SPECIES STATUS ASSESSMENT FOR THE OKINAWA WOODPECKER (*DENDROCOPOS NOGUCHII*)

U.S. Fish and Wildlife Service
Division of Conservation and Classification
Branch of Delisting and Foreign Species
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CHAPTER 1 – INTRODUCTION

1.1 SPECIES OVERVIEW

The Okinawa woodpecker (*Dendrocopos noguchii*) is a large woodpecker species that is endemic to the island of Okinawa. The island of Okinawa is part of the Central Ryukyu Island chain and is under the jurisdiction of Japan. The species occurs within mature forested areas in the northern part of Okinawa, generally known as the Yambaru (or Yanbaru) Forest. The Okinawa woodpecker is also known by the common names Noguchigera, Noguchi Gera, Noguchi's woodpecker, and Pryer's woodpecker (Short 1973, p. 5; Gorman 2014, p. 255).

The Okinawa woodpecker is categorized as Endangered by the Red List of the International Union for Conservation of Nature and Natural Resources (IUCN) (BirdLife International 2024, p. 1), and listed as critically endangered on the Red List of the Environmental Agency of Japan (Itô 2003, p. 12; Ministry of the Environment (MOE) 2020, p. 4). The Okinawa woodpecker is also designated as a National Endangered Species in Japan (Government (Govt) of Japan 2019, pp. 239–240).

1.2 PREVIOUS FEDERAL ACTIONS

On November 28, 1980, we received a petition from the International Council for Bird Preservation to list 79 bird species as endangered or threatened species under the Act. The International Council for Bird Preservation was renamed Birdlife International in 1994. Sixty species were foreign species, including Okinawa woodpecker (*Sapheopipo noguchii*), and 19 species occur on United States (U.S.) territory. On May 12, 1981, we published in the *Federal Register* (46 FR 26464) a 90-day finding in which we announced that the petition contained substantial information indicating that listing may be warranted for 77 of the 79 bird species, including the Okinawa woodpecker. At the time of the petition, the Okinawa woodpecker was classified as *Sapheopipo noguchii*. However, we recognized the Okinawa woodpecker in the genus *Dendrocopos* in 2009 and recognize the species as *Dendrocopos noguchii* and treat *Sapheopipo noguchii* as a synonym (74 FR 40540).

1.3 SSA FRAMEWORK

The Service uses the SSA framework (Service 2016, entire) to provide an integrated analytical approach to assess a species' current biological condition and its projected capability of sustaining populations in the wild into the future (Smith et al. 2018, entire). The purpose of the SSA Report is to provide a risk assessment of a species and assist in informing decisions and activities under the Endangered Species Act (Act).

Using the SSA framework we consider what a species needs to maintain its viability by characterizing the biological status of the species in terms of its resiliency, redundancy, and representation (3 Rs) (Shaffer and Stein 2000, pp. 308–311). For this assessment, we define viability as the ability of the species to sustain healthy populations in natural ecosystems within a biologically meaningful timeframe, based on the best available data to reasonably predict the potential effects of stressors within the range of the Okinawa woodpecker through this timeframe and capture a range of variation in environmental conditions for the species to sustain populations into the future. The 3 Rs are defined as follows:

- Resiliency is the ability of a species to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature, rainfall), periodic disturbances within the normal range of variation (fire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford et al. 2011, p. 40). Simply stated, resiliency is the ability of a species to bounce back and sustain populations through the natural range of favorable and unfavorable conditions. We can best gauge resiliency by evaluating population level characteristics such as: demography (abundance and the components of population growth rate -- survival, reproduction, and migration), genetic health (effective population size and heterozygosity), connectivity (gene flow and population rescue), and habitat quantity, quality, configuration, and heterogeneity.

- Redundancy is the ability of a species to withstand catastrophes. Catastrophes are stochastic events that are expected to lead to population collapse regardless of population health and for which adaptation is unlikely (Mangel and Tier 1993, p. 1083). We can best gauge redundancy by analyzing the number, distribution, and condition of populations relative to the scale of anticipated species-relevant catastrophic events. The analysis entails assessing the cumulative risk of catastrophes occurring over time. Redundancy can be analyzed at a population or regional scale, or for narrow-ranged species, at the species level.

- Representation is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments – referred to as adaptive capacity – is essential for viability as species need to continually adapt to their continuously changing environments (Nicotra et al. 2015, p. 1269). Species adapt to novel changes in their environment by either moving to new, suitable environments or by altering their physical or behavioral traits (phenotypes) to match the new environmental conditions through either plasticity or genetic change (Nicotra et al. 2015, p. 1270; Beever et al. 2016, p. 132). The latter adaptation occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Zackay 2007, p. 1; Crandall et al. 2000, p. 290–291; Sgro et al. 2011, p. 327).

  We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas. In assessing the breadth of variation, it is important to consider both larger-scale variation (such as morphological, behavioral, or life history differences which might exist across the range and environmental or ecological variation across the range), and smaller-scale variation (which might include measures of interpopulation genetic diversity). In assessing the dispersal ability, it is important to evaluate the ability and likelihood of the species to track suitable habitat and climate over time. Lastly, to evaluate the evolutionary processes that contribute to and maintain adaptive capacity, it is important to assess natural levels and patterns of gene flow, the degree of ecological diversity occupied, and effective population size. In our species status assessments, we assess all three facets based on available data.

CHAPTER 2 – SPECIES BIOLOGY

In this chapter we provide basic information about Okinawa woodpecker, detailing its taxonomy, physical description, historical range and distribution, and general life history traits.

2.1 TAXONOMY

The Okinawa woodpecker (*Dendrocopos noguchii*) was first described as *Picus noguchii* in 1887 but was moved into the monotypic genus *Sapheopipo* in 1890, based on its distinct coloration (Seebohm 1887; Short 1973; Winkler et al. 2005). The Checklist of Japanese Birds retains the species in the monotypic genus *Sapheopipo* (Ornithological Society of Japan 2012, online checklist). However, the Integrated Taxonomic Information System (ITIS 2025, unpaginated) and International Union for Conservation of Nature (IUCN) (BLI 2024 p. 1) recognize this species as *Dendrocopos noguchii*, based on genetic evidence in combination with a reevaluation of its morphology. This reevaluation places the species within *Dendrocopos*, a polytypic genus (Winkler *et al.* 2005, pp. 103–109; Ornithological Society of Japan 2024). We consider Winkler *et al.* (2005, pp. 103–109), Pons *et al.* (2021, pp 160–161), and the Ornithological Society of Japan 2024 to represent the best scientific and commercial data available regarding the species' taxonomy and recognize the taxon *Dendrocopos noguchii* and treat *Sapheopipo noguchii* as a synonym.

2.2 PHYSICAL DESCRIPTION

The Okinawa woodpecker is a relatively large woodpecker that is 31–35 centimeters (cm; 12–14 inches (in)) in length. It has a dark red belly and vent, and some red on the breast and mantle (BLI 2024, p. 1, Brazil 2014, p. 284). The species is generally dark brown with red tips on all feathers and white spots on the primary feathers (BLI 2024, p. 1) (figure x1). Males are brighter than females, with a deep-red crown and nape (Brazil 2014, p. 284). Female lacks red on head, have a black crown and nape and often with brown or gray bases of feathers evident. Immature birds are grayer, duller, and less red than adults (Short 1982, p. 511; Brazil 2014, p. 284).


Figure x1: Image of an Okinawa woodpecker (Ambrosini 2008, unpaginated).

2.3 RANGE AND DISTRIBUTION

Japan is a country off the east coast of Asia of several thousand islands with various topographies and climates (Department of Defense (DOD) 2019, p. 18; Shalishe et al. 2024, p. 145). Four major islands make up 97 percent of Japan's area of 377,682 square kilometers (km^2) (145,823 square miles (m^2)). These major islands, from north to south are Hokkaido, Honshu, Shikoku, and Kyushu. The remaining land area of Japan is made up of almost 4,000 small islands, including the Ryukyu Islands (DOD 2019, p. 18). The Ryukyu Islands are a chain of islands scattered in an arc about 1,200 kilometers (km) 746 miles (mi) long between Kyushu, Japan and Taiwan that demarcates the boundary between the Pacific Ocean in the east and the East China Sea in the west (DOD 2019, p. 18; Govt of Japan 2019, p. iii) (see figure x3).

The Ryukyu Islands chain is divided into three groups: the North Ryukyus, Central Ryukyus, and South Ryukyus (Toyama 2014, cited in Govt of Japan 2019, p. 16) (figure x2). Okinawa is in the Central Ryukyus, in the Okinawa Island Group, and it is the largest island in the Ryukyu Islands chain (Govt of Japan 2019, p. 19). The Okinawa Prefecture, which is one of 47 prefectures, is Japan's southernmost and most western prefecture and comprises 160 islands with only 40 that are inhabited (DOD 2019, p. 18). Okinawa is approximately 103 km (64 mi) long from southwest to northeast and averages 11 km (7 mi) wide (DOD 2019, p. 18). The total area of Okinawa is about 1,207 km^2 (120,700 hectares (ha) or 466 mi^2) (Govt of Japan 2019, p. 20).

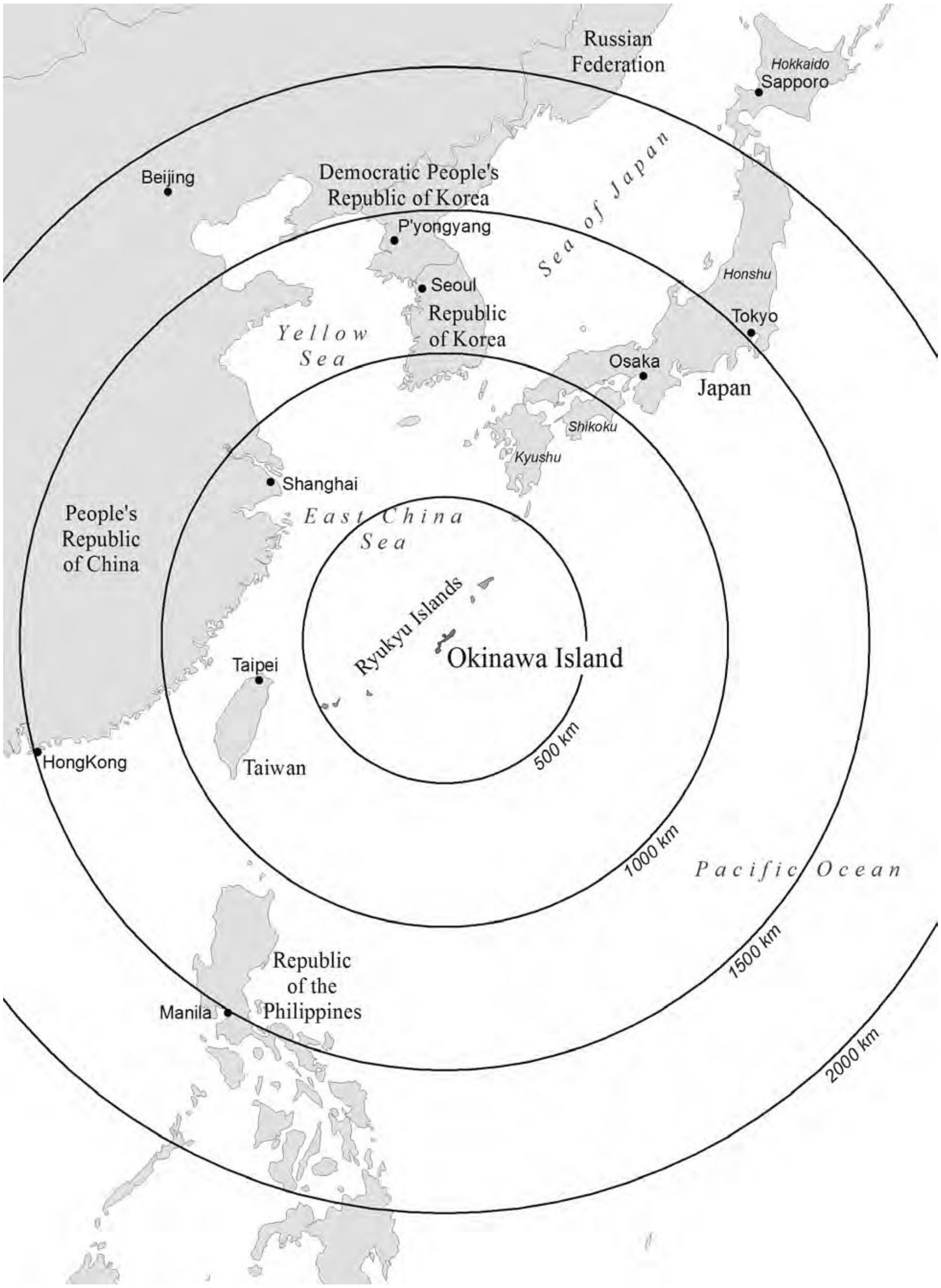


Figure x2. Vicinity map of Okinawa Prefecture (DOD 2019, p. 19)

The Okinawa woodpecker is endemic to Okinawa, Japan, and mainly occurs within mature and undisturbed (old growth) forest in the northern part of the island, although recent studies have documented successful nesting in secondary forests that have regenerated after clear-cutting (Kotaka et al. 2021, p. 193). The northern section is generally known as the Yambaru (or Yanbaru). Yambaru does not have a single fixed definition and is commonly referring to forests north of the ST line (from Shioya Bay in Ogimi to Taira in Higashi) or the SF line (from Shioya Bay to the Fukuji Dam) in the northernmost part of Okinawa Island (figure x3; Yagihashi et al. 2021, p. 2251; Govt of Japan 2019, p. 34; Kotaka 2025, pers comm.).

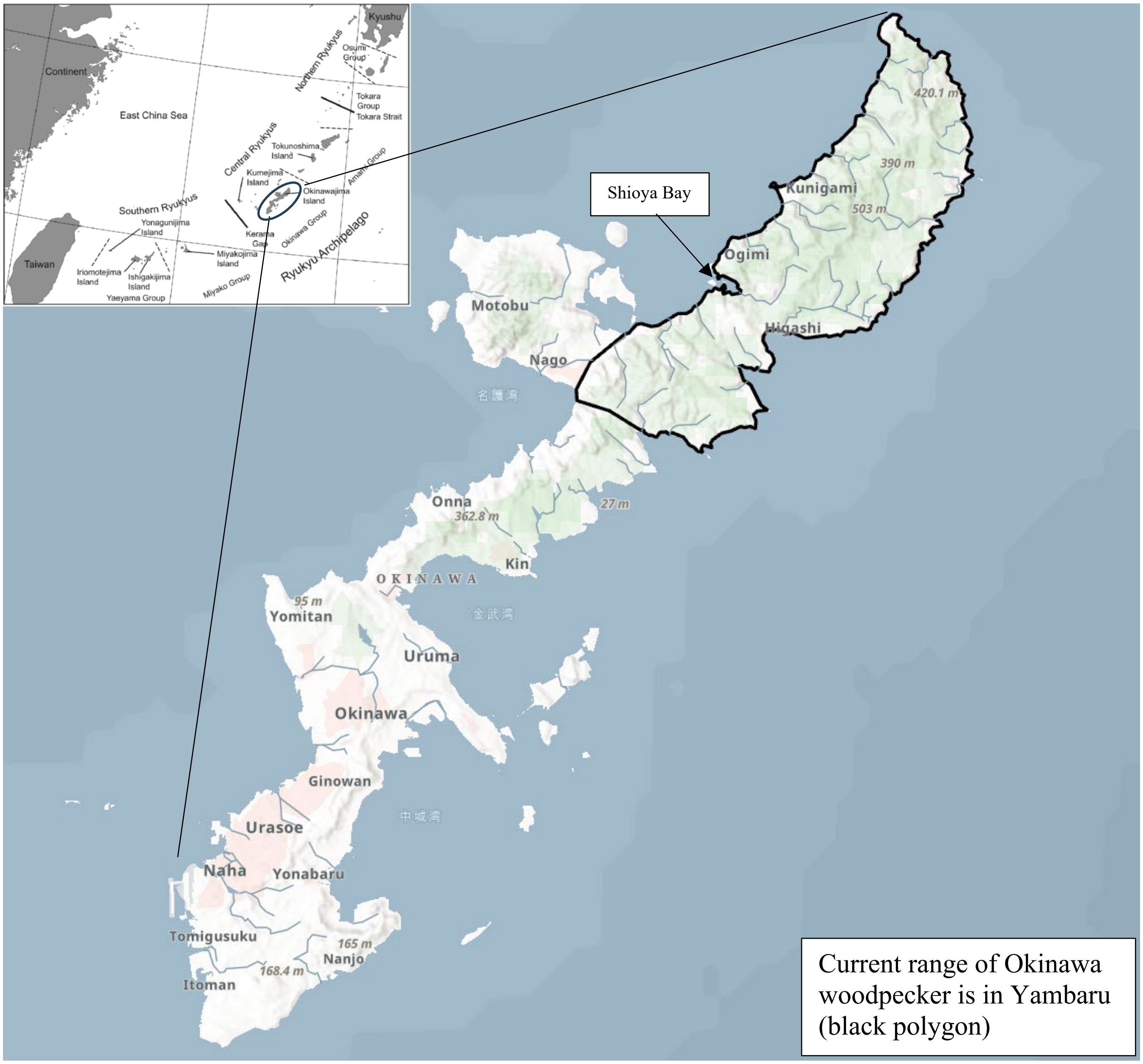


Figure x3. Current range of the Okinawa woodpecker is shown in black bordered polygon in the northern part of Okinawa (IUCN 2025, unpaginated). The range includes the three villages of Kunigami, Ogimi, and Higashi as well as portion of Nago City. Map of the Ryukyu Archipelago showing geographic locations of islands, island groups, and straits is based on Toyama 2014. Okinawa is circled (upper left corner).

The Okinawa woodpecker mainly occupies mature, subtropical evergreen broad-leaved forests, and occasionally they occur in secondary forests outside its main range (del Hoyo 2002, p. 549;

Kotaka et al. 2021, p. 193). The species has also been observed nesting in well-forested coastal areas (Kodaka 2018, as cited in Katayama et al. 2022, p. 101), and it was observed in Nago City during the breeding season (BLI 2001, p. 1879 citing many authors; Kotaka 2025, pers. comm.).

The current range of the Okinawa woodpecker (figures x3–x5) includes both the stable populations in the northern three villages of Kunigami, Ogimi, and Higashi and dispersing individuals in Nago City where breeding attempts occur but stable populations have not been established ((Kotaka 2025, pers. comm., citing Kotaka et al. 2025, abstract in the 2025 Annual Meeting of the Biological Society of Okinawa, in Japanese.). Historically, the species was reported to occur as far south as the Onna Village area and Mt. Ishikawadake prior to World War Two (WWII). Mt. Iyudake was previously described as the southern limit of the range Ogasawara and Ikehara 1977, p. 17). Multiple records, including observations during the breeding season, were reported from within Nago City during the 1970s and 1980s, and breeding populations are thought to have existed in Nago City until the 1980s, but from the 1990s through the 2000s, records of Okinawa woodpeckers from Nago City became very scarce (Kotaka, in prep., cited in Kotaka 2025, pers. comm.).

