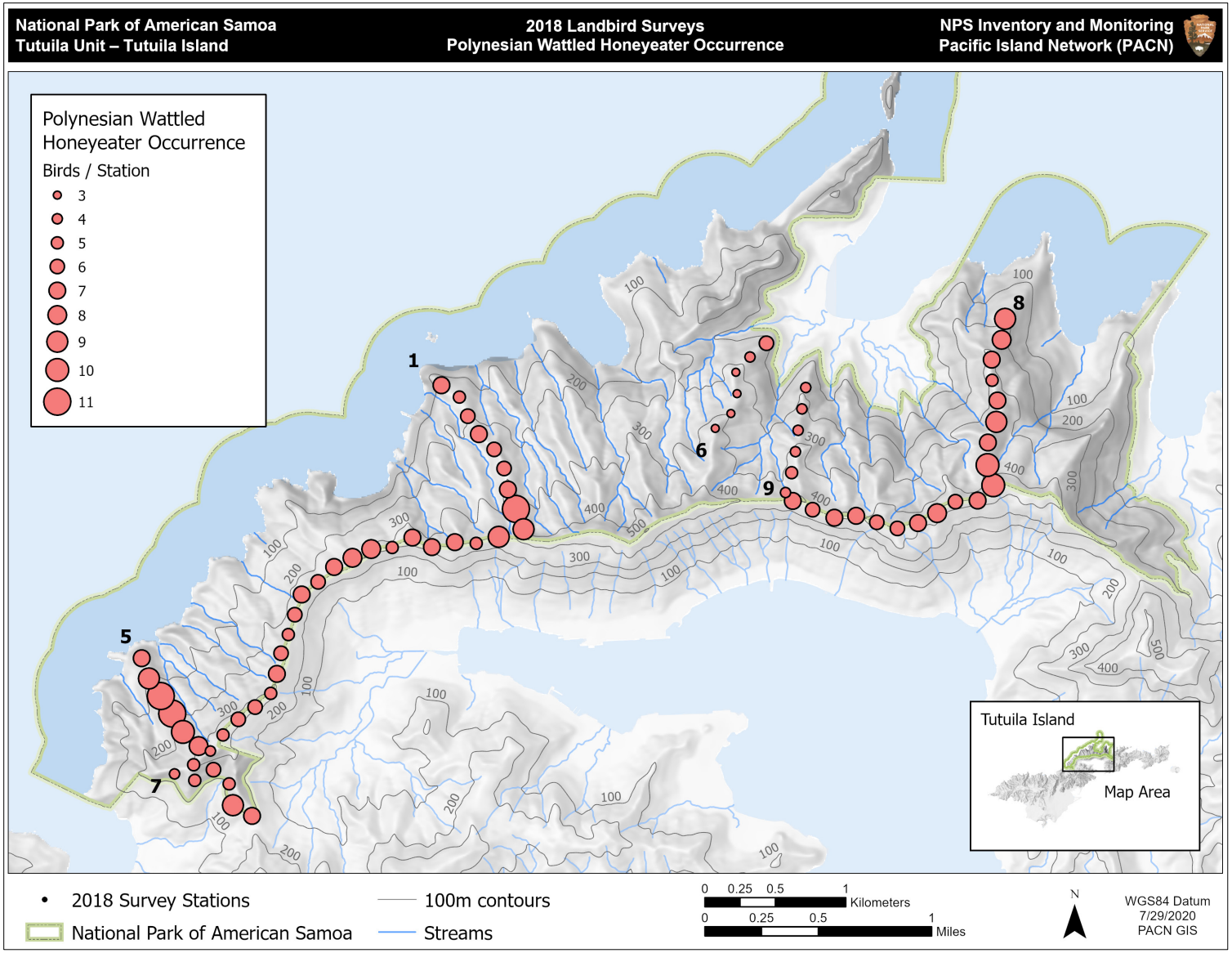
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