2

Description

2.a. Description of Property

2.b. History and Development

View from the summit of Mt. Inokawadake, Tokunoshima Island (Photo: MOEJ)

2. Description

2.a. Description of Property

2.a.1. Overview of the natural environment of the nominated property

2.a.1.1. Geology and geography

2.a.1.1.1. Geology and geography of the Ryukyu Chain

The nominated property is part of the Ryukyu Chain comprising more than 900 large and small islands, including about 70 inhabited islands, scattered in an arc, about 1,200 km long, lying between the south end of Kyushu and Taiwan. It consists of four islands: Amami-Oshima Island and Tokunoshima Island in the Amami Island Group, Okinawa Island in the Okinawa Island Group, and Iriomote Island in the Sakishima Island Group (Figure 1-1 to 1-6).

Although the World Geographical Scheme for Recording Plant Distributions (Brummitt 2001) uses the name Nansei-shoto for this area, Nansei-shoto is not actually equal to the Ryukyu Chain. The Daito Islands and other islands whose formation process is different are excluded from the Nansei-Shoto Islands to make for the Ryukyu Chain. How we call these islands is not necessarily uniform (Mizutani 2009; Ajiro and Warita 2009), but this document calls the so-called Ryukyu island arc the Ryukyu Chain (see page ii), following the names and classification proposed to be used in scientific papers (Toyama 2014 partially altered). Located at the boundary of the Eurasian Plate and the Philippine Sea Plate, the Ryukyu Chain is thought to have been generated by tectonic deformation associated with the subduction of the Philippine Sea Plate under the Eurasian Plate in Ryukyu Trench that happened sometime after the late Miocene (Machida et al. 2001; Hase 2010). Located in an arc from the Pacific Ocean side to the Continental side are the Ryukyu Trench (5,000–7,000 m deep), Ryukyu outer arc slope, Ryukyu non-volcanic outer arc swell, Ryukyu volcanic inner arc swell, Okinawa Trough (1,000–2,000 m deep), and East China Sea continental shelf (less than 200 m deep), forming a typical arc-trench system (Figure 2-1). The nominated property is part of islands formed on the Ryukyu non-volcanic outer arc.

The north end of the Ryukyu Chain, the Osumi Island Group, is separated from mainland Kyushu by the Osumi Strait, and the south-west end, Yonaguni Island, is separated from Taiwan by the Yonaguni Strait. The Tokara Strait and the Kerama Gap are both more than 1,000 m deep and 50 km wide, dividing the Ryukyu Chain geological structurally (Figure 2-1). These straits (gaps) are known to be effective as the boundaries of biogeography as well (Mizutani 2009). From geological, geomorphological and biogeographical perspectives, the Ryukyu Chain can be divided into three areas: the North Ryukyus, the Central Ryukyus, and the South Ryukyus (see page ii) (Toyama 2014).