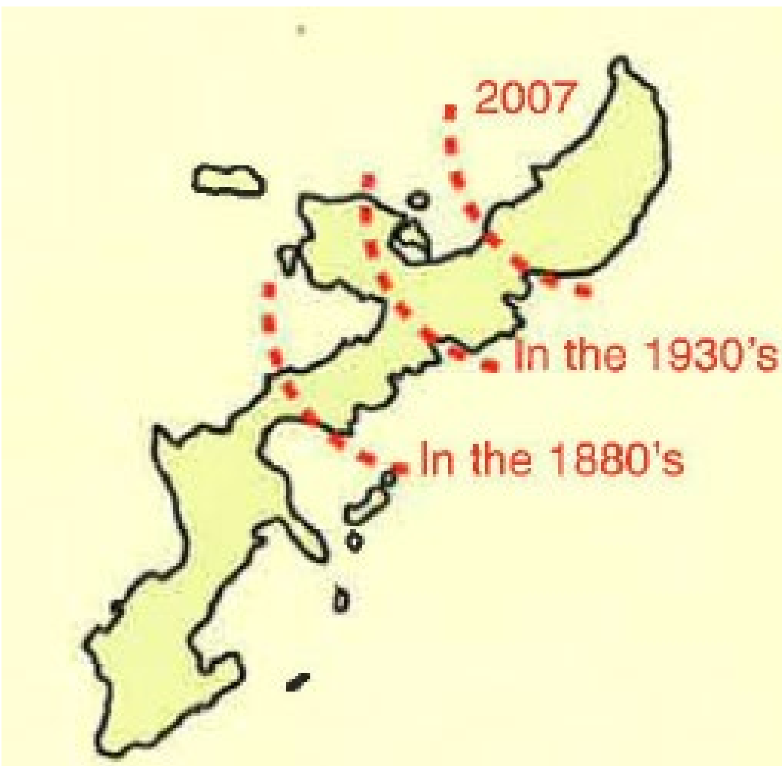


Figure x4. Changing of Okinawa woodpecker's distribution over time (MOE 2008).

Several forested peaks run from north to south along the central mountain range in Yambaru that contain mature, undisturbed forest (see figure x5). The main ridge line has an elevation of about 400 meters (m) (1,312 feet (ft)) and the peak or maximum elevation is 503 m (1,650 ft) at Mt. Yonahadake, which is also the highest point in Okinawa (Govt of Japan 2019, p. 19). Evergreen forests widely occur in areas above 200 m (656 ft) elevation, including at peaks in the mountain range of Yambaru such as (from north to south) Mount (Mt.) Hedo, Mt. Nishimedake, Mt. Terukubi, Mt. Ibudake, Mt. Yonahadake, Mt. Iyudake, and Mt. Nago (Govt of Japan 2019, p. 34;

(Ogasawara and Ikehara 1977, p. 17). The Okinawa woodpecker primarily occurs between Mt. Nishimedake and Mt. Iyudake (BLI 2024, p. 2; Gorman 2014, p. 257). In recent years, dispersing individuals of Okinawa woodpecker have been observed in Nago City and occasional nesting was observed but no stable breeding population has been confirmed (Kotaka 2025, pers. comm.).

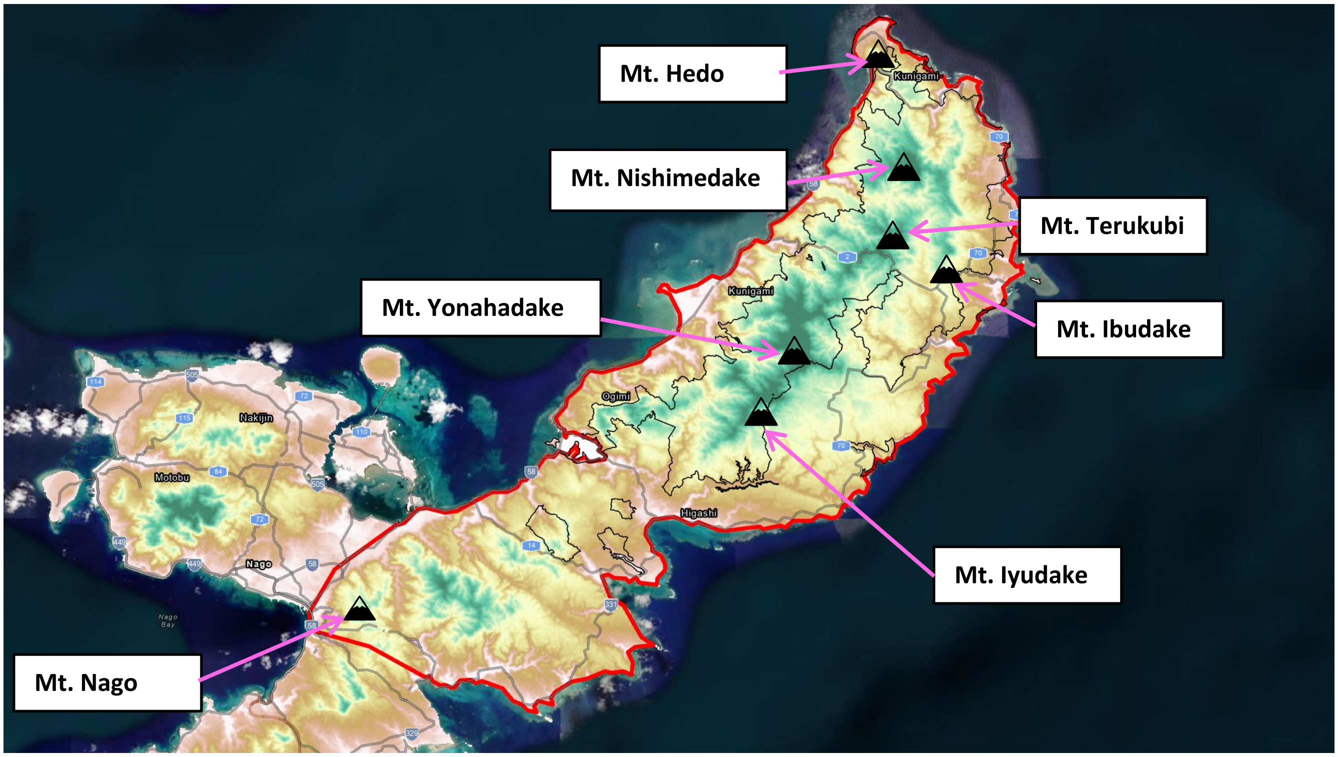


Figure x5. Current range of the Okinawa woodpecker in northern Okinawa (red boundary). Map reflects elevation gradient where green areas are of higher elevation. Peak elevation is 503 m (1,650 ft) at Mount Yohahadake. Mountain peaks (approximate locations) are represented by black mountain icons.

2.4. POPULATION SIZE

Data indicate the Okinawa woodpecker is rare and the population has likely always been small (del Hoyo et al. 2002, pp. 549–550) (see Table x1). The population was much reduced in the 20th century due to forest loss and degradation; the majority of Yambaru forests were degraded as the forest was used for fuelwood during WWII and for timber in postwar reconstruction. (Xu et al. 2008, p. 272; Kotaka et al. 2021, p. 192, citing Takashima et al. 2008; Wu et al. 2006, p. 75). Similar regional extinctions and population contractions of woodpecker species related to socio-economic development that causes forest loss and degradation have been described from temperate and subtropical zones (e.g. Pettersson 1984, Virkkala et al. 1993, Jackson 1994, Mikusinski & Angelstam 1997, 1998, cited in Mikusinsk 2006, p. 93).

By the 1930s, the species was close to extinction (Gorman 2014, p. 255). Population estimates from 1950 through the 1980s have ranged from 40 to 200 individuals (excluding Nago City) (Brazil 1991, p. 191; Short 1973, p. 18; Short 1982, p. 48). In 1972, only 5 to 8 individuals were observed and data from field observations suggested a population of 20 pairs (40 individuals) up to as many as 60 pairs (120 individuals) (Short 1973, p. 18). In 1982, the population was estimated to be less than 200 individuals (Short 1982, p. 48). Brazil (1991, p. 191) reported that the population was about 90 individuals. However, in 1992, based on nest holes and identification of adults using playback or recorded territorial songs, the population was estimated at 400 to 500 individuals (Azama 1996 cited by Itô et al. 2000; Itô et al. 2003; Yosiaki 2006), which was the highest estimate of the population. In 2007 through 2016, the population was estimated to range between 120 and 200 individuals (Yagihashi et al. 2021, p. 2255; Gorman 2014, p. 255) (see Table x1).

The population of Okinawa woodpecker has at least remained stable and likely increased over the past 20 to 30 years, in part due to mongoose trapping efforts and forest regeneration (BLI 2024, pp. 4–5). A recent estimate, based on historical and recent surveys of individuals approximated 75 to 400 mature individuals, with a best estimate of 100 to 300 individuals (BLI 2024, p. 4). This estimate assumes: (1) not every bird has been detected in survey efforts, despite the use of playback, thus these numbers should be considered absolute minimum values; and (2) not all birds are mature individuals. Alternatively, considering the population size based on nest density of 2 mature individuals per km^2 and approximately 200 km^2 of suitable habitat (i.e., closed canopy forest) in the occupied range of the species, and occupancy is likely high, the population could be up to 400 mature individuals (Yagihashi et al. 2021 p. 2258, Kotaka et al. 2021, p. 196; BLI 2024, p. 4). However, based on nest density surveys conducted in different forest types between 2017 and 2019, combined with forest area data, the estimated breeding population of the Okinawa woodpecker north of the ST line in northern Okinawa (between Shioya, Ogimi Village, and Taira, Higashi Village) was 882 individuals with a 95% confidence interval of 515–1,249 individuals (Kotaka 2025, pers. comm.). The population estimates vary because of different survey effort and methodology used; regardless, the population shows an increasing trend.

Table x1. Population estimates of Okinawa woodpecker and year and source of the estimate.

Population Size	**Year**	**Citation**
Close to extinction	1928	Kobayashi 1930 – cited by Birdlife International (BLI) 2001
	1930s	Gorman 2014
100 to 200 individuals	1971	Kuroda 1971
40 to 120 individuals	1973	Short 1973
90 individuals	1975	Ikehara et al 1975
20 to <100 pairs (40 to 200 individuals)	1982	Short 1982
40 to 200 individuals	1950–1990	Brazil 1991
90 individuals	1991	
400 to 500 individuals	1992	Azama 1996 – cited by Itô et al. 2000; Itô et al. 2003; Yosiaki 2006

150–584 individuals (only 75 mature)	2001	Birdlife International 2001
<600 individuals	1990s	Gorman 2014
100 pairs (200 individuals)	2014	
120 individuals	2007	Yagihashi et al 2021
165 individuals	2010	
183 individuals	2013	
149 individuals	2016	
882 individuals (95% confidence interval 515–1,249 individuals)	2017 to 2019	Kotaka 2025, pers. comm.
<390 individuals	2020	Winkler et al. 2020 (Birds of the World)
213 active nests between 1999–2019	2021	Kotaka et al. 2021
75–400 mature individuals with a precautionary best estimate of 100 to 300 mature individuals	2024	Birdlife International 2024

2.5 HABITAT

Yambaru contains a rich biodiversity and many endemic plants and animals, providing a unique landscape (Govt of Japan 2019, p. 34). The climax community of Yambaru is a subtropical, evergreen, broad-leaved forest dominated by oaks, with a dense undergrowth of broad-leaved small trees, herbs, and ferns (Azuma et al. 1997, p. 156). This subtropical evergreen forest is characterized by rugged terrain, different soil types, short canopy with a dense understory, and highest biodiversity among all Japanese forests (Itô 1997, p. 125; Xu 2008, pp. 274–275; Jemali et al. 2015, p. 112; Takahashi 2004, p. 6; Yosiaki 2006, p. 13). Mean canopy height is about 10 m (33 ft) in plots that have not been disturbed since WWII (Xu et al. 2008, p. 272). Generally, the canopy height is less than 15 m (49 ft) (Wu et al. 2013, p. 536).

The Okinawa woodpecker mainly nests in mature and undisturbed forested areas on mountaintop areas. The broad-leaved evergreen forest zone in Okinawa's mountainous areas is variously referred to as the *Machilus-Castanopsis* forest or as the *Castanopsis* community. The forest in Yambaru is dominated by evergreen chestnut or chinquapin (*Castanopsis sieboldii*) or other close relatives in the oak/beech/chestnut (*Fagaceae*) family, with other evergreen broad-leaved trees such as Isu tree (*Distylium racemosum*), umbrella tree (*Schefflera octophylla*), Chinese guger tree or needlewood tree (*Schima wallichii* ssp. *liukiuensis*), Japanese bay tree (*Machilus thunbergii*), and Japanese blueberry tree (*Elaeocarpus japonicus*) (Miura and Yamamoto 2003, p. 122; Xu et al. 2001, cited in Wu et al. 2013, p. 536; Itô 2000, p. 305; Jemali et al. 2015, p. 111; Kubota et al. 2004, p. 234).

Forested habitat in Yambaru has been affected by the historical clear-cutting associated with WWII and post-WWII reconstruction. Although by 2008, 84 percent of the forests in Yambaru were over 40 years old and 60 percent were over 50 years old (Yagihashi et al. 2021, p. 2258, citing Department of Agriculture, Forestry and Fisheries, Okinawa prefecture 2019). Therefore, most Yambaru's forested areas are currently over 50 years old due to the decrease in logging and natural regeneration. Secondary forests are widely distributed in northern Okinawa, with young secondary forests up to 50 years old and older secondary forests more than 50 years old. These secondary forests had been clear cut and regenerated naturally (Kubota et al. 2005, p. 882). In secondary succession after clear-cut, species with high sprouting ability initially dominate, and species with low-sprouting ability are likely to increase in the later stages of the succession (Abe et al. 2021, p. 188). In Yambaru not enough time has elapsed for species with low sprouting ability to become predominant (Abe et al. 2021, p. 188), such that *C. sieboldii*, which has a high sprouting ability, is the most dominant species in Yambaru forests (Kubota et al. 2005, pp. 894–896; Abe et al. 2021, p. 188).

Castanopsis sieboldii is an important tree of natural regrowth because it has a low stump mortality rate with abundant, fast-growing sprouts and seedling origin stems contributing to both the highest stem numbers and the highest basal areas in the regenerating forest after selective logging (Wu et al. 2013, p. 539; Kubota et al. 2005, p. 894). Thus, *C. sieboldii* is the dominant species in the early stage, suggesting that they might continue to dominate in the secondary forest in the future. However, while *C. sieboldii* dominated secondary forest because of fast regrowth, *Distylium racemosum*, another climax evergreen broadleaf tree species but slower growing than *C. sieboldii*, dominates at the late development stage and is a long-lived competing species that reduces the dominance of *C. sieboldii* and facilitates the co-occurrence of understory species (Kubota et al. 2005, p. 895). Older forests are dominated by trees with lower sprouting ability, a higher wood density, and a higher diversity of species (Kubota et al. 2005, p. 889). Wood density is generally known to be a good indicator of forest succession, positively correlating with forest age and species richness (Abe et al. 2021, p. 185–188). *Distylium racemosum* is considered a keystone species of the Yambaru Forest because it has important ecological functions and provides habitat to many species (Abe et al. 2021, p. 186). Lastly, the presence of *D. racemosum* indicates an area has not been disturbed for an extended period (Abe et al. 2021, p. 186).

Understory species are a major component in gaps in old-growth forest in Yambaru and were more abundant on slopes and ridges than in valleys. This suggests that richness of understory species is controlled by light conditions because gaps are created in the canopy of old-growth forest in which understory species can thrive (Kubota et al. 2004, p. 236). Understory species include tree ferns or Hikagehego (*Cyathea* sp.); Mokutachibana or Irushi (*Ardisia sieboldii*); Gordonia (*Lasianthus cyanocarpa*); Hainokika (*Symplocos mircocalyx*); Camellias, Ryukyu tsubaki, or Katashi (*Camellia japonica*); and Bochoji (*Psychotria rubra*) (DOD 2019, p. 32).

2.6 LIFE CYCLE/FECUNDITY/REPRODUCTION

The nesting season for the Okinawa woodpecker begins in April and runs through June, with pair formation in late winter (Kotaka *et al.* 2021, p. 193; Short 1982, p. 512; Short 1973, p. 12). Egg laying is from late February to May, typically in March and April. Nestlings are out of the nest by May and could be present up to June (del Hoyo 2002, p. 550). Clutch size ranges from two to a maximum of five eggs, with four being the most common (Kotaka 2025, pers. comm.). The incubation period lasts about 11 days, and like other woodpeckers the males take responsibility for nocturnal incubation (Kotaka 2025, pers. comm.).

The nestling period is approximately 4 weeks. Fledging success is about 90%. The number of fledglings is most often two, with a maximum of four recorded (Kotaka 2025, pers. comm.). Causes of breeding failure include predation by snakes such as the Akamata or Ryukyu odd-tooth snake (*Lycodon semicarinatus*) and by large-billed crows (*Corvus macrorhynchos*), rainwater intrusion into the nest cavity, and the collapse of nest trees during the breeding period. Nestlings are fed larvae and insects (Short 1982, p. 512). Fledgling and post-fledgling behavior are unknown (Short 1982, p. 512). The annual molt is from July to October (Short 1982, p. 512).

Both sexes are capable of breeding from 1 year of age. The species is monogamous, breeding once per year and pair bonds are thought to be strong; one pair was observed maintaining its bond for 10 consecutive years (Kotaka 2025, pers. comm.). Generation time is estimated at 4.7 to 5.2 years (BLI 2016, p. 10; BLI 2024, p. 11). The home range is around 4 to 7 hectares (10 to 17 acres) and the closest recorded distance between nests of the species in the same breeding season is 70 m (230 ft) (Kudaka and Taira 1994, cited in DOD 2019, p. 44). Territorial disputes occur primarily between individuals of the same sex, with little conflict observed between males and females (Kotaka 2025, pers. comm.).

CHAPTER 3 – SPECIES NEEDS

In this chapter we provide information about Okinawa woodpecker needs, detailing the habitat and resources that each life stage needs to breed, feed, and shelter to complete its life cycle.

3.1 NESTING

The availability of nest trees is a critical reproductive requirement for woodpeckers (Winkler and Christie 2010, cited in Kotaka et al. 2021, p.193). The Okinawa woodpecker prefers mature and undisturbed subtropical evergreen broadleaf forests, with trees that are at least 30 years old and greater than 20 cm (7.9 in) in diameter (Gorman 2014, p. 257; del Hoyo 2002, p. 550; Short 1982, p. 511); however, the youngest recorded forest age was 23 years old (Kotaka et al. 2021, p. 194). Dead trees are a habitat element that characterizes old growth forest (Kotaka et al. 2021, p. 196; Brazil 1991, p. 192; Short 1982, p. 511). Species richness of woodpeckers is positively correlated with the availability of dead wood and large deciduous trees (Angelstam et al. 2002, p. 33).

Okinawa woodpeckers are a primary cavity-nesting species, meaning they can excavate their own tree cavities (Kobayashi et al. 2022, p. 2). Nesting cavities are often made by Okinawa woodpeckers in *C. sieboldii* trees (Gorman 2014, p. 255). Generally, woodpeckers can excavate cavities in living and dead trees. However, most cavities are naturally formed (Takashima et al. 2021, p. 414). Most trees containing nests for Okinawa woodpecker are on steep slopes and the section of tree used invariably is dead or dying (Kotaka et al. 2021, p. 196). Nests are usually located on an inclined (inward) side of the trunk or stub (Short 1982, p. 512; Short 1973, p. 8). One oval-shaped nest entrance measured was 58 millimeters (mm; 2.28 in) wide by 76 mm (3 in) in vertical length, with a chamber 24 by 38 cm (9.45 by 14.96 in) forming the nest (Short 1982, p. 512). Cavities that are smaller in volume, higher off the ground, and with a greater entrance area correlate with more woodpecker foraging visits to the cavity (Kobayashi et al. 2022, p. 8). Researchers reported that the species uses nests year after year; however, local Okinawans stated that nest sites change annually (Short 1973, p. 8). Nest cavities are likely reused in younger forests that generally lack suitable trees for woodpeckers (Kotaka *et al.* 2021, p. 197). Younger forests may contain dead trees because exotic pest species cause die offs and cavity formation, such as in Japanese alder (*Alnus japonica*) and Ryukyu Island pine (*Pinus luchuensis*). Dead trees in younger forests are an ephemeral resource following die offs from pests and disease (Kotaka et al. 2021, p. 198). Dead trees in Okinawa are generally short-lived because decomposition rates are high in the humid subtropical and tropical forest system (Kotaka et al. 2021, p. 198, citing Cockle et al. 2011, 2017).