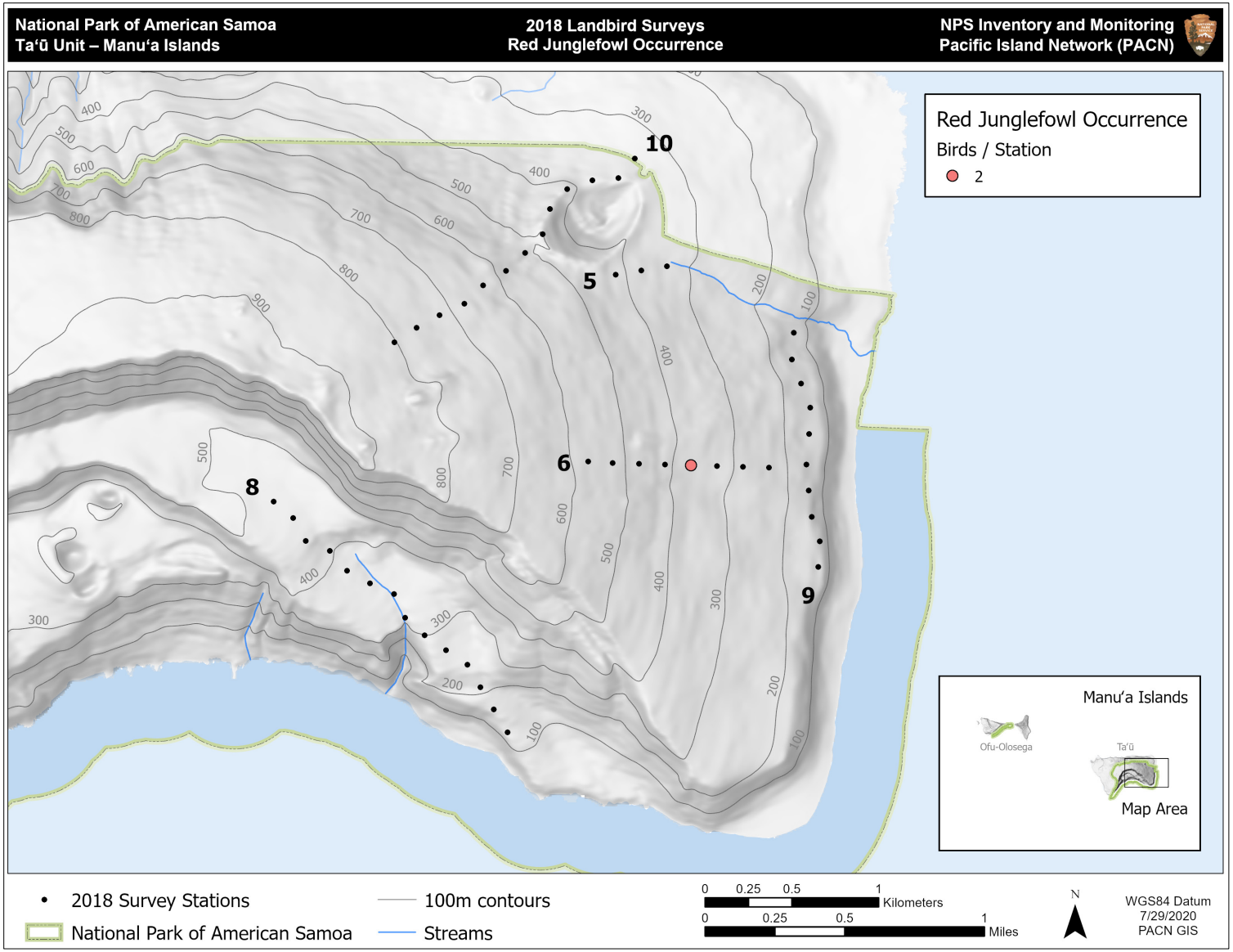
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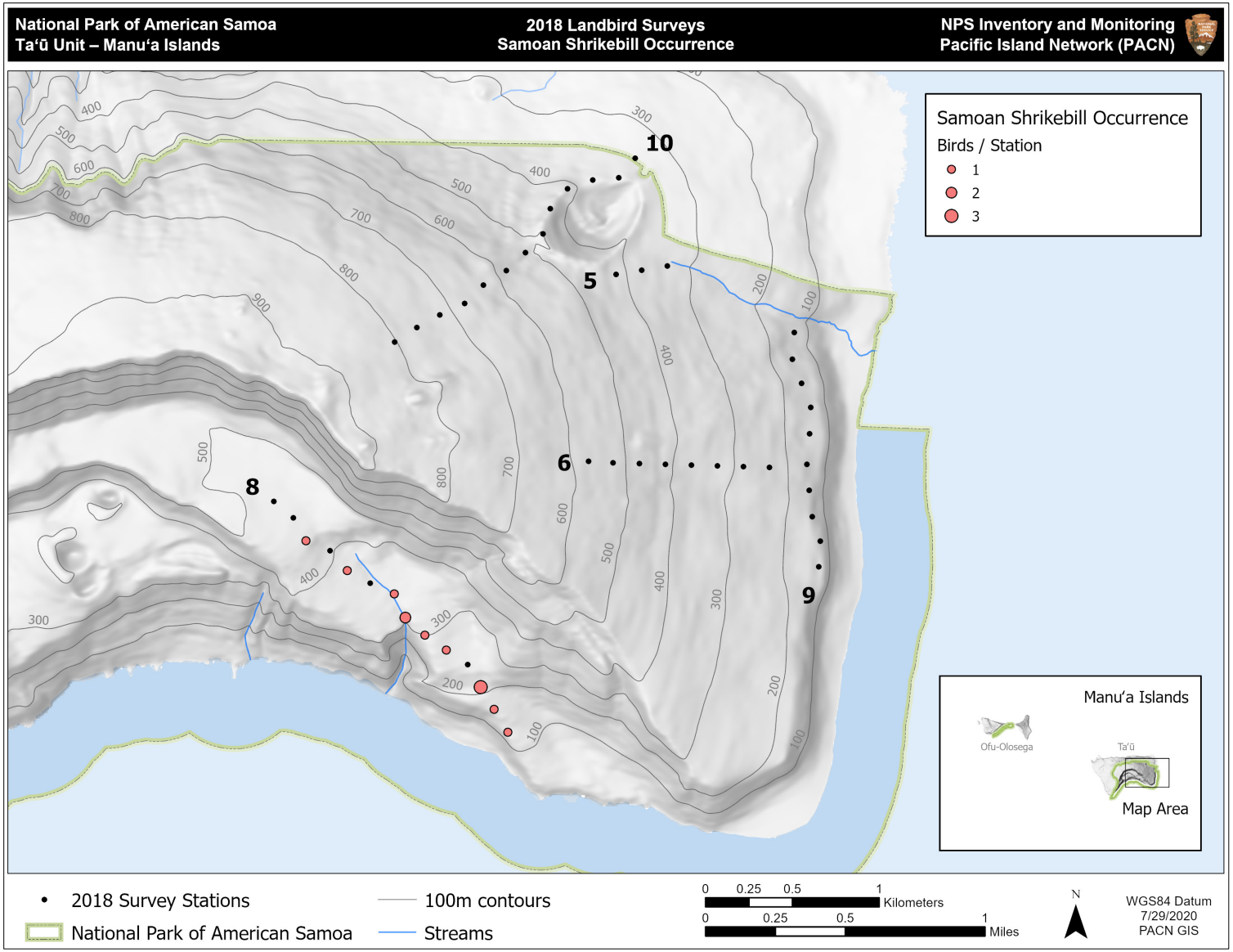