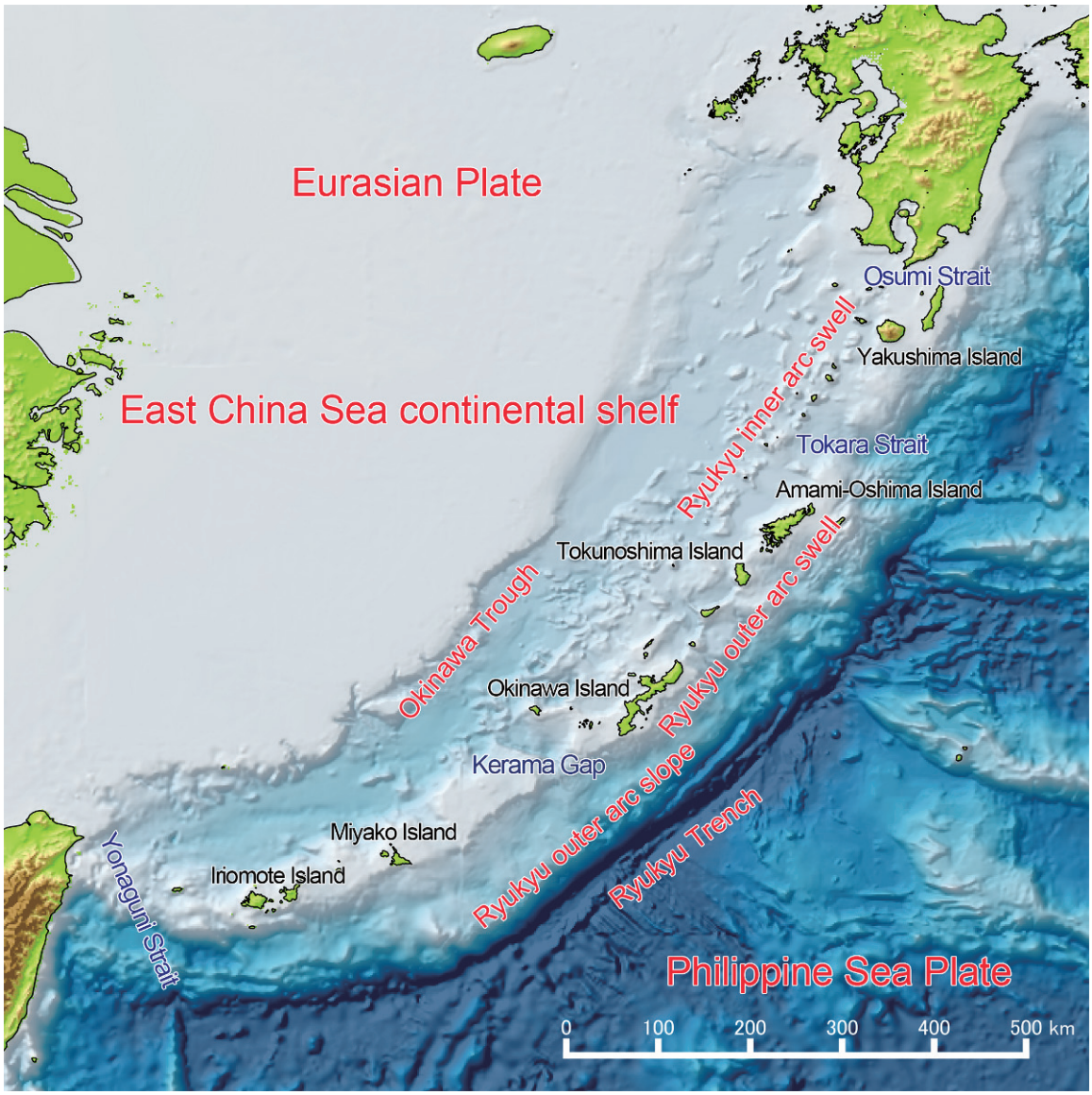


Figure 2-1: Bathymetric map of the area around the nominated property (prepared by using NOAA data)

The terrain of the islands in the Ryukyu Chain can be classified into several types, depending on the geological history, size, and shape. Among others, the islands on the non-volcanic outer arc swell are roughly divided into those with higher altitudes that comprise mountains and hills and those with lower altitudes that are covered with coral reef terraces. The former were formed in older days, and all the four regions containing the nominated property belong to this type.

Table 2-1 shows the difference of the geology of the Ryukyu Chain.

Table 2-1: Geology of the Ryukyu Chain

Area	Scope	Surface and basement geology
The North Ryukyus	Osumi Island Group, North Tokara	Miocene plutonic rocks Paleogene accretionary complex Miocene shallow-marine sediments Neogene to Quaternary volcanic rocks
The Central Ryukyus	South Tokara, Amami Island Group, Okinawa Island Group	Cretaceous to Neogene plutonic rocks Jurassic to Paleogene accretionary complex Paleogene fore-arc basin deposits / Pliocene sand and gravel sediments Marine sediments and coral reef limestones since the late Miocene Neogene to Quaternary volcanic rocks
The South Ryukyus	Sakishima Island Group (Miyako Islands, Yaeyama Islands)	Triassic to Jurassic metamorphic rocks Jurassic accretionary complex Eocene to Oligocene plutonic rocks Marine sediments and coral reef limestones since the Eocene

2.a.1.1.2. Geology and geography of four islands containing the nominated property