Surveys in Kunigami Village found 213 active woodpecker nests between 1999 and 2019, utilizing 17 different tree species and one tree fern species (Kotaka *et al.* 2021, p. 194). The density from 2006 to 2019 has not changed (Kotaka et al. 2021, p. 196) (see figure x6). However, the influence of tree disease around 2013 resulted in a large-scale die off of *Alnus japonica* caused by the exotic leaf beetle (*Plagiosterna formosana*) in 2010. Standing dead trees were heavily used for nesting that resulted in the peak density in 2013. This peak was associated with increased nesting north of the SF line and temporary sightings in Nago City (Kotaka 2025, pers. comm.). However, nesting density rapidly declined after 2013 because dead trees in this subtropical region are short-lived (Kotaka et al. 2021, p. 196; Kotaka 2025, pers. comm.).

Castanopsis. sieboldii was the most frequently used species for nesting, followed by *Alnus. japonica*, chinaberry tree (*Melia azedarach*), and *Pinus luchuensis*. The estimated minimum ages (with sample sizes in parentheses) are as follows: *C. sieboldii* (72) – 44 years, *M. azedarach* (24) – 26 years, *A. japonica* (52) – 23 years, and *P. luchuensis* (16) – 28 years (Kotaka et al. 2021, p. 195). None of the *C. sieboldii* trees were younger than 40 years old and most were more than 60 years old, reinforcing that trees greater than 40 years old are important breeding habitat for the species (Kotaka et al. 2021, pp. 196–197). However, other tree species used for nesting were mostly younger than 60 years old with some younger than 40 years old (Kotaka et al. 2021, pp. 196–197). Early successional trees that die from pests or diseases can become usable for nesting at younger ages than usual.

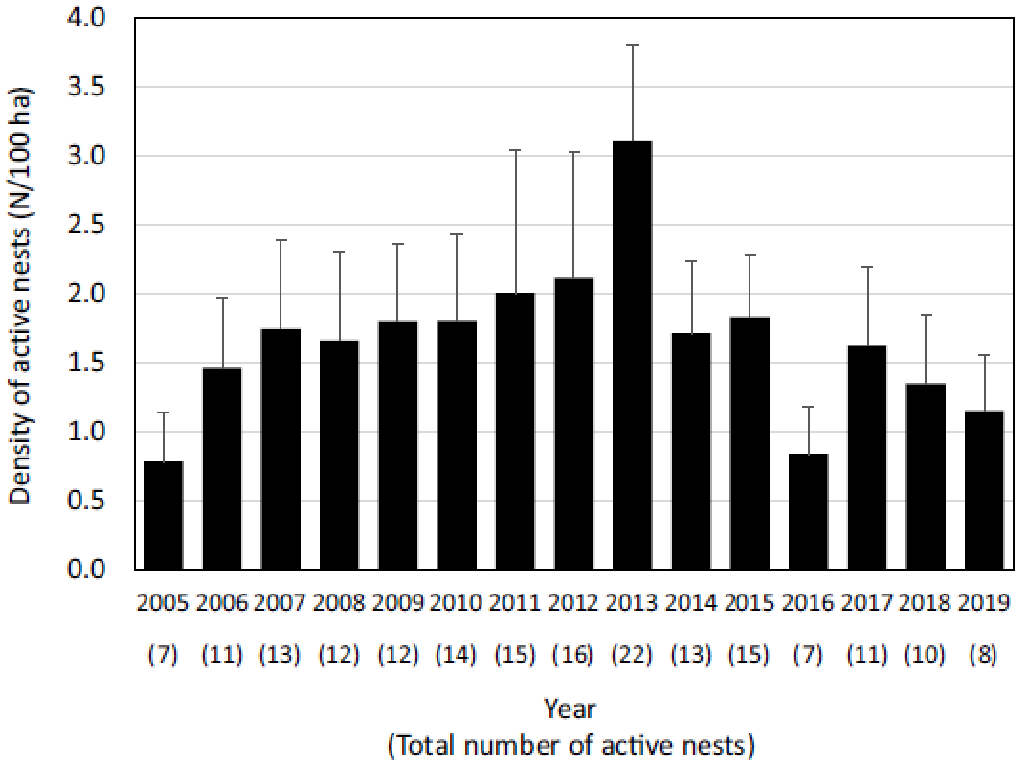


Figure x6. Annual changes in the average density of active nests from 2005 to 2019. Error bars indicate standard deviation (Kotaka et al. 2021, p. 196).

3.2 DIET

The Okinawa woodpecker feeds on large arthropods, notably beetle larvae, spiders, moths, and centipedes, as well as fruit, berries, seeds, acorns, and other nuts (del Hoyo 2002, pp. 549–550; Short 1982, p. 511). The foraging sites of the species indicate its dependence on mature, undisturbed forest with large dead or dying trees, accumulated fallen trees, rotting stumps, debris, and understory growth (Brazil 1991, p. 192; Short 1982, p. 511). The preference of the Okinawa woodpecker for rotten wood suggests that the health of live trees and stage of decomposition of dead trees are of greater significance to foraging woodpeckers than is the species of tree represented (Short 1973, p. 8).

Both females and males search dead and live tree-trunks and bamboo and fallen logs on the ground (Gorman 2014, p. 257; Short 1982, p. 511; Short 1973, pp. 7–8). The species frequent the base of trees and stubs and hops about on fallen logs and debris amid dense low bushes. Occasionally, the species hops across a small area of open ground near logs, to gain a more favorable position for feeding (Short 1973, pp 7–8). Foraging is often by excavating, tapping, pecking, and tearing apart rotting wood to get at the insects inside. Their activities are muted by the wet conditions and rotted wood on which they work (Short 1973, p. 8; Short 1982, p. 511). The sexes show significant differences in their foraging niche (Kotaka et al. 2006, p. 196). Males commonly forage on the ground, sweeping away leaf litter and probing for soil-dwelling prey such as trapdoor spiders and cicada larvae; however, females almost never touch soil arthropods like other species of the genus *Dendrocopos* (Kotaka et al. 2006, p. 196). In the winter months, when food is scarce, the Okinawa woodpecker has been known to feed on citrus fruits in fruit orchards (Kodaka 2018, as cited in Katayama et al. 2022, p. 101).

CHAPTER 4 – INFLUENCES ON VIABILITY

The following discussion provides a summary of the factors that are affecting, or could be affecting, the current and future condition of Okinawa woodpecker throughout its range, including both threats and conservation actions. We use the term threat to refer in general to actions or conditions that are known to or are reasonably likely to negatively affect individuals of a species. The term threat includes actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The term threat may encompass, either together or separately, the source of the action or condition or the action or condition itself. Actions that avoid or minimize threats are referred to as conservation actions.

In this section, we evaluate the significant past, current, and future threats, and current conservation efforts that are affecting Okinawa woodpeckers. We also consider how these factors may cumulatively affect the woodpecker both negatively and positively. Based on the best scientific and commercial information available and our assessment of conditions across the range of this species, we assessed the following threats that we consider are influencing the viability of the Okinawa woodpecker: (1) habitat loss, fragmentation, and modification, (2) disturbance related to U.S. military activities, (3) predation from nonnative mammal species, and (4) effects from climate change, including increases in extreme weather events such as typhoons.

4.1 HABITAT LOSS, MODIFICATION, AND FRAGMENTATION

Okinawa is equally divided between the relatively flat, densely populated southern section and the hilly and sparsely inhabited northern section, separated by a narrow middle section (Short 1973, p. 5) (see figure x7). The lowlands area in the southern part of Okinawa is where most of the human population and urban development occur on the island, including Naha, the largest and most populous city in Okinawa (Uyehara 1933, p. 403; JAXA 2025, unpaginated). For the purposes of this species report, the analysis only focuses on northern Okinawa where the Okinawa woodpecker occurs.

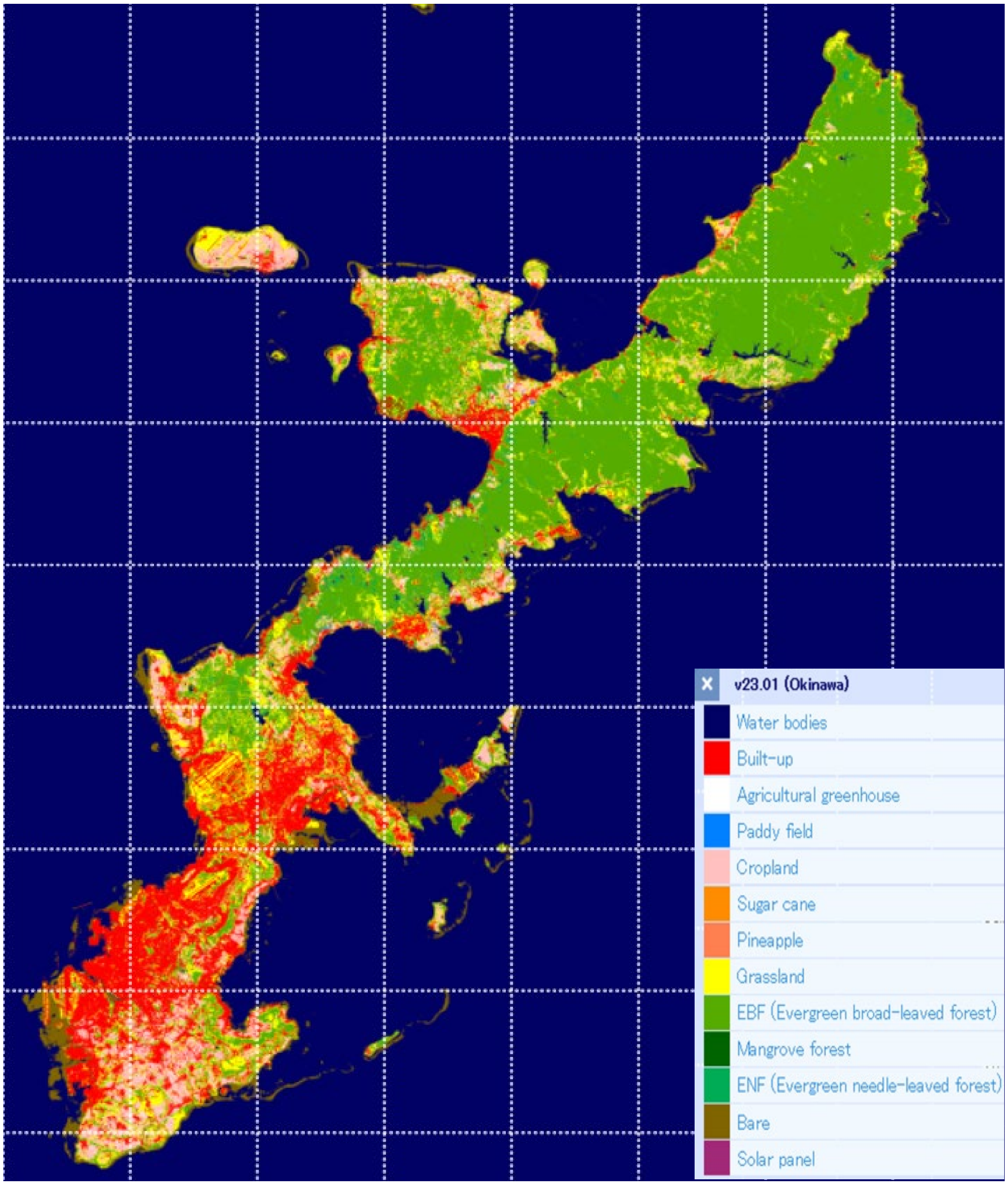


Figure x7. Land use in Okinawa. (JAXA High-Resolution Land-Use and Land-Cover Map-Japan)

Yambaru has been subject to forestry practices for hundreds of years (Abe et al. 2021, p. 182, citing Nakasuga 1995 and Nakama 2007). Forests in Yambaru were thinned through large-scale clear cutting and understory removal (Itô 2003, p. 11; Itô et al. 2000, pp. 310–312). Most of the forest within Yambaru is less than 100 years old and most areas have experienced a clear cut within the last 100 years (Abe et al. 2021, p. 182, citing Saito 2011). The lower slopes once covered by subtropical forest have mostly been converted to orange and pine plantations (Yamamori 1979, cited in Xu et al. 2008, p. 272). Overall, the forest age is relatively young and most of Yambaru's forests are secondary growth with limited old-growth forest (Kotaka et al. 2021, p. 192, citing many authors; Abe et al. 2021, p. 188). Secondary forest is recognizable in

Yambaru because of the presence of pine trees, which invade logged areas but cannot survive in climax forests (Itô 1997, p. 125).

Logging in Okinawa peaked from the mid-1920s through the 1950s in Yambaru (Yagihashi et al. 2021, p. 2251, citing Saito 2011). Trees were used for fuelwood during WWII. Following WWII, substantial logging occurred between 1945 and the 1970s to meet the increased timber demand related to post-WWII reconstruction (Kotaka et al. 2021, p. 192, citing Takashima et al. 2008 and Saito 2011). Deforestation continued through the 1980s and 1990s. For example, over a 13-year period, from 1979 to 1992, 2,443 hectares (6,037 acres or 24.43 km^2 or approximately 7 percent) of forests were cut in Yambaru (Itō et al. 2000, p. 311, citing Department of Agriculture and Forestry, Okinawa Prefecture Government 1992). More than 60 percent of the area affected during this 13-year period was in the central part of Yambaru where the central ridge exists, and nearly 50 percent of all natural forests outside of the U.S. Marine Corps Northern Training Area (also referred to as the Jungle Warfare Training Center (JWTC)) were clear-cut (Itō et al. 2000, p. 311).

Additionally, the removal of understory vegetation (i.e. tree seedlings, shrubs and herbs lower than 3 m (10 ft) above ground) was carried out under a government subsidy through the Natural Forest Improvement Project (Azuma et al. 1997, p. 156). Between 1972 and 1991, 3,069 ha (7,584 ac or 30.69 km^2) of understory was removed (Itō 1995 and 1997a as cited in Itō et al. 2000, p. 311). Clearing of the understory resulted in the loss of many animals, shrubs and herbs, and a decrease in insect species diversity. The Okinawa woodpecker feeds on large arthropods, as well as fruit, nuts, and seeds and forages in old-growth forests with large, dead or dying trees, accumulated fallen trees, rotting stumps and undergrowth (Brazil 1991, p. 192; Short 1982, p. 511). Therefore, the removal of understory vegetation in Yambaru decreased the diversity of food resources, and in turn likely negatively affected Okinawa woodpeckers because they feed mainly on insects and may feed near the ground or in debris or rotting wood near the forest floor (Azuma et al. 1997, p. 159; Yosiaki 2006, p. 14).

Yambaru was at its most degraded in the late 20th century (Itô et al. 2000, p. 311, cited in Kotaka et al. 2021, p. 192). Undisturbed forest likely amounted to no more than 1,500 hectares (3,707 ac or 15 km^2) in the 1970s. Mature forest was distributed on mountaintop areas, and in tiny patches that were interspersed on steep slopes, secondary forests, and cleared areas in the hills connecting the mountaintop areas (Short 1973, p. 5). By the early 1980s, many areas once occupied by the Okinawa woodpecker were degraded to the point where they no longer provided suitable habitat for the species (Brazil 1985b, cited in BLI 2001, p. 1881). By the mid-1990s, only approximately 4,000 ha (9,884 ac or 40 km^2) of suitable habitat on the central ridge was available for Okinawa woodpeckers. Much of the suitable habitat was part of the JWTC (Azama 1995 as cited in BLI 2001, p. 1882).

The greatest threat to the Okinawa woodpecker was fragmentation of the habitat because the only mature, undisturbed habitat suitable for the species existed on mountaintops along the central ridge, in interspersed patches on steep slopes, and in cleared areas connecting the mountains (Short 1973, p. 5). This habitat fragmentation caused the species' population to be scattered in tiny colonies or isolated pairs (Short 1973, p. 18). Fragmentation into smaller forest patches could cause scarcity and a reduction of food resources within those smaller fragments

(Kattan et al. 1994, pp. 141–143; Lees and Peres 2009, pp. 286–288; Lees and Peres 2010, p. 619; Vetter et al. 2011, p. 6). However, smaller fragments can be used by forest-dependent species if resources within in the smaller patch are supplemented by neighboring patches if they are accessible (Dunning et al. 1992, p. 173).

In the 21st century, the forest has since recovered to the basic features of a climax community (Itô 2003, p. 11). Currently, the habitat is not severely fragmented (BLI 2024, unpaginated), and the loss of forest in Yambaru has a declining trend because of increased environmental protection and a declining demand for timber (Department of Agriculture, Forestry and Fisheries 2019, cited in Yagihashi et al. 2021, p. 2251). For example, between 1999 and 2008, the logging area is Yambaru has been less than 0.1 km^2 per year, with a total of 0.87 km^2 from 1999 to 2008. By 2008, 84 percent of the forest in Yambaru was over 40 years old and 60 percent were over 50 years old (Department of Agriculture, Forestry, and Fisheries 2019, as cited in Yagihashi et al. 2021, p. 2258). Therefore, most of the forest would be over 50 years old currently. By 2015, natural vegetation including subtropical to tropical broadleaved forest constituted about 88 percent of the forest area and the remaining percentage belonged to native pine species (Jemali et al. 2015, p. 107). By 2019, forest area accounted for 91 percent of Yambaru (Govt of Japan 2019, p. 111).

Furthermore, over a recent 23-year period (2001 to 2024), tree cover within the range of the Okinawa woodpecker in Yambaru decreased only by 5.3 percent or 20.4 km^2 (7.9 mi^2) (Global Forest Watch (GFW) 2025, unpaginated). The three villages that make up Yambaru have similar percent tree cover losses, although Higashi and Ogimi have a higher percent loss of tree cover and less natural forests area than Kunigami (Table 2; GFW 2025, unpaginated).

Table x2. Percent tree cover loss and area of natural forest in the three villages that make up Yambaru in northern Okinawa (GFW 2025, unpaginated).

Village	Percent tree cover lost	Percent of area is natural forest
Kunigami	4.3%	85%
Ogimi	6.8%	79%
Higashi	7.3%	70%

4.2 JUNGLE WARFARE TRAINING CENTER

The United States (U.S.) returned sovereignty of Okinawa to the Japanese Government in 1972 (Sakuma 2022, p. 223). However, the U.S. still maintains several large military bases in the region. Forty-five years after Okinawa's reversion to Japan, Okinawa still hosts about 70 percent of all U.S. military bases in Japan even though Okinawa is only 0.6 percent of Japan's total land area (Kakazu 2018, p. 8). The Jungle Warfare Training Center (JWTC) (formerly known as Camp Gonsalves) is part of the U.S. Marine Corps installation on Okinawa Island (USMC in litt. 2012; Itô 2003, p. 11; Short 1973, p. 16) (figure x8). The mission of the JWTC is to maintain and develop quality support and to provide the instructional expertise, expeditionary camp, and training areas necessary to conduct training in a jungle environment for Marine, joint, and combined units (DOD 2019, p. 131).