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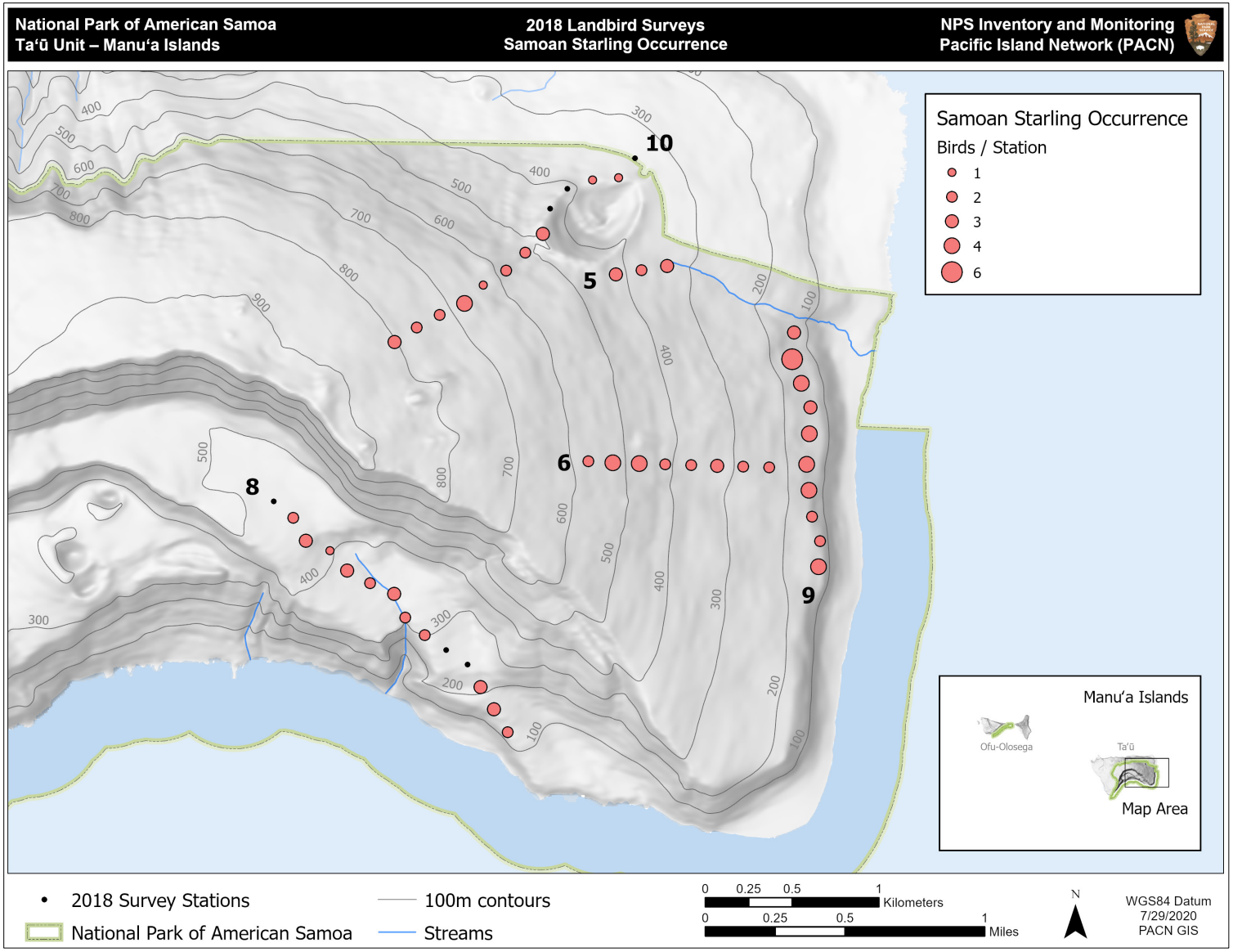