1) Amami-Oshima Island

Amami-Oshima Island is about 200 km south-southwest of Yakushima Island across the Tokara Strait. Amami-Oshima Island is the second largest island in the Ryukyu Chain, behind Okinawa Island. Its general landform is undulating and complex, cut by convoluted valleys, while eroded low-relief surfaces, about 300 m high, spread over the mountain ridges (Machida et al. 2001). Amami-Oshima Island is surrounded by complex ria coasts, and marine terraces and lowlands are rarely found in the island. Marine terraces are focused, if any, in the north-east part of the island, and the east side is tilted because of the uplift since the late Pleistocene (Ikeda 1977).

Amami-Oshima Island is mainly comprised of Mesozoic accretionary complex, and very few Miocene to recent marine sediments and coral reef limestones are found. The nominated property corresponds to the mountains at the center of the island. It is mainly comprised of Cretaceous accretionary complex composed of mudstone, basalt, sandstone, and alternation of sandstone and mudstone (Sakai 2010b).

2) Tokunoshima Island

Tokunoshima Island is located about 45 km south-west of Amami-Oshima Island. The central to north part of the island is the mountain area while the south to west part is dominated by low-lying slopes and well-developed marine terraces.

The gently sloping area surrounding the mountains consists of not only bedrocks but also middle Pleistocene sedimentary rocks (coral reef complex deposits) at the height lower than 210 m (Yamada et al. 2003). The nominated property corresponds to the mountains in the central to north area, where Cretaceous accretionary complex composed of slate, sandstone and basalt, and late Cretaceous to Palaeocene plutonic rocks (granites) that intruded into the accretionary complex are exposed (Kawano and Kato 1989; Kawano and Nishimura 2010; Saito et al. 2010). Most accretionary complex has been subject to contact metamorphism due to the intrusion of granites and thus difficult to be eroded. That is thought to be why they have remained as mountains (Saito et al. 2010).

3) Okinawa Island

Okinawa Island is located about 100 km south-west of Tokunoshima Island. Stretching from north and south, Okinawa Island is the largest island in the Ryukyu Chain. In the north area of the island, mountains and marine terraces are widely distributed and Paleogene and older bedrocks are exposed. The south area is comprised of late Miocene to recent sedimentary rocks and Quaternary coral reefs and shelf deposits. Many marine terraces are seen in this area, but they are located at lower altitudes and became emergent later than those in the north area (Machida et al. 2001).

The nominated property is the mountain area in three Yambaru villages. Its general landform is undulating, and valleys are highly convoluted. The main ridge line, the altitude of about 400 m, runs from north-east to south-west, and its peak, Mt. Yonahadake, is also the highest place in Okinawa Island. There are several steps of marine terraces at the height lower than the altitude of 240 m (Koba 1980).

The bedrocks of the nominated property are mostly comprised of Mesozoic to Eocene accretionary complex, including black schist, phyllite, sandstone, and alternation of sandstone and mudstone. Jurassic accretionary complex such as limestone blocks are sometimes found (Sakai 2010b; Takeuchi 2010).

4) Iriomote Island

Iriomote Island is about 400 km southwest of Okinawa Island. The whole island constitutes a low relief surface, 300–450 m high, except for the east end. Rivers such as the Urauchi River and the Nakama River erode the mountains, where the low relief surface is located, forming deep gutter-shaped valleys. Large brakish water area is developed at the river mouths because of the tides. The south side of this mountainous island are sea cliffs while there are lowlands near river mouths and marine terraces in the north to southeast part of the island (Machida et al. 2001). Its geology is older in the east area and younger toward the northwest area.