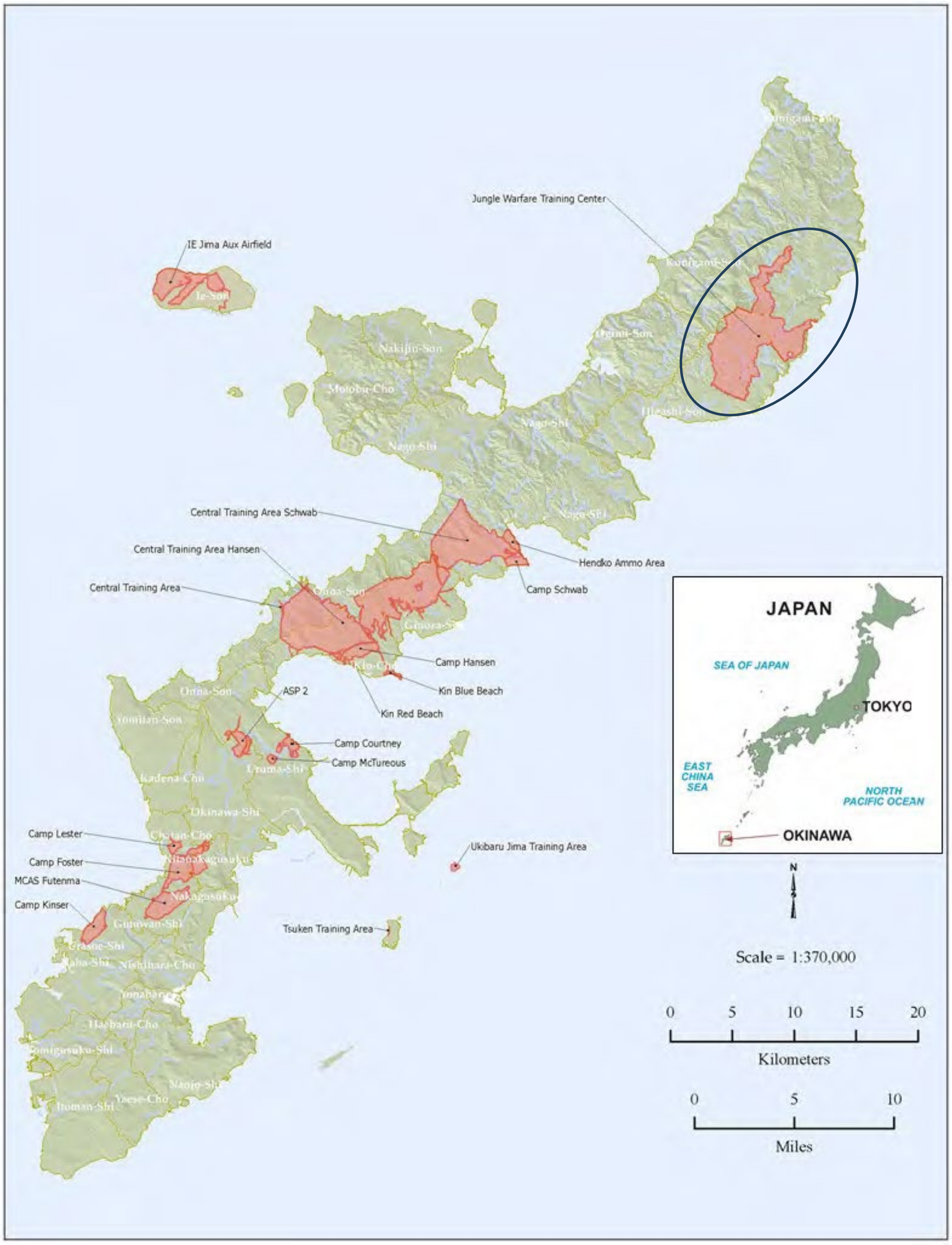


Figure x8. United States military bases in Okinawa. The Jungle Warfare Training Center in northern Okinawa is encircled (DOD 2019, p. 6).

The JWTC is located in Higashi Village and Kunigami Village in northern Okinawa. The installation is 3,533 ha (8,730 ac or 35.33 km^2). Most of the land in the JWTC is owned by the Government of Japan and managed by the Okinawa District Forest Office, Ministry of Agriculture, Forestry and Fisheries (DOD 2019, p. 128). The eastern boundary is adjacent to civilian use and predominately agriculture. The western boundary runs along the central mountain ridge and borders Yambaru National Park (DOD 2019, p. 128) (see Conservation Actions, below).

The JWTC is relatively undisturbed, and until recently it was kept in a natural state for jungle training exercises, which has likely benefitted the Okinawa woodpecker (Short 1973, p. 16). However, six helipads for MV–22 Osprey aircraft were recently constructed on the base, and in exchange for construction of the helipads, the U.S. Government returned land to Japan in 2016 (Tanaka 2017 unpaginated) (see figure x9). Two helipads were completed in 2014 near the Takae community of Higashi and the remaining four were completed in December 2016, also near Takae (Nogami 2017a, unpaginated). The helipads are 75 m (246 ft) in diameter and numerous access roads were built for their construction and maintenance (Nogami 2017b, unpaginated; Itō et al. 2000, p. 312). About 30,000 trees were cut down in Yambaru within the JWTC to construct the helipads and access roads (Nogami 2017a, unpaginated). MV-22 Ospreys use each helipad 420 times a year (Nogami 2017a, unpaginated).

Okinawa woodpeckers occur at five of six landing zones for the MV-22 Ospreys (DOD 2019, p. 142); thus, the helipads were constructed in Okinawa woodpecker habitat. During construction, it was expected that the birds fled elsewhere and were not killed or injured (Nogami 2017a, unpaginated). However, if mature forest trees were removed it is likely that birds living in the area were negatively affected through loss of nesting and foraging habitat (Nogami 2017a, unpaginated, citing T. Kanaizuka from the Conservation Network for Forest Ecosystem in Japan). Additionally, noise from helicopters and trucks likely interrupts breeding activities and the movement of mammals, birds, and amphibians (Itō et al. 2000, p. 312). For example, in 2015 following construction and use of one of these helipads in Takae, five Okinawa woodpeckers were found dead next to buildings in nearby Higashi Village. The cause of these mortalities was believed to be from collisions with the buildings, possibly related to noise disturbance from the operation of the MV–22 Ospreys over the area (Japan Update 2014, p. 1).

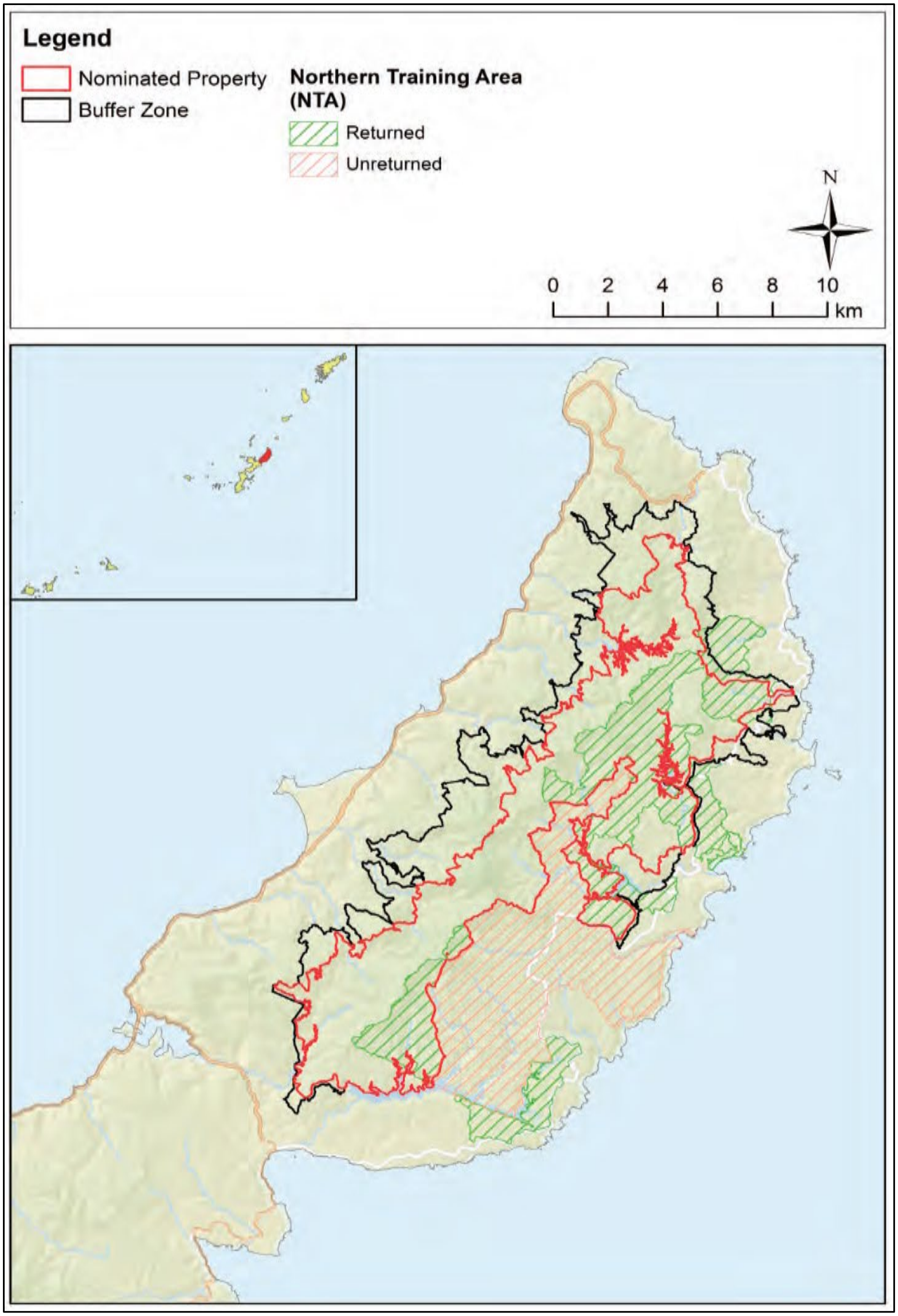


Figure x9. Jungle Warfare Training Center land, including land returned to Japan in 2016 (Govt of Japan 2019, p. 119). This figure also includes the property nominated as a World Heritage Site in Yambaru and a buffer zone that is a class II special zone (see Conservation Actions, below).

Integrated Natural and Cultural Resources Management Plan
The Okinawa woodpecker is listed in the U.S. Marine Corps' Integrated Natural and Cultural Resources Management Plan (INCRMP) (DOD 2019, p. 44). The Corps must first evaluate impacts from a proposed project on the species and then take actions to minimize or mitigate the impacts (USMC in litt. 2012, unpaginated, cited in DOD 2019, p. 44). Actions in the INCRMP that benefit the Okinawa woodpecker include monitoring of the species and invasive species management to reduce populations of the small Indian mongoose (*Herpestes auropunctatus*) (see nonnative invasive species, below). These efforts to avoid and minimize impacts appear to be successful, as even with the ongoing activities to construct helipads at the JWTC in recent years, the Okinawa woodpecker population has stabilized and is likely increasing.

Initially, it was not clear how the lands that the U.S. Government returned to Japan in exchange for construction of helipads would be used and if they would become part of the Yambaru National Park (Ryukyu Shimpo 2016c, unpaginated). Ultimately, the land that was returned to Japan was designated for environmental conservation and most of the returned land became part of Yambaru National Park (Pon 2016, unpaginated; Govt of Japan 2019, p. 117).

4.3. NONNATIVE INVASIVE SPECIES

The Okinawa woodpecker is vulnerable to nonnative predators such as feral cats (*Felis catus*) and the small Indian mongoose (*Herpestes auropunctatus*) (BLI 2024, p. 5; MOE Japan 2012, pp. 42, 55). The Yambaru ecosystem historically lacked carnivorous mammals, and the native species are not equipped to defend themselves against invasive predators (MOE Japan 2014, p. 2). Okinawa woodpeckers forage near the ground and are susceptible to nonnative predators, particularly males because they forage on the ground for soil-dwelling arthropods (BLI 2024, p. 5; Kotaka et al. 2009, p. 28; Kotaka et al. 2006, p. 196). Statistical analysis found that the number of woodpeckers at a given site is inversely proportional to the number of mongooses (Yagihashi et al. 2021, p. 2255). Similarly, researchers have found remains from Okinawa woodpeckers in feral cat feces (Jogahara et al. 2003, abstract, p. 37). The threat from cats may be growing because people abandon domestic cats in vulnerable habitats on Okinawa, including the Yambaru Forest (Japan Bureau of Statistics 2015 as cited in Sbeghen 2017, p. 12; Takahashi 2004, p. 138). A mongoose control program has been implemented and is important for conservation of the Okinawa woodpecker. An action plan for feral cats is progressing and is also important for Okinawa woodpecker conservation (see Conservation Actions, below).

4.4 CLIMATE CHANGE EFFECTS

Northern Okinawa is in the subtropical zone between the tropical and temperate zones. The Japan Meteorological Agency (JMA) characterizes Okinawa's climate as a subtropical oceanic climate with hot and humid summers and mild winters (JMA 2018, cited in DOD 2019, p. K-4). Average temperature is 21 to 24 degrees Celsius (°C) (70 to 75 degrees Fahrenheit (°F)) (Govt of Japan 2019, p. 25). In summer, the average temperature reaches 27 to 29 °C (80 to 84 °F); days with the minimum night-time temperature above 25 °C (77 °F) continue for about three months partly because the diurnal range of temperature is small (Yamazaki et al. 1989, cited in Govt of Japan 2019, p. 25). Even in winter, the climate is warm with the average temperature of 15 to 18 °C (59 to 64 °F) (DOD 2019, p. 20; Govt of Japan 2019, p. 25).

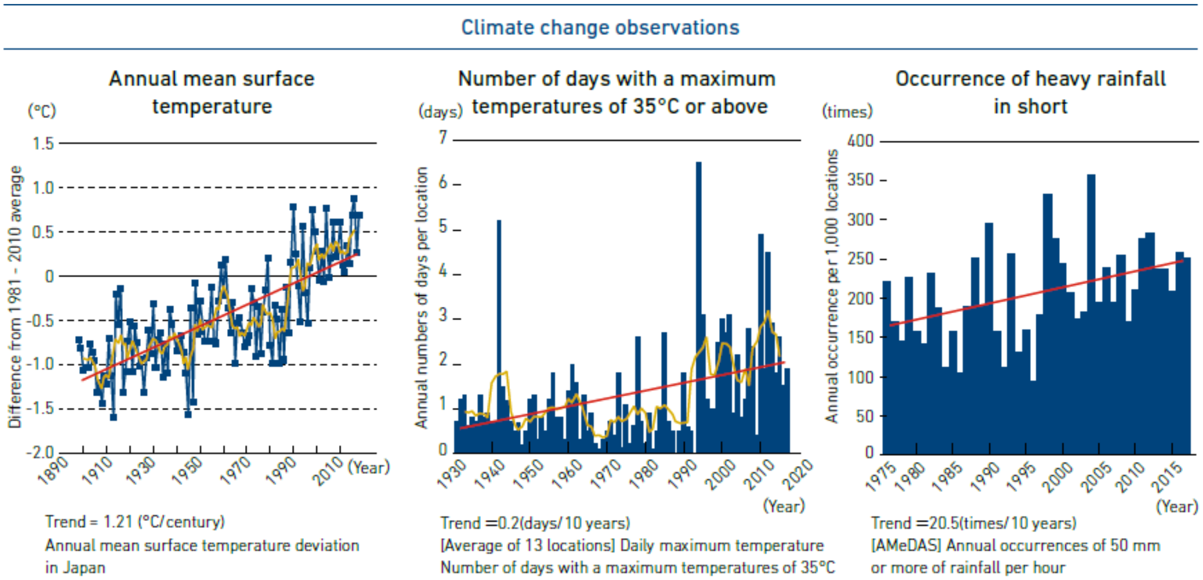


Figure x10. Climate change observations (MOE 2019a, p. 11).

Temperature and Precipitation

The average annual mean surface temperature over Japan has increased and is rising faster in Japan than in the rest of the world (approx. 1.21 °C per 100 years vs. a global average of approx. 0.73 °C) (MOE 2018, p. 2; MOE 2019a, p. 11). A significant rise in temperature is found in all seasons for all four areas of Japan — Northern, Eastern, and Western Japan, and Okinawa-Amami (Ministry of Education, Culture, Sports, Science and Technology (MEXT) et al. 2009, p. 13). The annual number of days with a maximum temperature of 30 °C (86 °F) or above (called as "manatsu-bi" in Japanese) and 35 °C (95 °F) or above ("mosho-bi" in Japanese) have increased from 1931 to 2016 and are expected to become even more frequent in the future (MEXT 2009, p. 13; MOE 2019a, p. 11) (see figure x10).

The annual precipitation varies largely from year to year and ranges from 1,900 mm to 4,000 mm (74 to 157 in) with a mean of 2,475 mm (97 in) (Kubota et al. 2004, p. 231). No clear trends of increases or decreases have been observed (MEXT and JMA 2025, p. 12). Overall, the number of days with precipitation has decreased; however, the number of extreme precipitation events and days with heavy rain of more than 100 mm (3.9 in) per day has increased (MOE 2018, p. 2; MOE 2019a, p. 11). Most rainfall occurs during May and June (the rainy season or tsuyu), and rainfall is especially heavy during the typhoon season (July to October) (Okinawa Regional Headquarters, JMA 1998, cited in Govt of Japan 2019, p. 25; DOD 2019, p. 20). Typhoons bring high rainfall and strong winds to the island (Xu et al. 2008, p. 271).

Climate change may affect the evergreen broadleaved forest ecosystem in Okinawa. However, the impacts to evergreen broadleaf forest trees vary depending on the region (Nakao et al. 2014, p. 640; Govt of Japan 2019, p. 195). Evergreen broadleaf forests may have greater exposure to droughts because they keep their leaves throughout the year. However, they have high stability relative to other biomes because they have a high resistance to droughts (Huang and Xia 2019, p. 3494).

An effect to forest tree composition and diversity would in turn affect Okinawa woodpeckers because the species is dependent on mature, undisturbed forest for food, shelter, and reproduction. Warming temperatures may cause a reduction or northward shift because tree species make natural adjustments to respond to global warming by shifting to higher latitudes for their survival. These range shifts are correlated with the level of warming experienced (Chen 2011, pp. 1024–1026), and shifts in phenology that have occurred are overwhelmingly in the direction expected from climate change (Parmesan and Yohe 2003, p. 38). This likely impacts endemic species that have a limited distribution (Govt of Japan 2019, p. 195). *C. sieboldii* is a fast-growing species and the dominant tree species in Yambaru and is not limited by low colonization rates. However, in the Ryukyu Islands (which includes Okinawa), the potential habitat of *C. sieboldii* was predicted to decrease because of a changing climate. The decrease could be explained by upward range shifts of the species due to its geographical isolation and narrow elevational ranges (Nakao et al. 2014, p. 649).

Species may adapt at a slower rate than the rate at which temperatures and rainfall amounts change due to climate change, particularly if they are habitat specialists, immobile species that cannot colonize across fragmented landscapes, or possess other traits associated with low extinction or colonization rates. Species may also show individualistic physiological responses to different aspects of the climate, such as different sensitivities to maximum and minimum temperatures at critical times of their life cycles (Chen 2011, p. 1025). However, birds are endothermic and may tolerate a wider range of temperatures. Thus, species such as birds that shift their ranges may be responding more to gradual changes in habitat availability, food resources based on long-lived elements of their ecosystem (trees), and response of competitors, than to temperatures, per se (Forero-Medina et al. 2011, p. 4).