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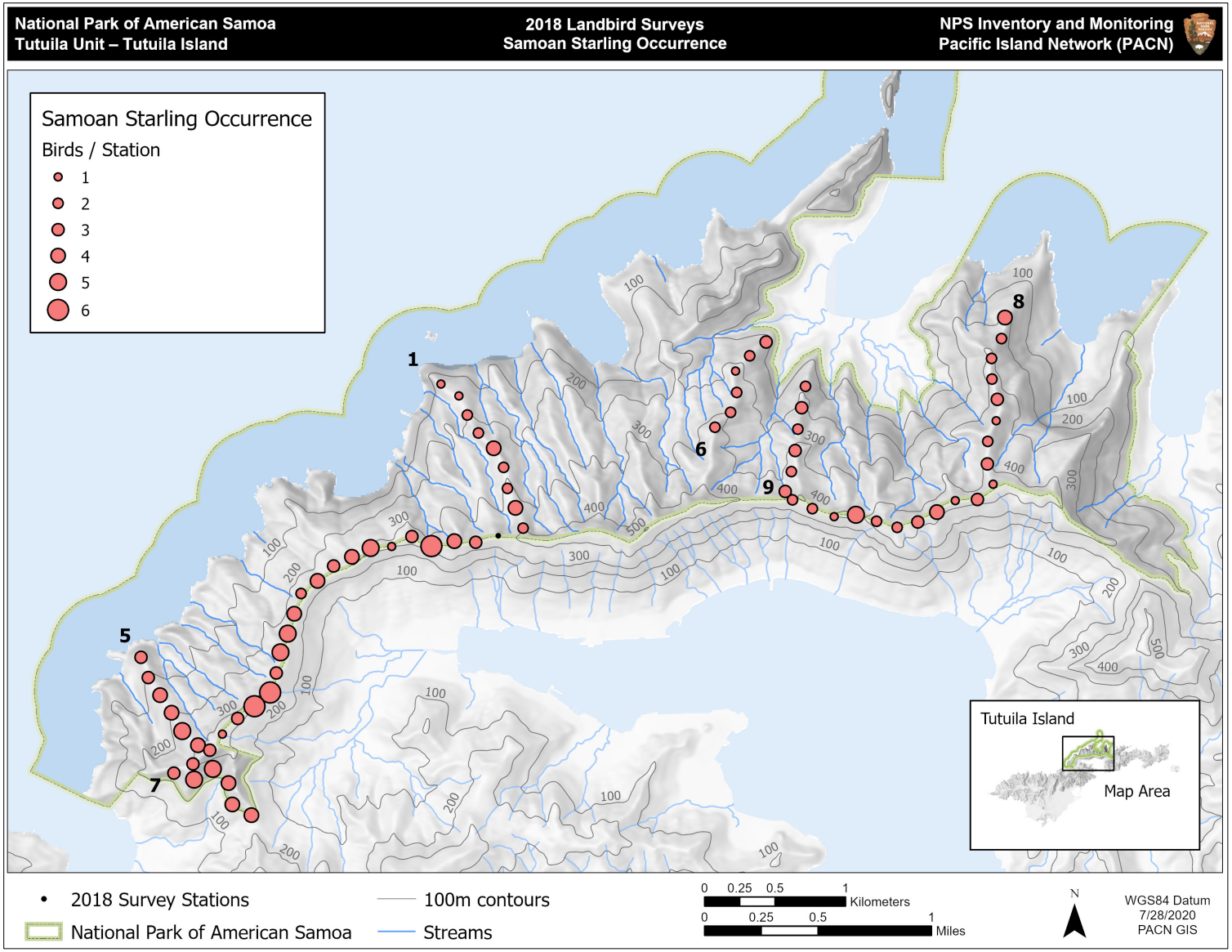
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