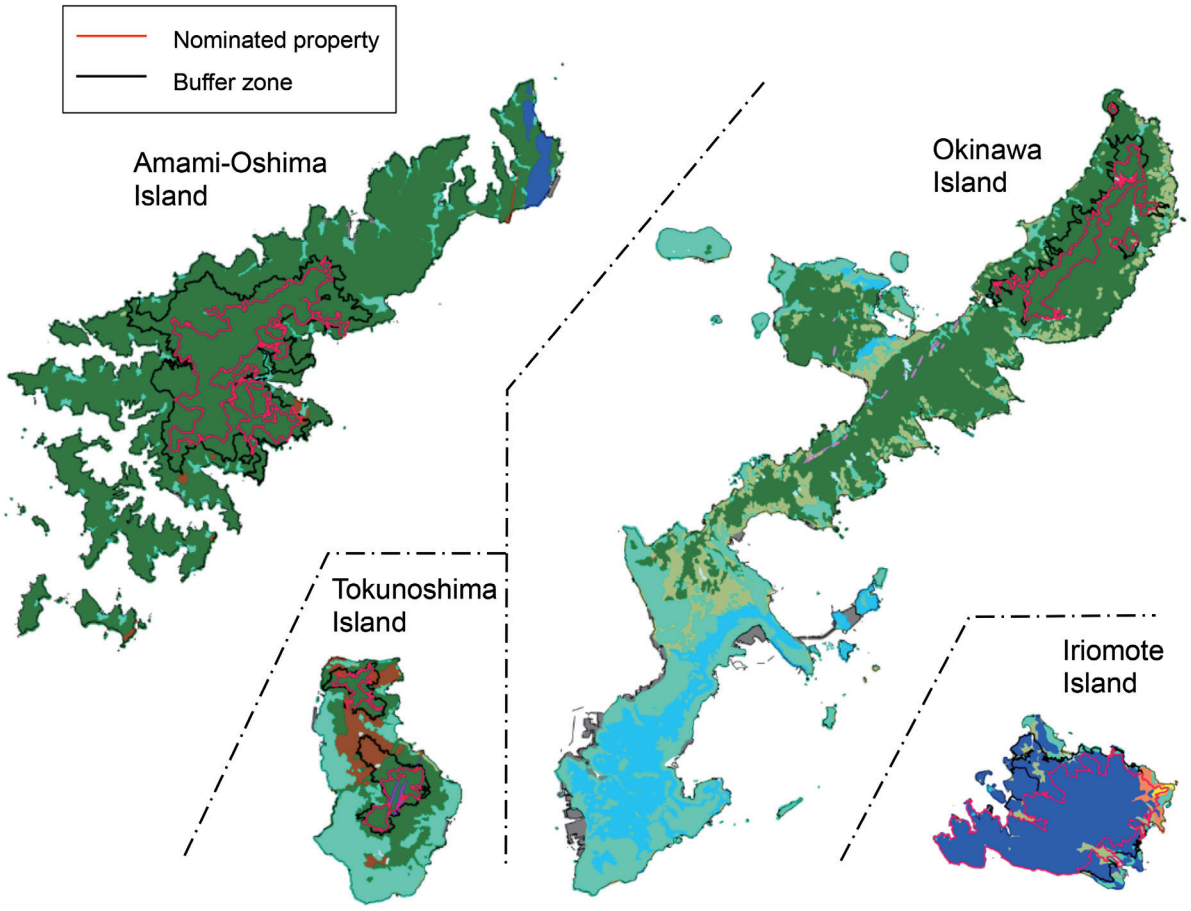
The nominated property corresponds to most of the mountains in the island. Its surface geology is dominated by Miocene shallow-marine or terrestrial sedimentary rocks—mostly conglomerate, sandstone, mudstone, and alternation of sandstone and mudstone, and between those are found coal seam and sandy limestone (Nakagawa et al. 1982; Kaneko 2007; Iryu and Matsuda 2010). At the northeast corner, Triassic to Jurassic metamorphic rocks and Eocene shallow marine sediments and volcanic rocks are exposed on a small scale (Nakagawa et al. 1982; Kaneko 2007). Also, terraces in the north to southeast area are comprised of Pleistocene sedimentary rocks (Nakagawa et al. 1982).