Typhoons

Typhoons are common in Okinawa. Typhoons and hurricanes are regionally specific names for a strong tropical cyclone. For example, in the Northwest Pacific it is called a typhoon and in the North Atlantic, central North Pacific, and eastern North Pacific the term hurricane is used (National Ocean Service 2025, unpaginated).

The Ryukyus Islands are one of the most vulnerable zones to typhoons globally (Govt of Japan 2019, p. 195; Ross et al. 2023, p. 3, citing many authors). The Ryukyu archipelago is increasingly exposed to more frequent and intense typhoons, with annual typhoon seasons bringing disturbance events of varying magnitude (Elliott and Nino 1960 cited in Ross et al. 2023, p. 3). Although the number of typhoons varies annually, the annual average is 26 (14 to 39) and 12 (4 to 19) of the total approach Japan (Govt of Japan 2019, p. 26). On average, 7.6 (3 to 15) typhoons approach and make landfall on northern Okinawa annually, or about 30 percent of the total typhoons occurring (Govt of Japan 2019, pp. 26, 195). The peak typhoon months are August and September (DOD 2019, p. 20).

Direct effects of typhoons to the Okinawa woodpecker include mortality from exposure to strong winds, rains and storm surges, and geographic displacement of individuals. Indirect effects include loss of food supplies or foraging substrates, loss of nests and nesting or roosting sites, increased vulnerability to predation, microclimate changes, and increased conflict with humans.

The short-term response of bird populations to hurricane damage, before changes in plant succession, includes shifts in diet, foraging sites or habitats, and reproductive responses (Wiley and Wunderle 1993, p. 321).

Typhoons in northern Okinawa affects habitat by causing turnover of tree species because frequent disturbances and chronic wind stress cause higher mortality and loss of biomass, especially on ridges (Kubota et al. 2004, p. 230). Diversity and productivity of woody species are higher on ridges than in valleys and slopes because ridges are more affected by frequent typhoons and fallen trees create canopy gaps. This enables various tree species to coexist because of less competition for light in gaps (Kubota et al. 2004, p. 236). Studies suggest that primary forest with a mix of vegetation types and life forms is most likely to resist and recover from typhoon disturbance (Abbas et al., 2020; Zampieri et al., 2020, cited in Ross et al. 2023, p. 2). Dead trees and snags that the Okinawa woodpecker uses are affected by typhoons, although dead trees are at higher risk than live trees of collapse during typhoons. Therefore, typhoons may lead to lower woodpecker breeding success in dead trees than in live trees (Kotaka et al. 2021, p. 198, citing Kilham 1971 and Kotaka 2009).

Closed canopy specialists, frugivores, granivores, and nectarivores should be most vulnerable to food resource losses following typhoons (Chevalier et al., 2019, cited in Ross et al. 2023, p. 3; Wiley and Wunderle, 1993, p. 325; Zhang et al., 2016, p. 6), while insectivores may benefit from increased access to prey in canopy gaps (Seki 2005, p. 117, citing many authors). Strong winds strip flowers, fruits, and seeds from plants, while arthropod populations might be initially reduced by hurricanes, but because of their shorter life cycles and rapid reproductive rates, they may recover more quickly than vegetation (Wiley and Wunderle 1993, p. 325). The Okinawa woodpecker has a diverse diet and feeds on insects, fruit, seeds, and nuts. Thus, while some food resources may be depleted following typhoons, resources such as insects may increase or become more available following a typhoon. Overall, wildlife in this region have adapted to frequent typhoons and heavy rains over a long period of time (Govt of Japan 2019, p. 195). Therefore, the species has resiliency to withstand the direct and indirect effects of typhoons.

4.5 CONSERVATION ACTIONS

Conservation actions that benefit the Okinawa woodpecker and its habitat include more sustainable logging practices, designation of protected areas, and successful trapping and eradication of nonnative invasive species. The IUCN formerly considered Okinawa woodpecker to be Critically Endangered because of a declining population trend. The species has been recategorized as Endangered because increased protection of forests and successful programs to eradicate mongoose have stabilized the species population (BLI 2024, p. 1). Logging for timber was prevalent in the 20th century in Yambaru, including before and after WWII to meet the increased timber demand related to postwar reconstruction (Takashima et al. 2008; Saito 2011, in Kotaka et al. 2021, p. 192). Subsequently, the logging industry has moved toward more sustainable practices that have reduced the threat of deforestation (Govt of Japan 2019, pp. 111–112). Therefore, threats from logging have been reduced, but it takes time for secondary and clear-cut forest habitat to transition to mature forests that are preferred by Okinawa woodpeckers. Most forested areas in Yambaru are at least 50 years old and the habitat is not severely fragmented, which has increased habitat suitability for the species.

The Okinawa woodpecker is listed under Japan's Act on Conservation of Endangered Species of Wild Fauna and Flora (MOE 2020 unpaginated). The species is also designated as a National Natural Monument under the Law for the Protection of Cultural Properties (Law No. 7). The law's stated purpose is to preserve and use cultural properties to advance the culture of the Japanese people and contribute to the knowledge of the evolution of world culture (DOD 2019, p. 101). Animals, plants, and geological features and minerals of significant scientific value to Japan are designated by the Minister of Education, Culture, Sports, Science and Technology. Additionally, prefectural and municipal governments can designate cultural properties that are under the control of each local government and have not been designated by the Minister of Education, Culture, Sports, Science and Technology (DOD 2019, p. 101). These laws require review and mitigation procedures to assess potential impacts on known cultural assets.

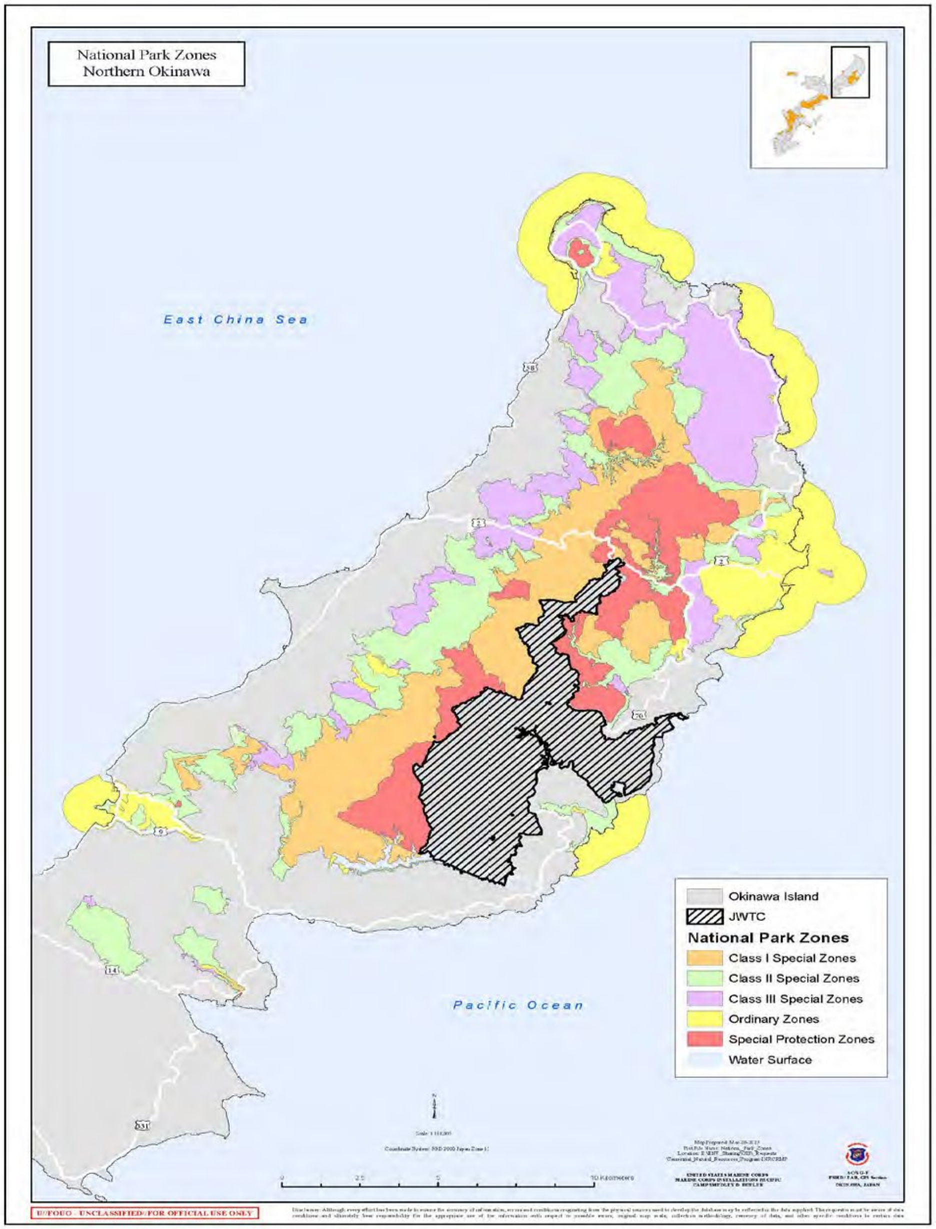
4.5.1. Habitat Protection

Yambaru National Park

The Japanese Government established Yambaru National Park in September 2016 under the Natural Parks Act (National Parks of Japan 2025, unpaginated) (figure x11). It covers 173 km^2 (66.8 mi^2) with 136 km^2 (52.5 mi^2) of land area in the northern part of Okinawa (MOE 2025, unpaginated). The goal of the park is to protect one of the largest subtropical evergreen forests within Japan, along with the many rare species that inhabit the area (Ryukyu Shimpo 2016a, unpaginated). The plan for Yambaru National Park sets a policy to ensure that no species within the park becomes extinct and designates 2,888 ha (28.88 km^2 or 11.12 mi^2) of old-growth forest (greater than 70 years old) as Special Protection Zones for Okinawa woodpecker habitat (Gov't of Japan 2019, p. 5–44). The plan also designates an additional 4,811 ha (48.11 km^2 or 18.58 mi^2) of Okinawa woodpecker habitat as Class I Special Zones, which contain forests that are 30 to 60 years old (Gov't of Japan 2019, p. 5–45).

World Heritage List

In 2016 and 2019, the Japanese Government nominated the Amami-Ryukyu Islands as a World Natural Heritage site with the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Centre (UNESCO 2016, unpaginated). These nominations were denied, mainly due to the U.S. military's close presence at the JWTC (Yoshikawa and Kawamura 2019, p. 1–4). However, in May of 2021, a UNESCO advisory panel recommended that the northern part of the main Okinawa Island, which contains Yambaru National Park, along with Amami-Oshima Island, Tokunoshima Island, and Iriomote Island in Japan be added to the list of natural World Heritage sites (figure x12). These sites were approved in July 2021 (UNESCO World Heritage Committee 2021, unpaginated). While listing a site does not automatically lead to funding for the protection of a site, UNESCO World Heritage listing invites prestige and further attention and recognition (Maurel, 2017, unpaginated).



Classification of Zones in National Parks, and Regulation on Activities

National Park The Classification of zones is decided in park conservation plan	Special Zone	Special protection zone	Areas required to maintain scenic beauty strictly	Erection of structures is prohibited in principle.
		Class I special zone	Areas ranking after special protection zone and required to maintain scenic beauty somewhat strictly and required to conserve the present scenic beauty as far as possible	Erection of structures is prohibited in principle. Namely, the regulation of special protection zone applies correspondingly to this zone.
		Class II special zone	Areas required to adjust the activities of agriculture, forestry and fisheries as far as possible	Establishment of facilities required for the daily life of local people such as housing and other facilities relating to normal activities of agriculture, forestry and fisheries, is permitted in principle. Also establishment of resting facilities, villas, cottages and the like which are not obstructive to scenic beauty will be allowed.
		Class III special zone	Areas other than Class I special zone and Class II special zone, and where there is little fear of affecting the maintenance of scenic beauty in principle even though ordinary activities of agriculture, forestry and fisheries are performed.	Regarding 6rection of structures, regulation is almost same as in the Class II special zone. With regard to forestry, clear cut is allowed.
	Marine park zone		Areas where seascapes are excellent due to abundant marine animals and plants	Same regulation as in the special protection zone.
	Ordinary zone		Areas surrounding special zone of scenic beauty and they are required to conserve scenery as buffer zones in a sense. In many cases there are some settlements and farms. Sea area is also included in this zone.	As for large buildings which may obstruct scenic beauty, administrative action can be taken for the purpose of conservation.

Figure x11. Special Protection Zone and Class I Special Zone of the National Park in Yambaru bordering the Jungle Warfare Training Center was selected as a nominated World Natural Heritage property. Yambaru National Park include all special zones, Marine park zones, and Ordinary zones.

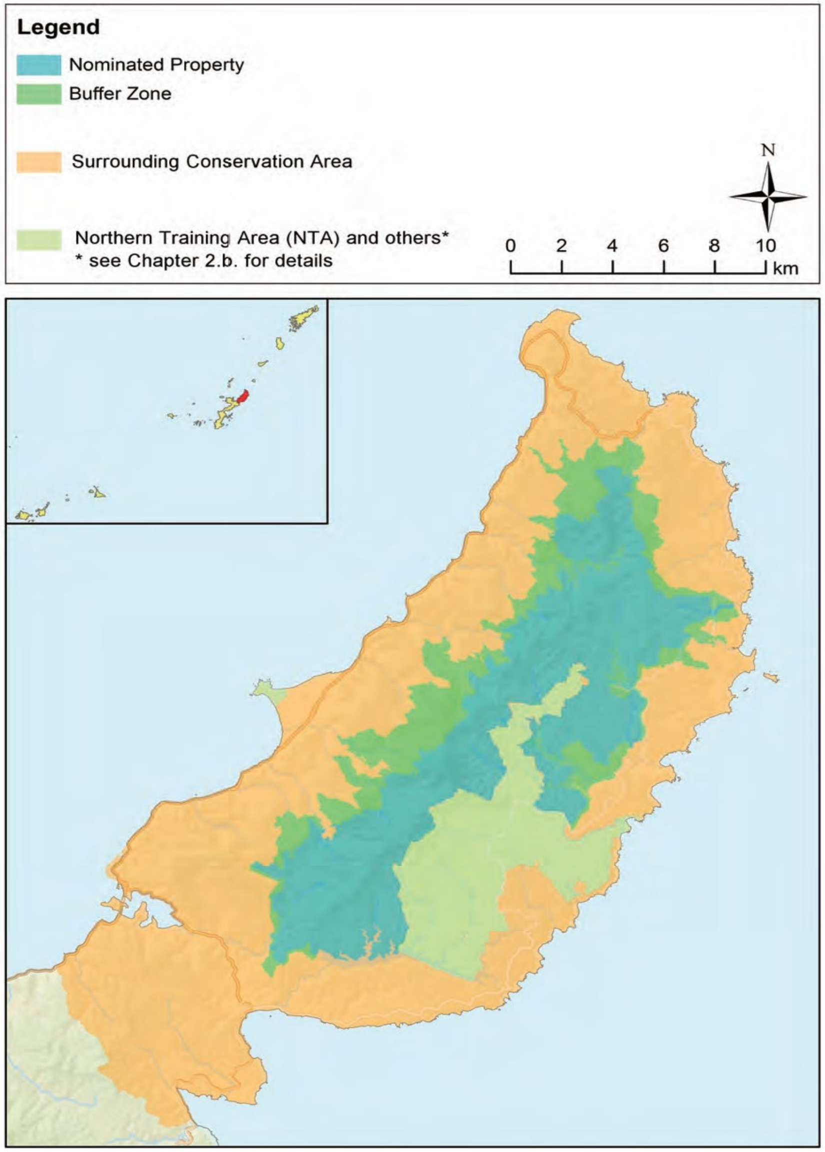


Figure x12. Nominated property in northern Okinawa for Inscription on the World Heritage List.

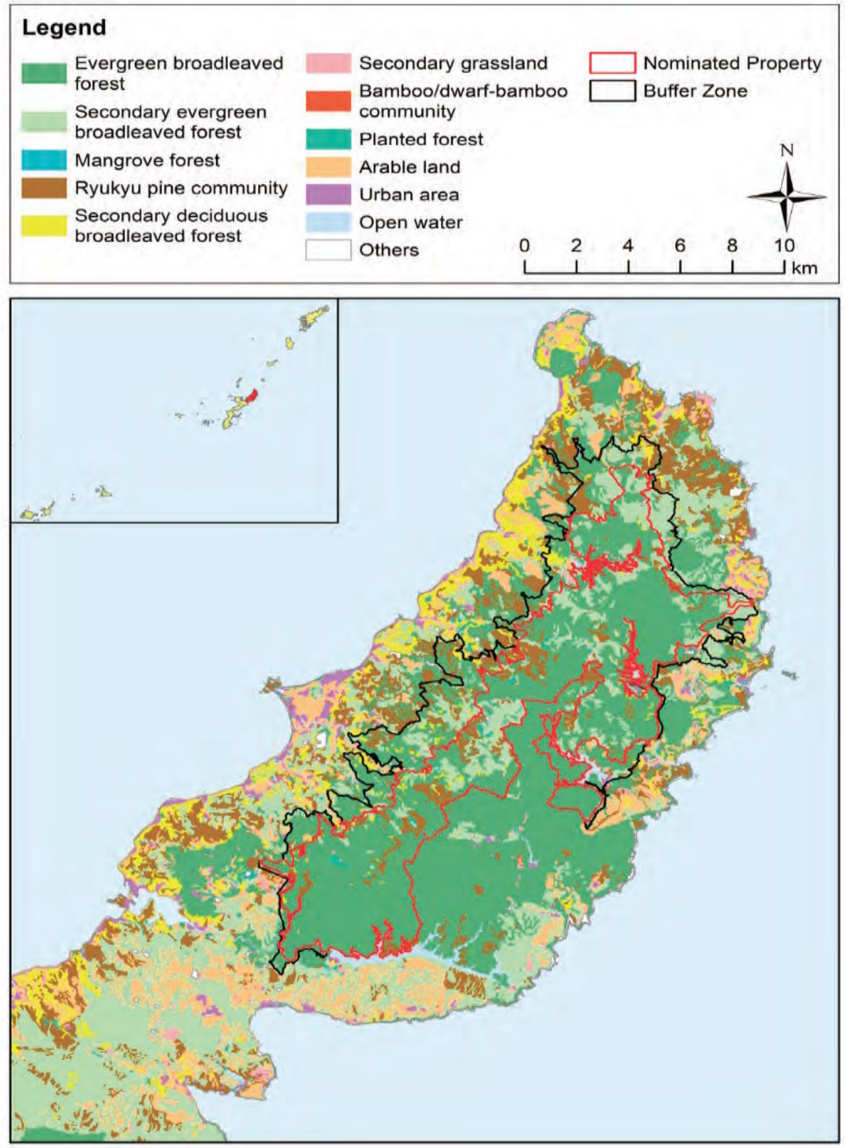


Figure x13. Vegetation of the nominated property (Northern part of Okinawa Island). The Sixth and Seventh Rounds of the National Survey on the Natural Environment (vegetation surveys) by MOE.

4.5.2. Nonnative Invasive Species Management

Mongoose and feral cat predation continue to be a threat to Okinawa woodpeckers. After being released into the southern part of Okinawa Island, mongoose gradually expanded its distribution area, and it is thought that it invaded north of the SF line in the 1990s (MOE 2024, unpaginated).