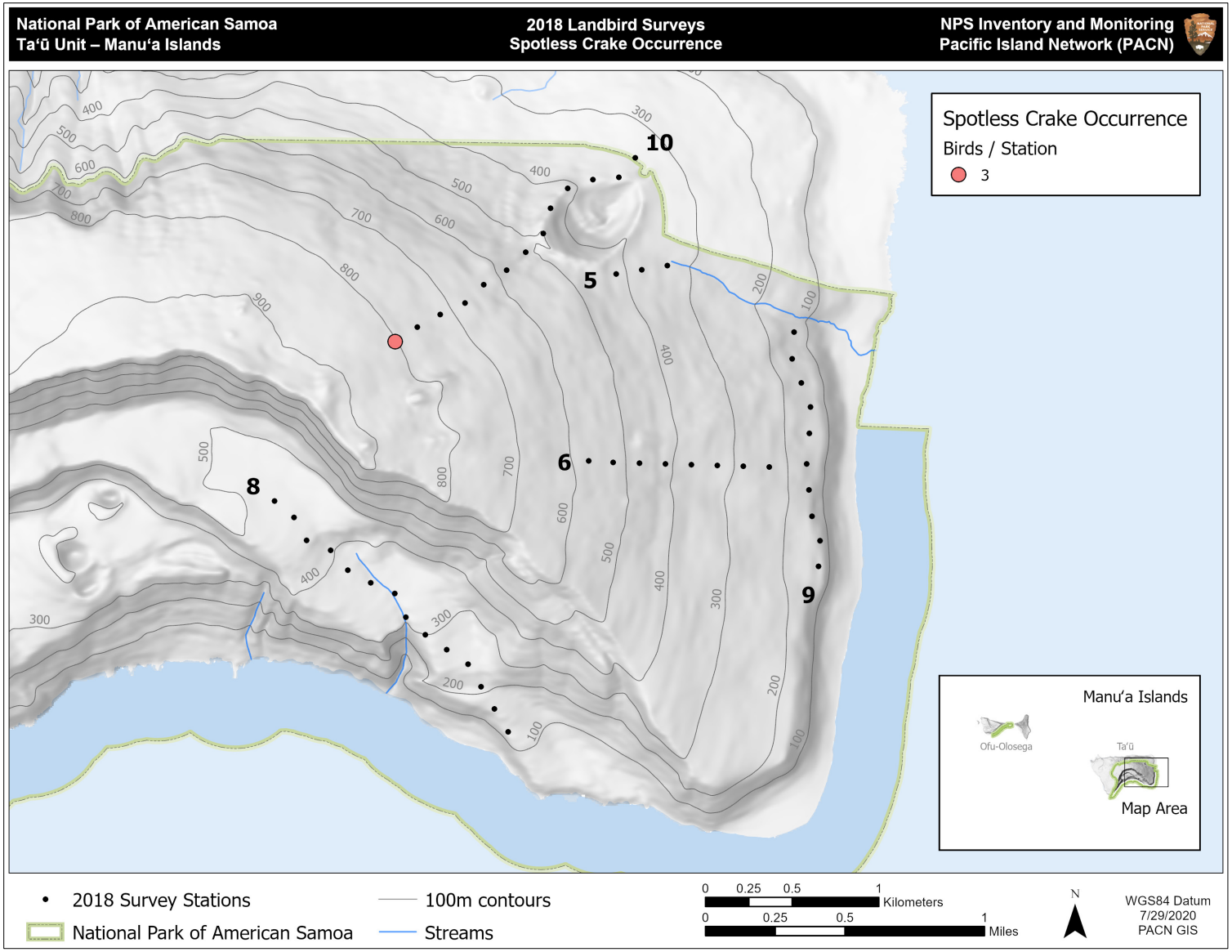
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