Table 2-2: Area of the four islands containing the nominated property and their highest altitudes

	Area of island	Peak
Amami-Oshima Island	71,235 ha	694 m (Mt. Yuwandake)
Tokunoshima Island	24,785ha	645 m (Mt. Inokawadake)
Okinawa Island	120,696ha	503 m (Mt. Yonahadake)
Iriomote Island	28,961ha	470 m (Mt. Komidake)

Source: Statistical reports on the land area by prefectures and municipalities in Japan, 2015 by Geospatial Information Authority of Japan

Sea cliff of Ryukyu limestone, Tokunoshima Island (Photo: MOEJ)



Island	Classification	Legend (Colors correspond to the map above)
Amami-Oshima Island	Plutonic rocks	Eocene plutonic rocks
	Accretionary rocks	Mesozoic accretionary complex
	Sedimentary rocks	Eocene sedimentary rocks
		Pleistocene to Holocene sedimentary rocks
		Pleistocene to Holocene terrace/sand dune deposits
Tokunoshima Island	Plutonic rocks	Ultramafic rocks
		Cretaceous to Palaeocene plutonic rocks
	Accretionary complex	Cretaceous accretionary complex
	Sedimentary rocks	Pleistocene to Holocene sedimentary rocks
		Pleistocene to Holocene sand dune deposits
Okinawa Island	Volcanic rocks	Oligocene volcanic rocks
		Miocene volcanic rocks
	Accretionary complex	Mesozoic to Eocene accretionary complex
	Sedimentary rocks	Late Miocene to early Pleistocene sedimentary rocks
		Pleistocene to Holocene sedimentary rocks
		Pleistocene to Holocene terrace/sand dune deposits
Iriomote Island	Metamorphic rocks	Triassic to Jurassic metamorphic rocks
	Volcanic rocks	Eocene volcanic rocks
	Sedimentary rocks	Eocene to middle Miocene sedimentary rocks
		Middle Miocene to early Pleistocene sedimentary rocks
		Pleistocene to Holocene sedimentary rocks
		Pleistocene to Holocene sand dune/swamp deposits
Over-all	Other	Lake, river, etc.
		Reclaimed land

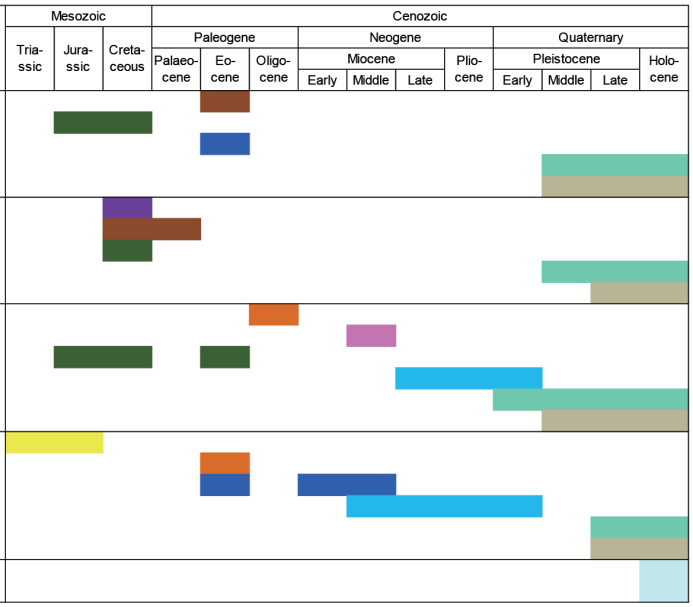


Figure 2-2: Geology of four islands containing the nominated property

This geological map was prepared and adapted based on "1:200,000 Seamless Geological Map of Japan" by Geological Survey of Japan, AIST (https://gbank.gsj.jp/owscontents/index_en.html) and Creative Commons Attribution NoDerivs 2.1 Japan (https://creativecommons.org/licenses/by-nd/2.1/jp/deed.en) as well as Takeuchi 1993; Nakae et al. 2009; Saito et al. 2009; Iryu and Matsuda 2010; Kawano and Nishimura 2010; Nakae et al. 2010; Sakai 2010a, b.

2.a.1.2. Climate

The nominated property belongs to subtropical climate, which has hot summers like those in tropical climate and relatively mild winters. Subtropical climate is characterized by the fact that it is controlled by subtropical high-pressure belts and tropical air masses derived from them, roughly covering the area between 20–30°N and 20–30°S. It is further classified into humid climate and dry climate depending on precipitation. Much of the subtropical part of the world is in the mid-latitude dry zone with low precipitation. Its vegetation is mostly dry, including monsoon forest, savanna, steppe, and desert (Shimizu 2014) (Figure 2-3).