The presence of mongooses remains a threat to the conservation of the Okinawa woodpecker. Recognition of the mongoose's impact became widespread after systematic control efforts began in the 2000s (Kotaka 2025, pers. comm.). Thus, concerted efforts to eradicate the mongoose from northern Okinawa are ongoing and proven beneficial for woodpecker conservation (MOE Naha 2014, entire). The Japanese Government listed the mongoose as an "invasive alien species" under the Invasive Alien Species Act in 2005 (Yagihashi et al. 2021, p. 2250). The Okinawa Prefecture started a mongoose control project in 2000, and the Ministry of the Environment started a mongoose control project in 2001. In 2005, the Ministry of the Environment and Okinawa Prefecture began working together to implement a control project in response to the designation of mongooses as a specified alien species (MOE 2024, unpaginated). An eradication plan was created in 2005 with a second plan created in 2013 (MOE Nah 2014, p. 5) and a third plan created in 2017 (MOE 2017d, p. 5; DOD 2019, p. 149). Additionally, the Yambaru Mongoose Busters, a volunteer organization formed in 2008, works diligently to eradicate mongoose using a variety of techniques such as traps and sniffing dogs (MOE 2017b, unpaginated; MOE 2014, p. 6).

Fences were erected in 2005 and 2006 as a northern barrier to mongoose movement, and eradication efforts have focused to control mongoose's access to the northern part of Okinawa (Yagihashi et al. 2021, p. 2250) (see figure x14). Three mongoose control fences have been installed: the first fence at the SF line, the second fence at the ST line, and the third fence along Prefectural Route 14 (see figure x14). The third fence marks the boundary between the World Heritage site and Nago City. Between the first and second fences (the "first buffer"), eradication has been nearly achieved, and in the area between the second and third fences (the "second buffer"), mongoose numbers are declining, with signs of recovery of the Okinawa woodpecker and other native birds such as the Okinawa robin (*Larvivora namiyei*) and the Okinawa rail (*Hypotaenidia okinawae*). The recovery of these endemic bird species in the second buffer, which lies outside the World Heritage site, has strengthened the need for further mongoose control and biodiversity restoration in areas outside the heritage zone, including Nago City.

The blue shaded area in figure x14 is north of the SF line. The two areas south of the SF line, the yellow shaded area and pink shaded area separated by the second and third fence, respectively, are buffer zones where traps are used to prevent mongoose re-entry north of the SF line (MOE 2024, unpaginated). Currently, the Ministry of the Environment (MOE) is responsible for the area north of the SF line, while Okinawa Prefecture Government (OPG) is responsible for the area south of the SF line (MOE 2024, unpaginated).

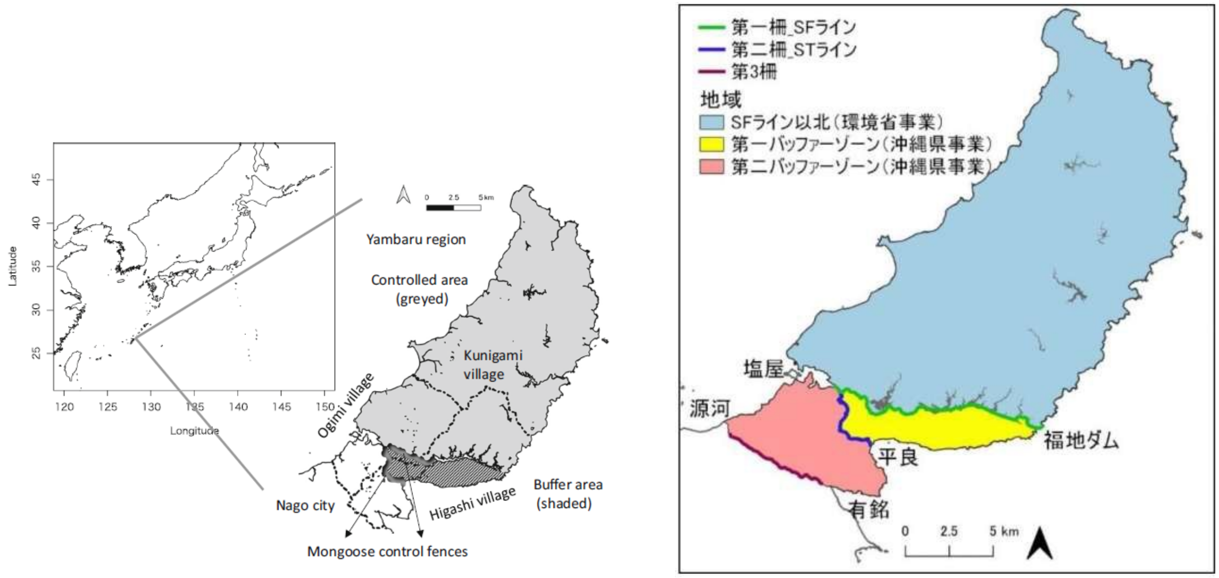


Figure x14: Map of mongoose control area on Okinawa Island (Yagihashi *et al.* 2021, p. 2252) (left). Mongoose control areas implemented in 2023. The green line is the first fence, the purple line is the second fence, and the red line is the third fence (right).

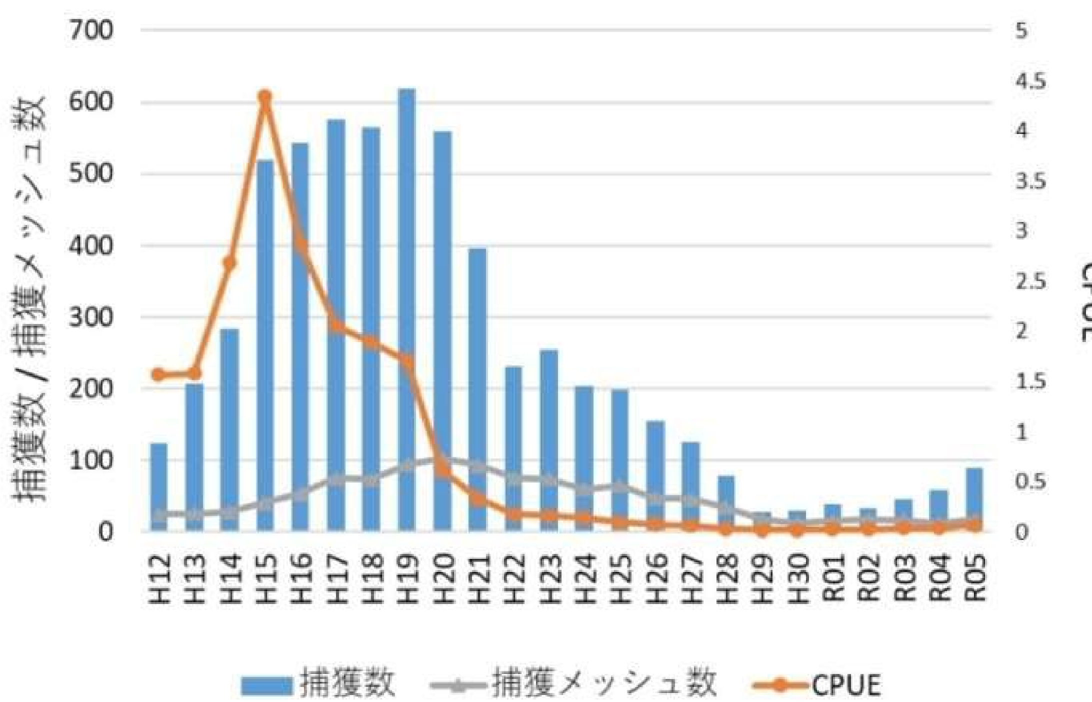


Figure x15. Annual trends in the number of mongoose captures (blue bars), number of capture meshes (gray line), and capture per unit effort (CPUE) (orange line) north of the SF line (MOE 2024, unpaginated).

Most of the remaining mongoose north of the SF line are within the JWTC (see figure x16). The removal of remaining individuals within the JWTC is the highest priority for achieving eradication north of the SF line. The OPG and MOE have conducted mongoose trapping with live and kill traps throughout the southern part of the JWTC with the approval of the U.S. Forces Japan since 2004. Cumulatively, because of the OPG, MOE, and Marine Corps Base Camp Butler Environmental Affairs Branch (EAB) trapping programs, 1,624 mongooses have been trapped in the JWTC as of March 2019 (DOD 2019, p. 147) (see figure x17).

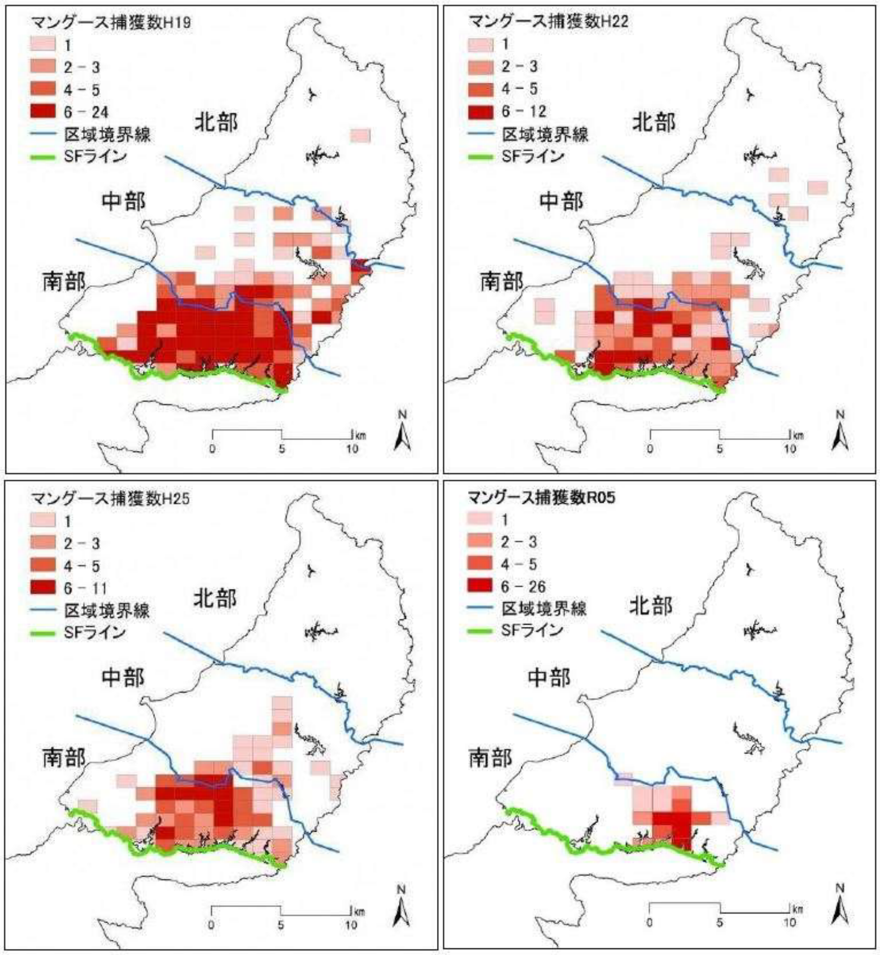


Figure x16. Annual capture north of the SF line (top left: H19, top right: H22, bottom left: H25, bottom right: R05). H and R refer to the Japanese era names: H19 = 2007, H22 = 2010, H25 = 2013, R05 = 2023. In the bottom-left panel (R05, 2023), mongooses remain within the JWTC area (MOE 2024, unpaginated).

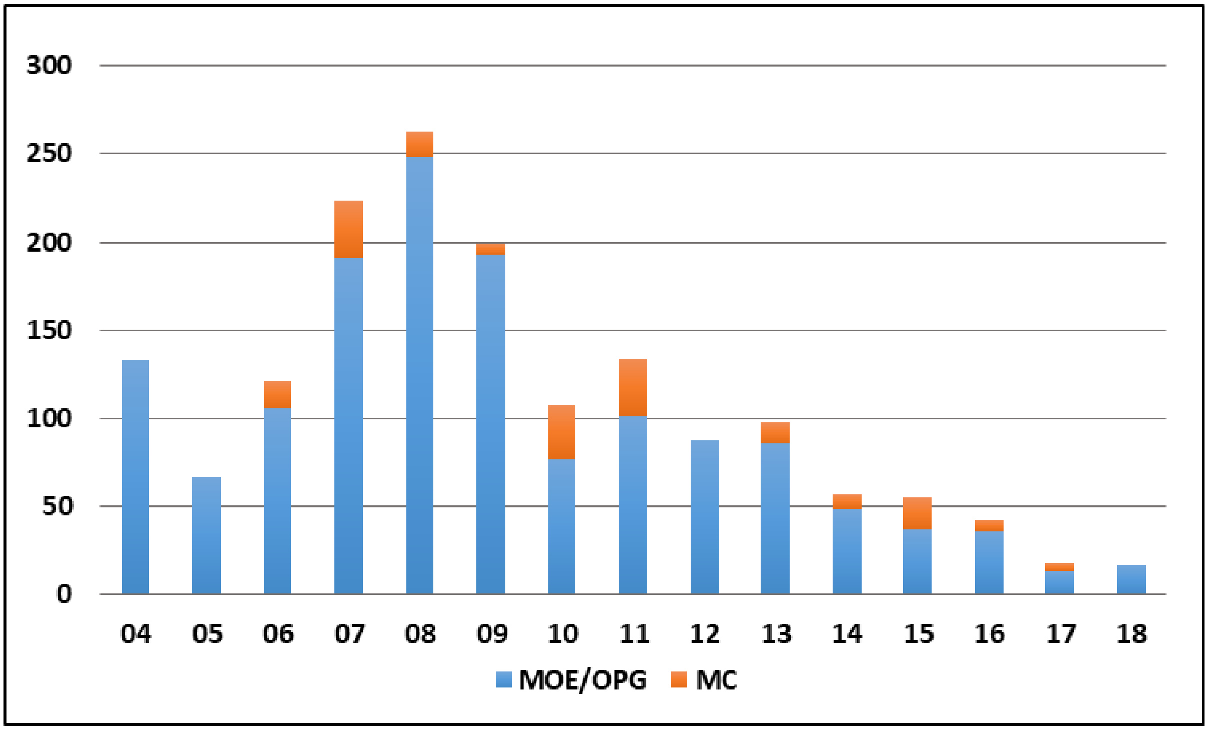


Figure x17. Total catches of mongoose in JWTC since 2004 (DOD 2019, p. 147)

The number of mongooses captured each year since the program began in 2000 have measurably declined (see figures x14–x18), indicating that the mongoose population has decreased overall (MOE 2012, pp. 55, 94). Thus, the results of the eradication plans have shown a steep decline in the mongoose population, and eradication efforts will continue until the population reaches zero (MOE 2017d, p. 7–11; MOE 2019b, pp. 5-280–5-286). However, the eradication of mongooses north of the SF line by 2027 is difficult and is expected to be revised in the near future and there is a clear commitment to eradication of mongoose in northern Okinawa. To accomplish complete eradication of mongooses from Okinawa Island, initiatives within U.S. military bases further south in Okinawa (e.g., Camp Hansen and Camp Schwab) will also be of critical importance.

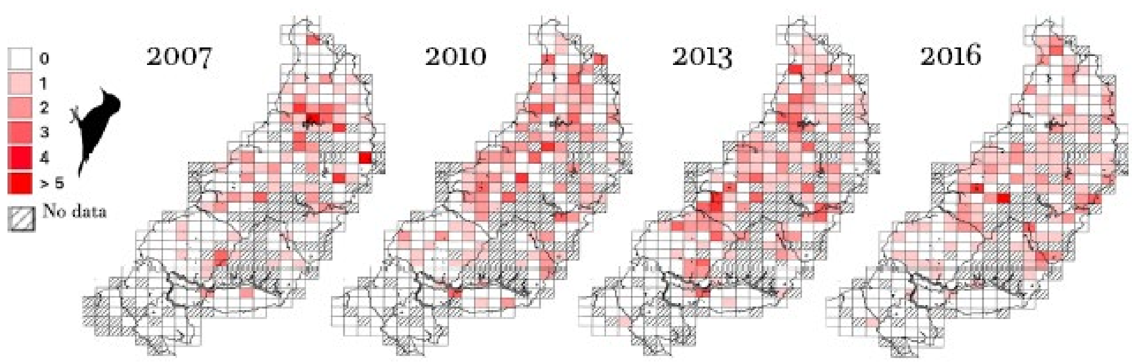


Figure x18: Numbers of Okinawa woodpeckers detected during playback surveys between 2007 and 2016. Each grid cell represents one of 281 survey sites. The number of sites at which woodpeckers were detected was 67, 96, 104, and 100 in each year, respectively, showing an increasing trend over time. (Yagihashi et al. 2021, pp. 2254–2255).

Control programs for feral cats have proven complex and less successful. Domestic cats are abandoned in Okinawa, and due to the lack of spaying and neutering efforts and partially due to the traditional beliefs that prohibit taking life through euthanasia, the release of unwanted animals is a relatively common practice in Japan (Takahashi 2004, p. 138). Considerable opposition from animal welfare groups exists regarding lethal removal of cats from Yambaru, despite the threat that cats pose to the Okinawa woodpecker and other sensitive species (such as the Okinawa rail) (Takahashi 2004, p. 140). However, an action plan has been developed by the three villages (Kunigami, Ogimi, and Higashi) and Okinawa Prefecture that covers a 10-year period (2023–2032). Okinawa Prefecture has also been running a long-standing campaign on responsible cat ownership, and management is being strengthened and gradually progressing, particularly in Kunigami and Ogimi Villages (Kotaka 2025, pers. comm.).

4.6 SUMMARY OF FACTORS INFLUENCING VIABILITY

We evaluate each threat and the expected effects on the species as a whole. We also consider the cumulative effect of the threats considering those actions and conditions as well as any actions that will have positive effects on the species, such as any existing regulatory mechanisms or conservation efforts (see figure x17). Because the SSA framework considers not just the presence of the threats, but to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors and replaces a standalone cumulative-effects analysis.

In summary, of the identified threats of habitat loss, modification, and fragmentation; activities associated with the JWTC; nonnative invasive species; and the effects of climate change, the primary threat currently and directly impacting the Okinawa woodpecker is nonnative invasive species. Nonnative mammals such as feral cats, and the Indian mongoose in particular, negatively affect the Okinawa woodpecker's survival because of predation. Japan's Ministry of the Environment, Okinawa Prefecture Government, and the U.S. Marine Corps at the JWTC are actively trapping and removing mongoose from northern Okinawa to improve habitat and survival for native species, including the Okinawa woodpecker. This conservation effort has been successful reducing the abundance of mongoose and has resulted in an increase of the Okinawa woodpecker population. The management plan anticipates that all mongooses will be removed from northern Okinawa by 2027, although eradication is difficult, and efforts may be extended beyond 2027. However, there is a clear commitment to eradicate mongoose from northern Okinawa. Control programs for feral cats have proven less successful because there is considerable opposition from animal welfare groups regarding lethal removal of cats from Yambaru. There is an action plan in the three northern villages and Okinawa Prefecture to address feral cats in Okinawa that is being strengthened, and management is gradually progressing. Even though eradication effort for feral cats is less successful than mongoose eradication, the Okinawa woodpecker population has stabilized and is likely increasing.

Historically, deforestation and fragmentation of suitable habitat directly affected the species, especially leading up to WWII and during post-war reconstruction in Japan. The historical loss of forest continues to have legacy effects because the forest is relatively young and trees need time to regenerate to primary forest that is suitable for the Okinawa woodpecker's life history needs. More sustainable logging practices, decreased demand for timber, and designation of formal protected areas have minimized impacts of forest loss and reduced habitat fragmentation. The forest contains patches of mature and undisturbed trees on a few mountaintop areas along a central ridge in Yambaru that provide for the needs of Okinawa woodpecker, and the species is also able to use resources found within naturally regenerated secondary forest, such as *C. sieboldii*, as well as forested habitat and citrus orchards at lower elevations within coastal areas. The species' habitat was at its most degraded in the late 20th century because of the loss of trees and understory vegetation. However, most of Yambaru has been formally designated as a national park, a world heritage site, or both, with requirements to minimize impacts to the environment. Currently, the forest has recovered to the basic features of a climax community. Therefore, because of a decreasing trend of forest loss and formal protection of the forest in Yambaru, the habitat for the Okinawa woodpecker is currently more suitable for the species than it was for most of the 20th century, and it continues to improve.