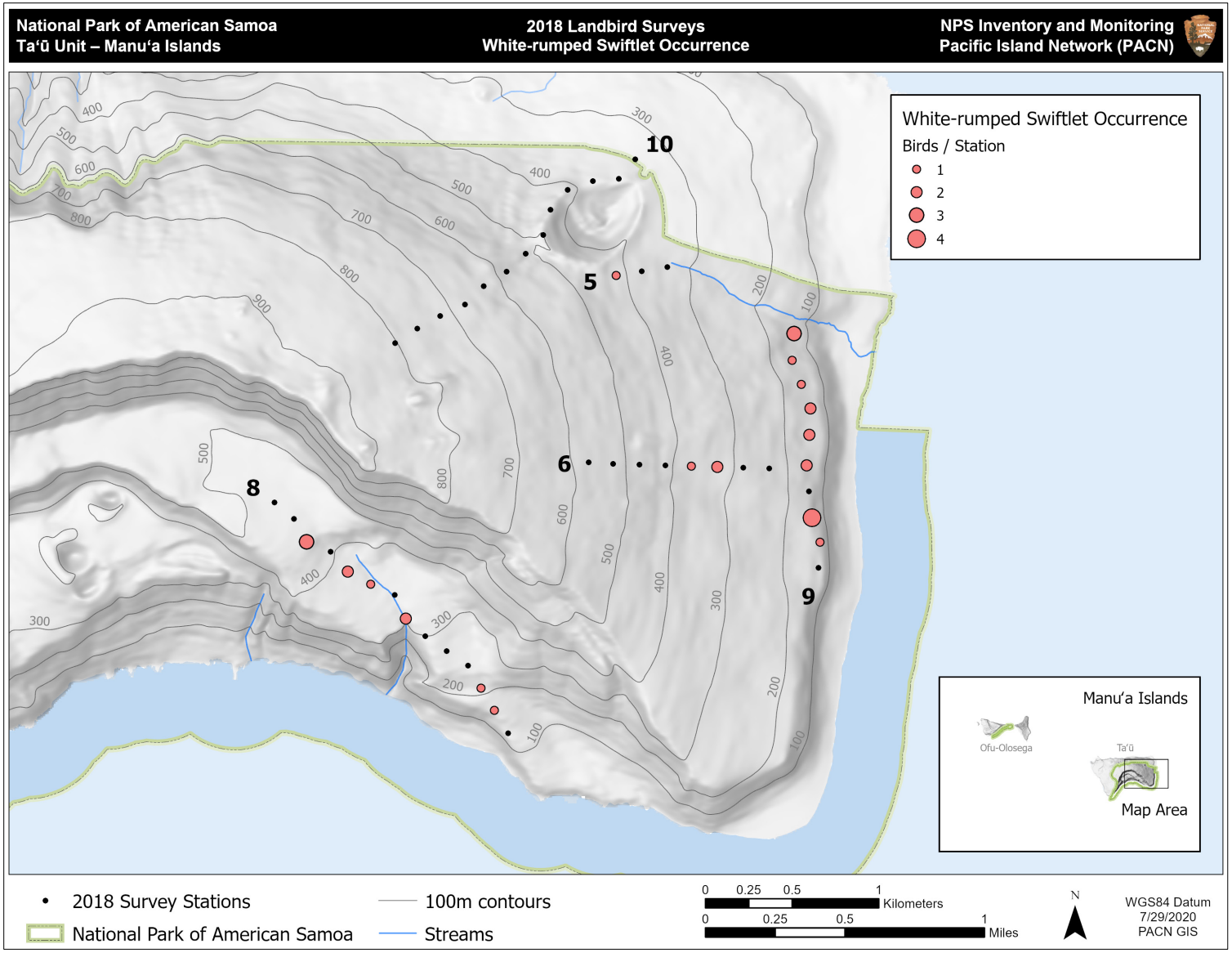
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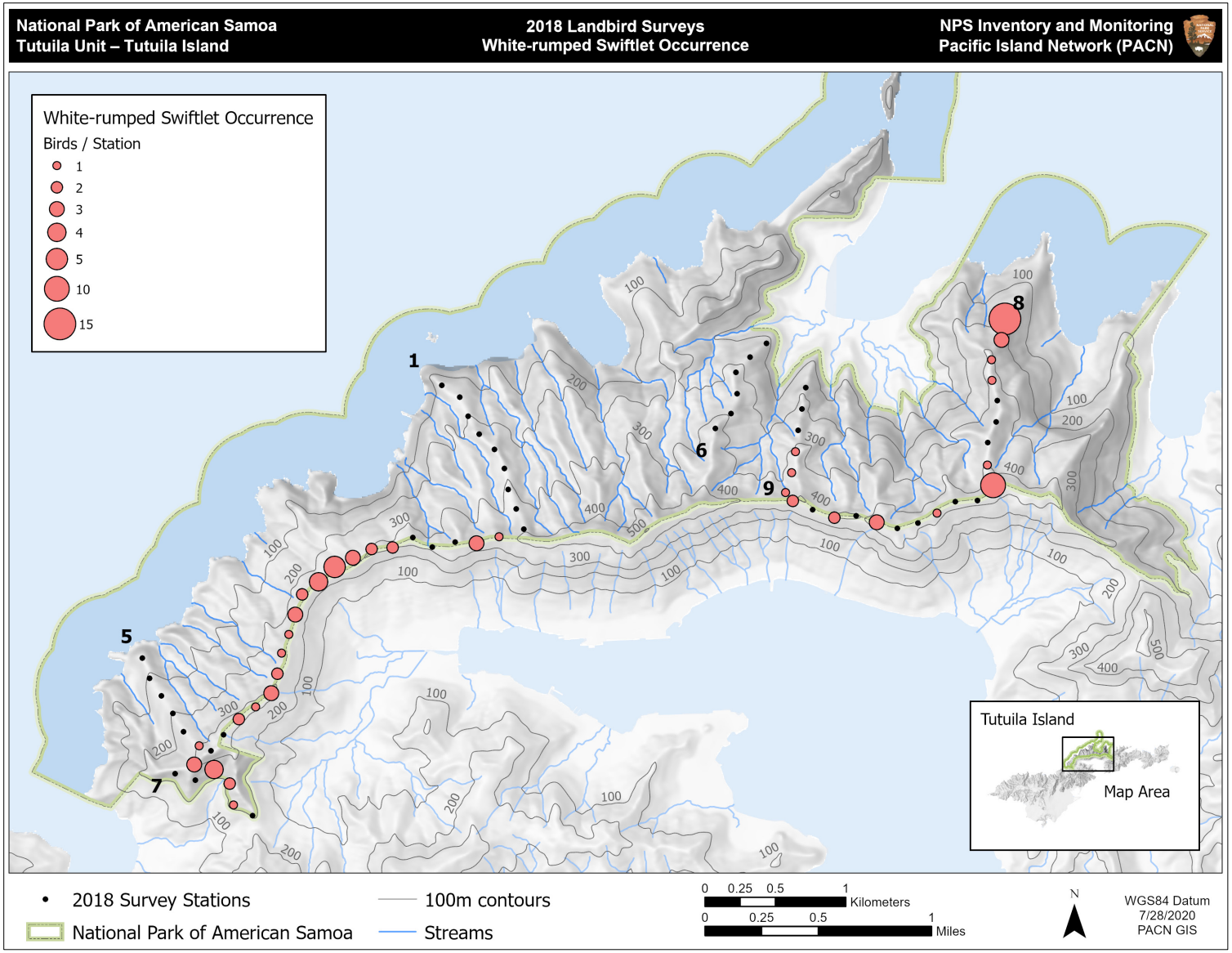
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Appendix D: NPSA Habitat Survey Results