The nominated property is located in the subtropical area, but its climate is called subtropical marine climate, which has precipitation of more than 2,000 mm per year, influenced by the warm Kuroshio Current flowing nearby and monsoons (Figures 2-4 and 2-5). This makes the area a globally rare place where rainforests are found in the subtropical zone. Climate is not so different among the component parts of the nominated property (Table 2-3 and Figure 2-6).

Figure 2-3: Vegetation landscape of global subtropical areas of the same latitude as the nominated property (Website of Yambaru Wildlife Conservation Center)

Ainsliaea macroclinidioides var. *oblonga*
(Photo: JWRC)

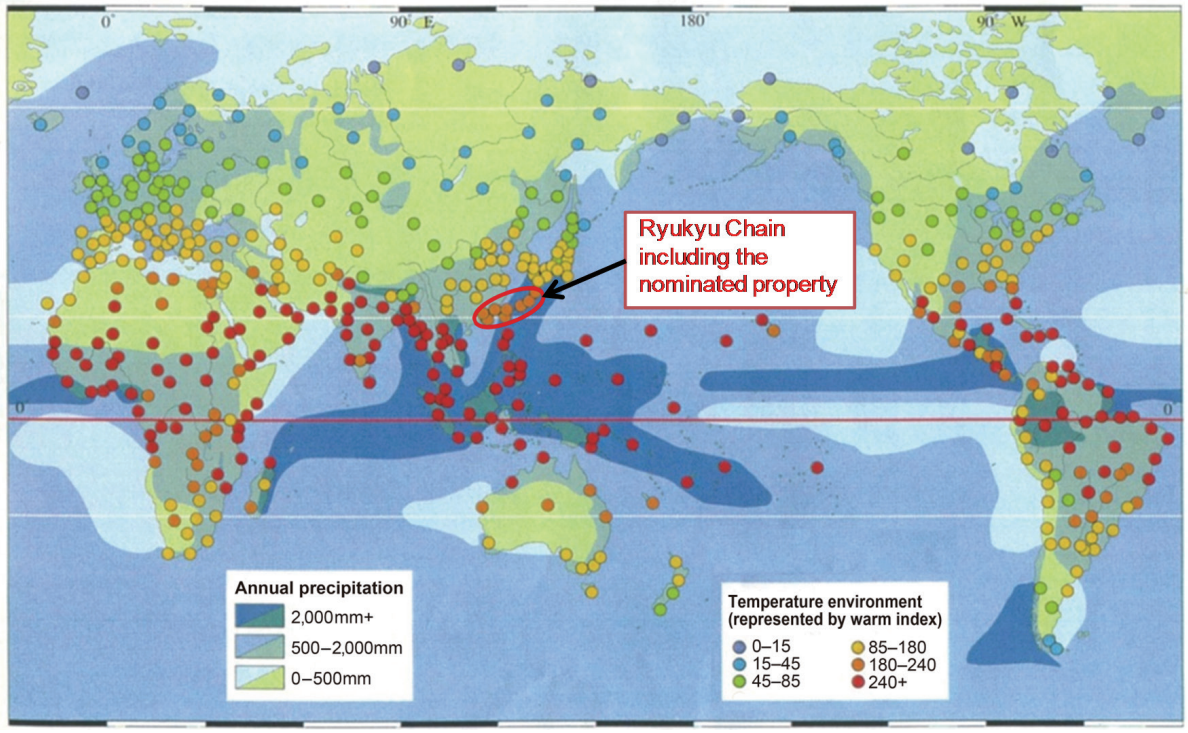


Figure 2-4: Distribution of temperature environment and precipitation on the earth (based on Hotta 1997)
The temperature environment shown in Figure 2-5 is represented by the warm index of Kira (1977).
The index of 180–240 is equivalent to the subtropical zone.