The effects of climate change are not currently a threat to the species. Climate change may affect forest tree composition and diversity through drought conditions, typhoons, or both. Warming temperatures may cause a reduction or northward shift of tree species and their habitats. Species may adapt at a slower rate than the rate at which temperatures and rainfall amounts change due to climate change if they are habitat specialists, immobile species that cannot colonize across fragmented landscapes, or possess other traits associated with low extinction or colonization rates. Species may also show individualistic physiological responses to different aspects of the climate, such as different sensitivities to maximum and minimum temperatures at critical times of their life cycles. However, birds are endothermic and may tolerate a wider range of temperatures; thus, a shift in their ranges may be responding to gradual changes in habitat availability and food resources based on long-lived elements of their ecosystem (trees) and response of competitors. Typhoons are common in Okinawa and may cause impacts to the habitat, species, or both because of strong winds and heavy precipitation that effects the composition of suitable nesting trees, dead trees and snags, and availability of food resources. However, evergreen broadleaf forests have high stability relative to other biomes because they have a high resistance to droughts. Additionally, primary forest with a mix of vegetation types and life forms is most likely to resist and recover from typhoon disturbance. Lastly, the Okinawa woodpecker has a diverse diet, including insects which are a food resource that may increase in abundance following typhoons. Therefore, typhoons may negatively impact Okinawa woodpeckers, but Okinawa already experiences a relatively high frequency of typhoons, and the species has adapted to the effects of typhoons and heavy rains such that they are not causing a decrease in the population.

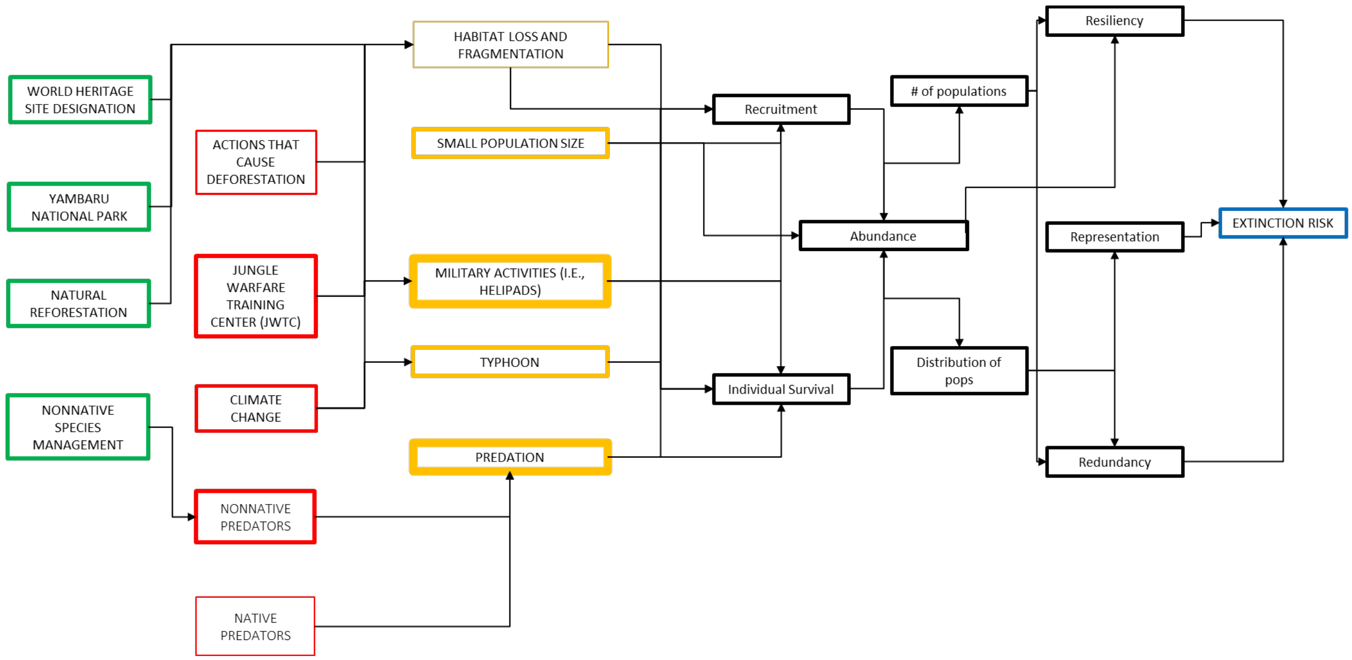


Figure x19. Influence diagram of all factors that affect Okinawa woodpecker and how those factors affect the species' extinction risk.

CHAPTER 5 – CURRENT CONDITION

Current condition may be described in terms of past and ongoing changes in a species' habitat, demographics, and distribution (Smith *et al.* 2018, p. 306). We assessed current condition of the Okinawa woodpecker in terms of the conservation biology principles of resiliency, redundancy, and representation.

The Okinawa woodpecker occurs in northern Okinawa and occurs at several mountaintop areas with mature and undisturbed forest. However, there is minimal information describing population units, subpopulations, or any other information to distinguish analysis units in northern Okinawa. Therefore, we assess resiliency, redundancy, and representation at the species scale for this analysis and northern Okinawa is considered one analysis unit, the Yambaru analysis unit.

5.1 RESILIENCY

We define resiliency for the Okinawa woodpecker as having sufficiently robust populations for the species to withstand stochastic events. A healthy Okinawa woodpecker population can be characterized in terms of its abundance, reproductive rates, survival, and connectivity. Abundance data for the Okinawa woodpecker population is available; however, data on subpopulations are not available. The Okinawa woodpecker is capable of breeding from one year of age and survival rates of breeding individuals at Nishimedake, where old-growth forest remains and mongooses are absent, is approximately 70% for males and 80% for females. Clutch size most commonly consists of four eggs, and fledging success ranges from 1 to a maximum of 4 chicks, with 2 being the most frequent outcome (Kotaka 2025, pers. comm.) We estimated resiliency of Okinawa woodpecker by assessing temporal trends in population abundance, life history traits that guide the species' ability to rapidly recover from disturbances and population losses, existing conservation and regulatory measures, the status of threats and their effects, and cumulative effects to the species' viability. We consider current condition as the species' expected status now and in the near future (approximately 5 to 10 years). The results of our assessment of current condition are described below.

<u>Population Abundance</u>
The Okinawa woodpecker currently occurs in northern Okinawa and previously occurred as far south as Mt. Ishikawadake in the 1930s, prior to WWII and occurred in Nago City through the 1980s. However, the population became more restricted to northern Okinawa (north of Nago City in the 1990s and 2000s. Reports indicate the woodpecker has been considered rare, even close to extinction since the 1930s, and estimates from 1950 through the 1980s have ranged from 40 to 200 individuals. However, in the early 1990s, the population was estimated at its highest level, 400 to 500 individuals based on nest holes and identification of adults using playback or recorded territorial songs. It is not clear if this population estimate was an overestimate or reflected the true population size. Between 2017 and 2019, the Okinawa woodpecker's population was estimated at 882 individuals based on nest density surveys conducted in different forest types, combined with forest area data, and the most recent estimate of the population is 100 to 300 mature individuals occurring in Yambaru. Regardless of the varying population size estimates because of different methods used and areas surveyed, the population has an increasing

trend. The population has likely always been small because it is primarily dependent on mature and undisturbed forests within a finite area in northern Okinawa. Considering the ongoing activities of the U.S. military at the JWTC and predation by nonnative mammals, the Okinawa woodpecker continues to be negatively affected through direct and indirect mortality. However, these threats are effectively addressed through natural forest regeneration, formal protection of forested habitat in northern Okinawa, and trapping and removal of nonnative predators. Additionally, the U.S. military implements conservation measures under their INCRMP such as routine monitoring of the species and invasive species management to reduce populations of the mongoose. Furthermore, Japanese and Okinawa prefecture laws require review and mitigation procedures to assess potential impacts on known cultural assets, including the Okinawa woodpecker. As a result of the improvement in habitat condition, nonnative species management, and avoidance and minimization measures at the JWTC, the population of Okinawa woodpecker is at least stable and likely increasing.

Nonnative Species

The nonnative mongoose is currently a threat to the Okinawa woodpecker. The Yambaru ecosystem historically lacked carnivorous mammals, and the native species are not equipped to defend themselves against nonnative predators (MOE Japan 2014, p. 2). The Okinawa woodpecker is vulnerable to the mongoose because the woodpeckers forage near the ground and are susceptible to predation, particularly male woodpeckers because they commonly forage on the ground for soil-dwelling arthropods (BLI 2024, p. 5; Kotaka et al. 2009, p. 28; Kotaka et al. 2006, p. 196). The Japanese Government listed the mongoose as an “invasive alien species” under the Invasive Alien Species Act in 2005 (Yagihashi et al. 2021, p. 2250), and concerted efforts to eradicate the mongoose from northern Okinawa started in 2000. These efforts are ongoing and beneficial for woodpecker conservation (MOE 2014, entire). An eradication plan was created in 2005 with a second plan created in 2013 (MOE 2014, p. 5) and a third plan created in 2017 (MOE Japan 2017d, p. 5; DOD 2019, p. 149). The number of mongooses captured each year since the program began have measurably declined, indicating that the mongoose population has decreased (MOE Japan 2012, pp. 55, 94). Most of the remaining mongoose are within the JWTC, and mongoose captures north of the SF line have been rising in recent years and raising concerns. Nonetheless, statistical analysis found that the number of Okinawa woodpeckers at a given site is inversely proportional to the number of mongooses (Yagihashi et al. 2021, p. 2255). Therefore, as the mongoose population declines the Okinawa woodpecker population continues to increase. The current mongoose control plan anticipates eradication of mongoose from northern Okinawa by 2027, and even though eradication of mongoose has proven difficult there is a clear commitment to eradicate mongoose from northern Okinawa (MOE 2014, entire; DOD 2019, p. 79; Govt of Japan 2019, p. 179).

Similarly, researchers have found remains from Okinawa woodpeckers in feral cat feces (Jogahara et al. 2003, abstract, p. 37). The threat from cats may be a growing concern because people abandon domestic cats in vulnerable habitats on Okinawa, including the Yambaru Forest (Japan Bureau of Statistics 2015 as cited in Sbeghen 2017, p. 12; Takahashi 2004, p. 138). The lack of spaying and neutering efforts and partially due to the traditional beliefs that prohibit taking life through euthanasia, the release of unwanted animals is a relatively common practice in Japan (Takahashi 2004, p. 138). There is considerable opposition from animal welfare groups continues regarding lethal removal of cats from Okinawa, despite the threat that cats pose to the Okinawa woodpecker and other native sensitive species (such as the Okinawa rail) (Takahashi 2004, p. 140). An action plan has been developed by the three villages (Kunigami, Ogimi, and Higashi) and Okinawa Prefecture, which has also been running a long-standing campaign on responsible cat ownership, and cat management is being strengthened and gradually progressing (Kotaka 2025, pers. comm.). Even though eradication efforts for feral cats are less successful than mongoose eradication, the Okinawa woodpecker population has stabilized and is likely increasing.

Habitat Loss and Connectivity

Habitat loss has historically been a threat to the species. Yambaru has been subject to forestry practices for hundreds of years. Logging in Okinawa peaked from the mid-1920s through the 1950s in Yambaru. Substantial logging occurred during pre-WWII activities and continued through the 1970s to meet the increased timber demand for postwar reconstruction. Many areas of natural forest in Yambaru were affected by deforestation, except the area occupied by the JWTC. More than 60 percent of the area affected was in the central part of Yambaru, and nearly 50 percent of all natural forests outside of the JWTC were clear-cut (Itō et al. 2000, p. 311).

As a result of deforestation, Yambaru was at its most degraded in the late 20th century. The greatest threat to the species was fragmentation of its population into scattered and tiny colonies or isolated pairs (Short 1973, p. 18). The Okinawa woodpecker is an ecological specialist with a narrow range. Therefore, fragmentation of suitable nesting trees and patchy resources likely limits reproductive success of the species. A reduction in the range and distribution of resources is particularly harmful to endemic species that have smaller ranges (Velasquez-Tibata et al. 2012, p. 235). However, the condition of the forest is improving with a decreasing trend of tree loss and demand for timber as well as improved protection of the forest. For example, tree cover throughout Yambaru decreased by only about 5 percent from 2001 through 2024 (GFW 2025, unpaginated). Overall, the Yambaru forest has recovered to the basic features of a climax community and is no longer severely fragmented, although the forest is still considered relatively young, which may limit the opportunities for Okinawa woodpeckers because they need mature, undisturbed forest with trees of a particular age and size to nest. However, the increasing trend of tree cover and older age of trees in Yambaru reduces the threat of habitat loss and fragmentation and increases the suitability of forest habitat for Okinawa woodpecker.

The JWTC is relatively undisturbed and kept in a natural state for jungle training exercises, which has likely benefitted the Okinawa woodpecker (Short 1973, p. 16; DOD 2019, p. 148). However, six helipads for MV–22 Osprey aircraft were recently constructed on the base. About 30,000 trees were cut down in Yambaru within the JWTC to construct the helipads and access roads (Nogami 2017a, unpaginated). The helipads were constructed in Okinawa woodpecker habitat, and the species occurs at five of six landing zones for the aircraft (DOD 2019, p. 142). During construction, it was expected that the birds fled elsewhere and were not killed or injured (Nogami 2017a, unpaginated). However, if mature forest trees were removed it is likely that birds living in the area were negatively affected through loss of nesting and foraging habitat (Nogami 2017a, unpaginated, citing T. Kanaizuka from the Conservation Network for Forest Ecosystem in Japan). The U.S. military at the JWTC implements measures under the INCRMP such as routine monitoring to avoid and minimize impacts to the Okinawa woodpecker. These efforts to avoid and minimize impacts appear to be successful, as even with the construction of these sites and ongoing activities in recent years, the Okinawa woodpecker population has stabilized and is likely increasing.

Climate Change

Climate change may affect the evergreen broadleaved forest ecosystem in Okinawa. Evergreen broadleaf forests may have greater exposure to droughts because they keep their leaves throughout the year. However, these forests have high stability relative to other biomes because they have a high resistance to droughts (Huang and Xia 2019, p. 3494). The impacts to evergreen broadleaf forest trees vary depending on the region (Nakao et al. 2014, p. 640; Govt of Japan 2019, p. 195).

An effect to forest tree composition and diversity would in turn affect Okinawa woodpeckers because the species is dependent on mature, undisturbed forest for breeding, feeding, and nesting. Warming temperatures may cause tree species to make natural adjustments to respond to global warming by shifting to higher latitudes for their survival. These range shifts are correlated with the level of warming experienced (Chen 2011, p. 1026), and shifts in phenology that have occurred are overwhelmingly in the direction expected from climate change, which likely impacts endemic species that have a limited distribution (Govt of Japan 2019, p. 195). Species may adapt at a slower rate than the rate at which temperatures and rainfall amounts because of climate change, particularly if they are habitat specialists, immobile species that cannot colonize across fragmented landscapes, or possess other traits associated with low extinction or colonization rates. Species may also show individualistic physiological responses to different aspects of the climate, such as different sensitivities to maximum and minimum temperatures at critical times of their life cycles (Chen 2011, p. 1025). However, birds are endothermic and may tolerate a wider range of temperatures. Thus, species such as birds that shift their ranges may be responding more to gradual changes in habitat availability, food resources based on long-lived elements of their ecosystem (trees), and response of competitors, than to temperatures, per se (Forero-Medina et al. 2011, p. 4).

The Ryukyus Islands are one of the most vulnerable zones to typhoons globally (Govt of Japan 2019, p. 195; Ross et al. 2023, p. 3, citing many authors). On average, 7.6 (3 to 15) typhoons approach and make landfall on northern Okinawa annually, or about 30 percent of the total typhoons occurring (Govt of Japan 2019, pp. 26, 195). Typhoons in northern Okinawa affect habitat by causing turnover of tree species because frequent disturbances and chronic wind stress cause higher mortality and loss of biomass, especially on ridges (Kubota et al. 2004, p. 230). Dead trees and snags that the Okinawa woodpecker uses are affected by typhoons, although dead trees are at higher risk than live trees of collapse during typhoons. Therefore, typhoons may lead to lower woodpecker breeding success in dead trees than in live trees (Kotaka et al. 2021, p. 198, citing Kilham 1971 and Kotaka 2009). Studies suggest that primary forest with a mix of vegetation types and life forms (such as the Yambaru forest) is most likely to resist and recover from typhoon disturbance (Abbas et al., 2020 and Zampieri et al., 2020, cited in Ross et al. 2023, p. 2).

Direct effects of typhoons to the Okinawa woodpecker include mortality from exposure to strong winds, rains and storm surges, and geographic displacement of individuals. Indirect effects include loss of food supplies or foraging substrates, loss of nests and nesting or roosting sites, increased vulnerability to predation, microclimate changes, and increased conflict with humans (Wiley and Wunderle 1993, p. 321). Strong winds strip flowers, fruits, and seeds from plants, while arthropod populations might be initially reduced by hurricanes, but because of their shorter life cycles and rapid reproductive rates, they may recover more quickly than vegetation (Wiley and Wunderle 1993, p. 325). The Okinawa woodpecker has a diverse diet and feeds on insects, fruit, seeds, and nuts. Thus, while some food resources may be depleted following typhoons, resources such as insects may increase or become more available following a typhoon. Overall, wildlife in this region have adapted to frequent typhoons and heavy rains over a long period of time (Govt of Japan 2019, p. 195). Therefore, the species has sufficient resiliency to withstand the direct and indirect effects of typhoons.

Life History

The life history of the Okinawa woodpecker is not well known. Both sexes are capable of breeding from 1 year of age and generation time is estimated at 4.7 to 5.2 years. Clutch size ranges from two to a maximum of five eggs, with four being the most common (Kotaka 2025, pers. comm.). The number of fledglings is most often two, with a maximum of four recorded (Kotaka 2025, pers. comm.). The species has a narrow range and needs mature, undisturbed forest trees of a certain size and age to be large enough for nesting. Additionally, the species prefers nesting in trees with decaying heartwood, which are a characteristic of old growth forests, but can also be an ephemeral resource in younger forests because of pests that cause diseases and die offs of trees. The species is known to use several tree species for nesting and feed on a diversity of insects, fruits, seeds, and nuts. Therefore, the species' known life history traits likely would not limit recovery from annual variation in recruitment and survival as long as suitable habitat is present.

Conservation and Regulatory Measures

Conservation efforts have benefitted Okinawa woodpecker. Most forested areas in Yambaru are protected such that the range of the species is within protected forested areas. Most of Yambaru is designated as a national park or is within a UNESCO World Heritage site. Additionally, the Okinawa woodpecker is listed under Japan's Act on Conservation of Endangered Species of Wild Fauna and Flora (MOE 2020 unpaginated). The species is also designated as a National Natural Monument under the Law for the Protection of Cultural Properties (Law No. 7). These laws require review and mitigation procedures to assess potential impacts on known cultural assets. The Okinawa woodpecker is also included in the INCRMP for the U.S. Marine Corps at the JWTC that provides measures to minimize impacts of their activities to the species. Mongoose abundance in the JWTC is showing signs of increase and proving difficult to eradicate. However, the U.S. Marine Corps at the JWTC has dedicated efforts to eradicated mongoose from the base, which has benefited the Okinawa woodpecker, with eradication of mongoose from northern Okinawa anticipated by 2027, and even though eradication is difficult, there is a clear commitment to eradicate mongoose from northern Okinawa.