Ta‘ū Unit

Habitat composition tables for the Ta‘ū Unit are presented below (Appendix D–Table 1 through Appendix D–Table 3).

Appendix D–Table 1. Canopy composition classes documented at landbird monitoring stations in the Ta‘ū Unit (50-m radius plot). The most dominant classes are listed first and then followed by sub-dominant classes.

Canopy Class	Count	%
Native Trees, Native Ferns	18	37.5%
Native Trees	16	33.3%
Native Trees, Native Ferns, Native Vines	5	10.4%
Native Ferns, Native Trees	2	4.2%
Native Trees, Native Vines, Native Ferns, Native Orchids	2	4.2%
Native Trees, Tree Ferns, Native Vines, Native Orchids	2	4.2%
Native Trees, Native Ferns, Native Shrubs, Native Orchids	1	2.1%
Native Trees, Native Vines	1	2.1%
Tree Ferns, Native Trees	1	2.1%

Appendix D–Table 2. Understory composition classes documented at landbird monitoring stations in the Ta‘ū Unit (50-m radius plot). The most dominant classes are listed first and then followed by sub-dominant classes.

Understory Class	Count	%
Bare Ground	14	29.2%
Native Ferns, Native Shrubs	7	14.6%
Native Ferns, Native Vines, Native Shrubs, Introduced Shrubs	6	12.5%
Native Ferns, Native Vines, Introduced Shrubs	5	10.4%
Native Ferns, Native Vines, Introduced Shrubs, Bare Ground	3	6.3%
Native Ferns, Native Shrubs, Native Vines, Introduced Shrubs	2	4.2%
Introduced Shrubs, Native Ferns, Native Shrubs, Native Vines, Introduced Vines	2	4.2%
Native Ferns, Native Shrubs, Native Vines, Introduced Vines	1	2.1%
Native Ferns, Native Vines	1	2.1%

Appendix D–Table 2 (continued). Understory composition classes documented at landbird monitoring stations in the Taʻū Unit (50-m radius plot). The most dominant classes are listed first and then followed by sub-dominant classes.

Understory Class	Count	%
Native Ferns, Native Vines, Bare Ground, Introduced Vines, Introduced Shrubs	1	2.1%
Native Ferns, Introduced Shrubs, Bare Ground	1	2.1%
Native Shrubs, Native Ferns	1	2.1%
Native Shrubs, Native Orchids, Native Ferns	1	2.1%
Native Vines, Native Ferns	1	2.1%
Native Vines, Native Shrubs, Native Ferns, Introduced Shrubs	1	2.1%
Native Vines, Native Shrubs, Native Ferns, Introduced Vines, Introduced Shrubs	1	2.1%

Appendix D–Table 3. Canopy cover and canopy height classes recorded at landbird monitoring stations with the Taʻū Unit in 2018.

Canopy Cover	Count	Percent	Canopy Height	Count	Percent
Closed (>60% cover)	38	79.2%	3 (>10m tall)	36	75.0%
Open (25–60% cover)	6	12.5%	2 (5–10m tall)	7	14.6%
Scattered (5–25% cover)	4	8.3%	1 (2–5m tall)	5	10.4%

Tutuila Unit

Habitat composition tables for the Tutuila Unit are presented below (Appendix D–Table 4 through Appendix D–Table 6).

Appendix D–Table 4. Canopy composition classes documented at landbird monitoring stations in the Tutuila Unit (50-m radius plot). The most dominant classes are listed first and then followed by sub-dominant classes.

Canopy Class	Count	%
Native Trees	37	50.7%
Native Trees, Native Shrubs, Native Ferns	6	8.2%
Native Trees, Native Shrubs	4	5.5%
Native Trees, Native Ferns, Native Orchids, Native Shrubs	3	4.1%
Native Trees, Introduced Trees	2	2.7%
Native Trees, Native Ferns, Native Shrubs	2	2.7%
Native Trees, Native Ferns, Native Shrubs, Native Orchids	2	2.7%

Appendix D–Table 4 (continued). Canopy composition classes documented at landbird monitoring stations in the Tutuila Unit (50-m radius plot). The most dominant classes are listed first and then followed by sub-dominant classes.

Canopy Class	Count	%
Native Trees, Native Shrubs, Native Vines, Native Ferns	2	2.7%
Native Trees, Native Vines, Native Ferns, Native Orchids	2	2.7%
Other	13	<2%

Appendix D–Table 5. Understory composition classes documented at landbird monitoring stations in the Tutuila Unit (50-m radius plot). The most dominant classes are listed first and then followed by sub-dominant classes.

Understory Class	Count	%
Native Ferns, Native Shrubs, Introduced Shrubs	9	12.3%
Introduced Grasses, Introduced Vines	7	9.6%
Native Ferns, Native Shrubs, Bare Ground	6	8.2%
Native Ferns, Introduced Shrubs	5	6.8%
Native Ferns, Native Vines	4	5.5%
Introduced Grasses, Introduced Vines, Native Vines	3	4.1%
Native Shrubs, Native Ferns, Bare Ground	3	4.1%
Introduced Grasses, Native Vines	2	2.7%
Introduced Vines, Introduced Grasses	2	2.7%
Native Ferns, Introduced Grasses, Native Shrubs	2	2.7%
Native Ferns, Native Vines, Native Shrubs	2	2.7%
Native Ferns, Introduced Vines, Introduced Shrubs	2	2.7%
Native Vines, Introduced Shrubs	2	2.7%
Other	23	<2%

Appendix D–Table 6. Canopy cover and canopy height classes recorded at landbird monitoring stations with the Tutuila Unit in 2018.

Canopy Cover	Count	Percent	Canopy Height	Count	Percent
Closed (>60% cover)	45	61.6%	2 (5–10m tall)	49	67.1%
Open (25–60% cover)	1	1.4%	3 (>10m tall)	23	31.5%
Scattered (5–25% cover)	27	37%	1 (2–5m tall)	1	1.4%

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.

NPS 126/175025, February 2021



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