In summary, the Okinawa woodpecker has sufficient resiliency to withstand stochastic events that occur in northern Okinawa. The species' population is small and has likely always been small. The species' resiliency depends on the availability, condition, and connectivity of suitable forest trees in its range, all of which are increasing. The species has increasing connectivity of habitat in the central ridge because birds can disperse (through flight) to different mountaintop areas within its range and the habitat suitability is increasing throughout Yambaru. Additionally, the evergreen broadleaved forest has high stability in Okinawa, and because birds are endothermic, the species is more tolerable to changing climate conditions that may cause stochastic disturbances.

5.2 REDUNDANCY

Okinawa woodpecker redundancy (ability of the species to withstand catastrophic events) is determined by the number and distribution of resilient populations across the species' range in relation to catastrophic events that occur within the species' range. Typhoons are common in Okinawa. These catastrophic events may result in changes to forest composition because typhoons in northern Okinawa can cause turnover of tree species as frequent disturbances and chronic wind stress cause mortality and loss of biomass in the forest (Kubota et al. 2004, p. 230).

Species in Okinawa, including the Okinawa woodpecker, have adapted to frequent typhoons and heavy rains over a long period of time (Govt of Japan 2019, p. 195). The Yambaru forest has the highest biodiversity among all Japanese forests, and several studies suggest that primary forest with a mix of vegetation types and life forms like the Yambaru forest is most likely to resist and recover from typhoon disturbance (Abbas et al., 2020; Zampieri et al., 2020, cited in Ross et al. 2023, p. 2). The dominant tree species in Yambaru is *C. sieboldii*, which is an important tree of natural regrowth because it has a low stump mortality rate with abundant, fast-growing sprouts in a regenerating forest after disturbance (Wu et al. 2013, p. 539; Kubota et al. 2005, p. 894). Thus, *C. sieboldii* is the dominant species in the early stage and continue to dominate in the secondary forest. Trees with decaying heartwood and snags and dead trees are vital to Okinawa woodpecker. However, dead trees are vulnerable because they have low strength and a high risk of collapse due to decomposition in a humid climate, high winds, and heavy precipitation (Kotaka et al. 2021, p. 198). Nesting in dead trees that are at higher risk of collapse may lead to lower breeding success than woodpeckers that nest in live trees (Kotaka et al. 2021, p. 198, citing Kilham 1971 and Kotaka 2009).

There are multiple mountaintop areas along the central ridgeline in northern Okinawa and the Okinawa woodpecker would be able to disperse to suitable habitat if displaced by the effects of a typhoon. The home range of the Okinawa woodpecker is around 4 to 7 hectares (10 to 17 acres) and the closest recorded distance between nests of the species in the same breeding season is 70 m (230 ft) (Kudaka and Taira 1994, cited in DOD 2019, p. 44). With small home ranges and numerous mountaintops in Yambaru where the species occurs or has previously occurred, subpopulations likely exist at these mountaintops on the central ridge. However, there is no information on spatial trends or subpopulations to divide the habitat for the species. Therefore, we consider the population as one analysis unit. Overall, even with the limited range of the Okinawa woodpecker, it has some redundancy to withstand catastrophic events because there are multiple mountaintop areas with suitable mature forest habitat within the Yambaru analysis unit.

5.3 REPRESENTATION

Okinawa woodpecker representation (ability of the species to adapt to near-term and long-term change) is determined by the current diversity of ecological conditions and genetic diversity across the species range. The Okinawa woodpecker exists as a small population that occurs in northern Okinawa. Multiple mountaintop areas that contain mature and undisturbed forest that the species uses or has previously used occur on the central ridge of Yambaru. These mountaintop areas contain similar evergreen broadleaf forest habitat that the species needs for breeding, feeding, and nesting.

Growth rates, reproductive success, the age of first breeding, and pre- and post-fledgling behavior are unknown. Lower reproductive output in conjunction with other factors like a high degree of habitat specialization, and small population size typically equate to low innate adaptive capacity (Thurman et al. 2020, entire). Okinawa woodpeckers can persist in place because the condition of the forest has steadily improved over the last few decades and there are multiple mountaintop areas with suitable habitat. The species can also shift in space because it has high vagility and can disperse within its narrow range through flight to these mountaintop areas in Yambaru that have increased connectivity because of the improved habitat condition that is no longer severely fragmented.

We have no data about the genetic diversity of the species. Because the numerous mountaintop regions are within dispersal distance of Okinawa woodpeckers, it is reasonable to assume that connectivity between these areas allows for gene flow within the population. Microhabitats within the species' range are likely present because there are patches of mature, undisturbed forest on mountaintops and interspersed on steep slopes, in secondary forests, and in cleared areas connecting these mountains (Short 1973, p. 5). Historically, fragmentation of the habitat has been a significant threat to the population. However, with the improved condition of the forest because of less timber demand and formal protection of the forest areas, the habitat is no longer severely fragmented and connectivity between suitable patches has increased and will help maintain gene flow and reduce the loss of genetic diversity through drift.

Based on the best scientific and commercial data available, the Okinawa woodpecker exhibits some degree of behavioral plasticity. Trees greater than 30 years old and greater than 20 cm (7.9 in) in diameter are breeding habitat vital to the species. The Okinawa woodpecker uses a diversity of trees for nesting (Kotaka et al. 2021, p. 195). A citation claimed that the Okinawa woodpecker did not use coniferous trees for nesting (Short 1973, p. 8). However, a recent study confirmed that pine trees are used for nesting (Kotaka et al. 2021, p. 195). The Yambaru forest is relatively young, pine trees are present in secondary forest, and the Okinawa woodpecker will use pine trees as a nesting substrate if they are large enough and suitable for nesting, but only when the trees are standing dead. Additionally, the species has also nested in well-forested coastal areas and in dead trees around citrus orchards (Kodaka 2018, as cited in Katayama et al. 2022, p. 101). Younger trees can be used by the Okinawa woodpecker, as younger forests may contain dead trees because exotic pest species cause die offs and cavity formations in trees. Dead trees caused by exotic pests are an ephemeral source that the species has adapted to use. Lastly, the species has a diverse diet including insects, nuts, seeds, and fruits, and citrus fruits in orchards when resources are scarce in the winter (Kodaka 2018, as cited in Katayama et al. 2022, p. 101). Overall, the species has adapted to using a variety of trees for nesting and can move within the analysis unit in response to resource availability.

5.4 VIABILITY

In summary, the population of the Okinawa woodpecker is small and is at least stable and likely increasing. The species' area of occurrence is mostly limited to the central ridge in Yambaru, although they have been observed using well-forested coastal areas and in dead trees around citrus orchards in Yambaru. Okinawa woodpeckers use trees of a certain size and age that provide suitable sites to create nesting cavities or use existing cavities to nest. Information on subpopulations is unavailable, although the species is known to occur at multiple mountaintop areas within its range.

Habitat loss, degradation, and fragmentation; nonnative invasive predators; and indirect effects (i.e., noise) from the JWTC are the current factors affecting the species. Habitat loss, degradation, and fragmentation were a significant threat to the species historically. The habitat was affected throughout the 20th century because of timber demand pre-WWII as well as post-war reconstruction. The condition of Yambaru forests was at its lowest at the end of the 20th century and has improved over the last three decades due to more sustainable logging practices and formal protection of the forest habitat in Yambaru National Park and the UNESCO World Heritage site. Additionally, the ongoing trapping and removal of the mongoose has steadily decreased its population and has increased the Okinawa woodpecker population. However, in recent years (after 2019), the mongoose population has stopped declining within the JWTC, and they have proven difficult to eradicate. However, there is a clear commitment to eradicate mongoose from northern Okinawa. Even though feral cats are a concern in Okinawa, an action plan is being strengthened and progressing. The overall improved habitat condition and decrease in mongoose predation has resulted in an increase of the Okinawa woodpecker population. Additionally, the protected area of Yambaru National Park, UNESCO World Heritage site, and the U.S. Marine Corps base at the JWTC include management plans that will continue to provide conservation benefits to the Okinawa woodpecker. The Okinawa woodpecker will benefit from continued cooperation between Japan and the United States military.

Overall, the species is likely to maintain a healthy population into the near future (approximately 5 to 10 years). Even though the species' population is small, redundancy on mountaintops in northern Okinawa combined with the species' resiliency and ability to adapt to ongoing threats by utilizing diverse nesting sites and food resources supports the species viability in the face of ongoing threats.

CHAPTER 6 – FUTURE CONDITION

To assess the future condition, scenario planning is a comprehensive exercise that involves the development of scenarios that capture a range of plausible future conditions for the species, which is then followed by an assessment of the potential effects of those scenarios on a given species. Scenarios are not predictions or forecasts of what will happen in the future for a species but are projections or explorations into the range of conditions that may exist based on current information. Scenarios are intended to provide the "upper" and "lower" bounds of plausible conditions, outline uncertainties, and provide decision makers with a means for evaluating risk in current and future decisions.

We projected the species' status out three decades because the habitat condition for the species has steadily improved over the last three decades and protection of the species and its habitat is unlikely to change over the next three decades. Assessing the Okinawa woodpecker, the most plausible future scenario is a continuation of the species' current condition. Therefore, in this case we do not provide an upper and lower bound scenario analysis. The species' habitat is protected in Yambaru National Park, a UNESCO World Heritage site, as well as the U.S. military at the JWTC. These designated land uses are unlikely to change in the future. Additionally, the Okinawa woodpecker is a protected species in Okinawa and laws require review and mitigation procedures to assess potential impacts on known cultural assets, including the Okinawa woodpecker. Formal protection of the species and its habitat in Okinawa are likely to continue.

The Japan Ministry of the Environment, Okinawa Prefecture Government, and the U.S. military have worked together to conduct mongoose trapping. An eradication plan was created in 2005 with a second plan created in 2013 (MEO Nah 201, p. 5) and a third plan created in 2017 (MOE Japan 2017d, p. 5; DOD 2019, p. 149). The results of the eradication plans have shown a steep decline in the mongoose population, and eradication efforts will continue until the population reaches zero, which is anticipated by 2027 (MOE 2017d, p. 7-11; MOE 2019b, pp. 5-280–5-286). Eradication is difficult and may extend beyond 2027, but there is a clear commitment to eradicate mongoose from northern Okinawa. Thus, the threat of predation will be significantly reduced in the future. The Okinawa woodpecker will benefit from continued cooperation between Japan and the United States military. Even though feral cats in Okinawa are a concern, there is an action plan to address feral cats in Okinawa, and the woodpecker's population has stabilized and is likely increasing despite the feral cats. We do not anticipate that feral cats in Okinawa will be a greater concern in the future than they are currently.

Looking ahead, the eradication of mongoose from Camp Schwab and Camp Hansen will become a critical conservation challenge if Okinawa aims for island-wide eradication. Mongooses are a major extinction driver for the Okinawa woodpecker and other native bird species such as the Okinawa rail and Okinawa robin and many other species. Therefore, the eradication of mongoose from the entire island of Okinawa is expected to emerge as a realistic conservation goal in the future.

Climate change is expected to increase temperatures, change precipitation patterns, and amplify extreme weather events in Japan (MOE 2019a, p. 11; MOE 2018, p. 2; Govt of Japan 2019, p. 195, citing many authors). The climate is expected to be warmer and drier in the future, and the intensity of the extreme precipitation is likely to be much stronger over the entirety of Japan (Shalishe et al. 2024, p. 166) (see figure x20).

Overall, projections with the four Representative Concentration Pathways (RCP) scenarios indicate that annual mean temperature at the end of the 21st century will rise throughout Japan, with a greater increase under RCP8.5 than under RCP2.6 and a greater increase at higher latitudes. Under RCP2.6, temperatures at the end of the 21st century are expected to increase from 0.5 to 1.7 °C higher than those at the end of the 20th century. Under RCP8.5, temperatures are expected to increase from 3.4 to 5.4 °C higher (MOE 2019a, p. 11). Additionally, under the RCP8.5 scenario, the annual number of days with a maximum temperature of 35 °C (95 °F) or above for the end of the 21st century is projected to increase, especially in the Okinawa and Amami region, where an increase of about 54 days is projected compared to the end of the 20th century. The number of days without precipitation for the end of the 21st century is projected to increase under all four RCP scenarios (MOE 2019a, p. 11; MOE 2018, p. 2).

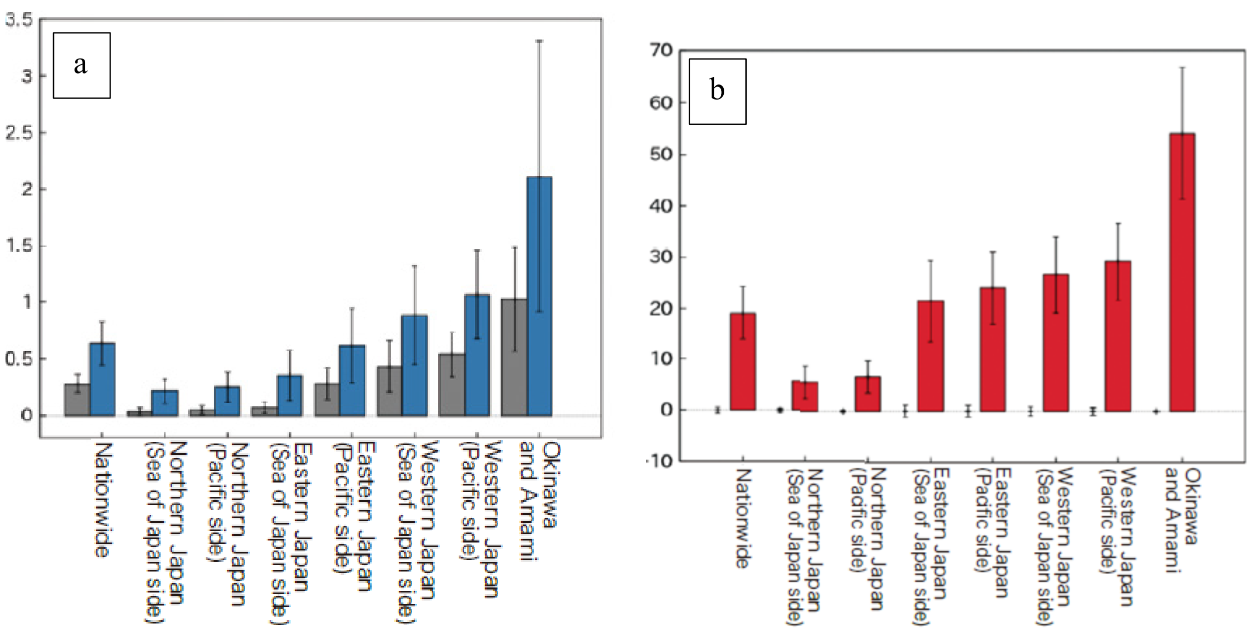


Figure x20. Figure (a) is the projected change in the annual number of events with precipitation of 50 mm/hour or more. The colored bars represent the number of occurrences per site (gray is the present, blue is the future). Figure (b) is the projected (future) change in the annual number of days with a maximum temperature of 35 °C (95 °F) or above. The thin black lines are the standard deviation of interannual variability. Okinawa is the column to the far right (MOE 2018, p. 2).

Climate change may affect the evergreen broadleaved forest ecosystem in Okinawa and the Okinawa woodpecker in the future. While evergreen broadleaf forests may have greater exposure to droughts because they keep their leaves throughout the year, this forest type has high resistance to droughts (Huang and Xia 2019, p. 3494). An effect to forest tree composition and diversity would in turn affect Okinawa woodpeckers because the species is dependent on mature, undisturbed forest for breeding, feeding, and nesting. *C. sieboldii* is a fast-growing species and the dominant tree species in Yambaru and is not limited by low colonization rates. However, in the Ryukyu Islands (which includes Okinawa), the potential habitat of *C. sieboldii* was predicted to decrease because of a changing climate. The decrease could be explained by upward range shifts of the species due to its geographical isolation on the island and its narrow elevational ranges in Yambaru (Nakao et al. 2014, p. 649). Range shifts are correlated with the level of warming experienced and are overwhelmingly in the direction expected from climate change (Govt of Japan 2019, p. 195).

Species such as the Okinawa woodpecker may also show individualistic physiological responses to different aspects of the climate, such as different sensitivities to maximum and minimum temperatures at critical times of their life cycles (Chen 2011, p. 1025). Data on temperature sensitivities for the Okinawa woodpecker are unknown. However, birds are endothermic and may tolerate a wider range of temperatures. Thus, species such as birds that would be affected by climate change may be responding more to gradual changes in habitat availability, food resources based on long-lived elements of their ecosystem (trees), and response of competitors, than to temperatures, per se (Forero-Medina et al. 2011, p. 4).

Extreme events of typhoons are common in Okinawa and are predicted to increase in frequency and intensity because of climate change (MEXT et al. 2009, p. 40). Typhoons in northern Okinawa affect habitat by causing turnover of tree species because frequent disturbances and chronic wind stress cause higher mortality and loss of biomass, especially on ridges (Kubota et al. 2004, p. 230). Direct effects of typhoons to the Okinawa woodpecker include mortality from exposure to strong winds, rains and storm surges, and geographic displacement of individuals. Indirect effects include loss of food supplies or foraging substrates, loss of nests and nesting or roosting sites, increased vulnerability to predation, microclimate changes, and increased conflict with humans. Overall, wildlife in this region have adapted to frequent typhoons and heavy rains over a long period of time (Govt of Japan 2019, p. 195). Therefore, the species has sufficient resiliency to withstand the direct and indirect effects of typhoons.

The Okinawa woodpecker is likely to have sufficient resiliency in the future to withstand stochastic events that occur in northern Okinawa. The species' resiliency depends on the availability, condition, and connectivity of suitable forest trees in its range, all of which are increasing and a trend that will likely continue. The species' known life history traits and ability to use a diversity of nesting trees and food resources would not limit recovery from annual variation in recruitment and survival as long as suitable habitat is present.

The evergreen broadleaved forest of Yambaru has the highest biodiversity among all Japanese forests and has high stability in Okinawa. Numerous mountaintops along the central ridgeline in northern Okinawa where the species occurs exist within the range of the species. These mountaintop areas in Yambaru will be available to the Okinawa woodpecker in the future. Therefore, even within its limited range, the Okinawa woodpecker will continue to have some redundancy to withstand catastrophic events because multiple mountaintop areas provide suitable mature forest habitat within the Yambaru analysis unit.

The Okinawa woodpecker has some degree of behavioral plasticity by using a variety of tree species for nesting and can move within the Yambaru analysis unit in response to resource availability. The species has a diverse diet and has adapted to use non-traditional food resources such as citrus orchards. The species also uses a suite of tree species for nesting. Thus, Okinawa woodpeckers will be able to persist in place because the condition of the forest has steadily improved over the last few decades and the age of the forest and size of trees will continue to increase because the habitat is protected in Yambaru National Park, the UNESCO World Heritage site, and the JWTC. The species can disperse to suitable habitats within its small range through flight to these mountaintop areas in northern Okinawa that have increased connectivity because of the improved habitat condition. Therefore, increasing connectivity between suitable patches will help maintain gene flow and reduce the loss of genetic diversity through drift.

Overall, the species is likely to maintain a healthy population into the future, particularly with concerted conservation efforts in Okinawa. Even though the species' population is small, redundancy on mountaintops in Yambaru combined with the species' resiliency and ability to adapt to ongoing threats by utilizing diverse nesting sites and food resources supports the species viability into the future in the face of ongoing threats.

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