Subtropical rainforest, Iriomote Island (Photo: MOEJ)

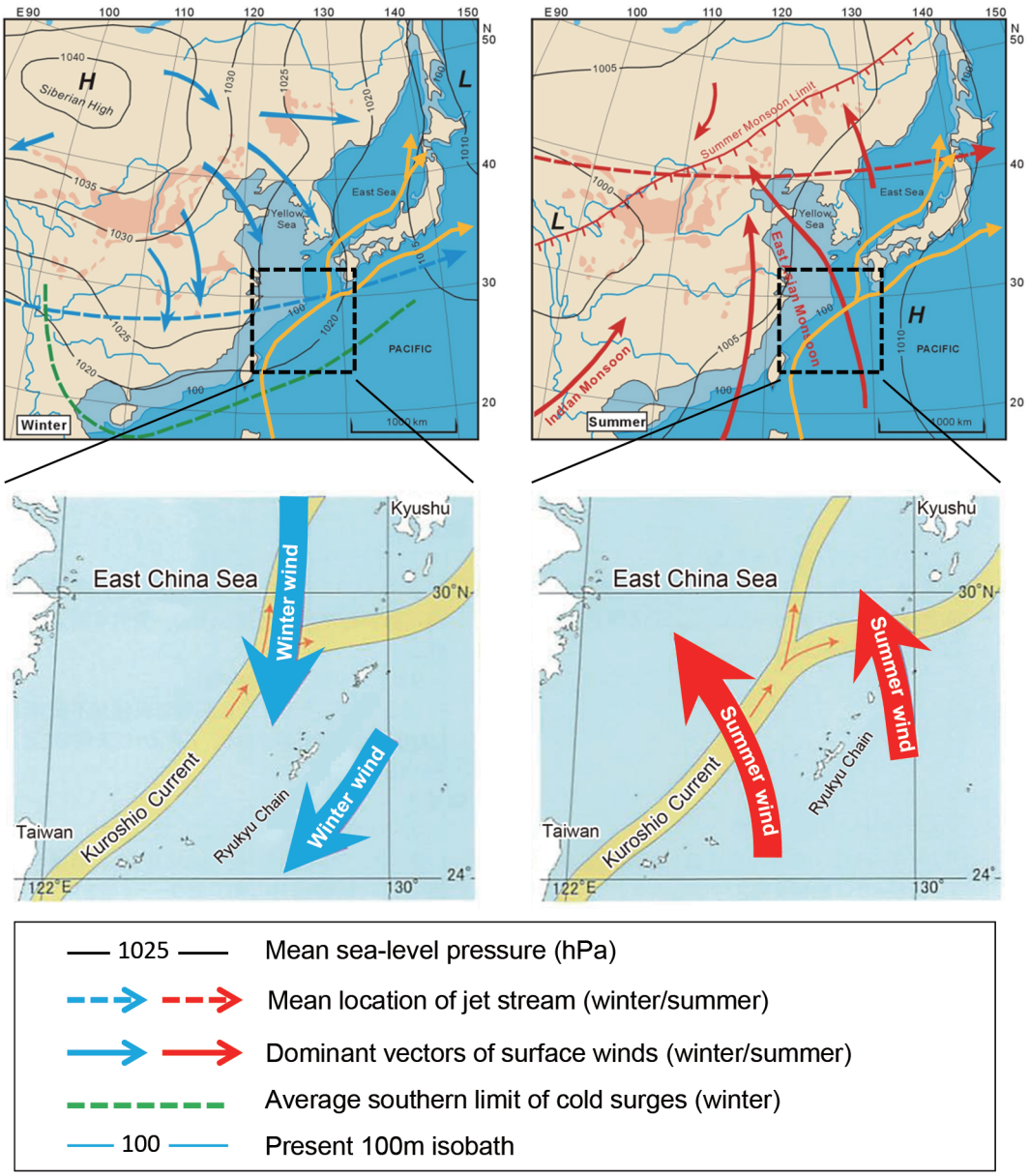


Figure 2-5: Relationship between pressure patterns and monsoons in summer and winter in the nominated property
Left: Pressure pattern in winter; Right: Pressure pattern in summer
Upper: Yi 2011 with added information; Lower: Based on Takara and Sasaki 1990

Orange oakleaf (*Kallima inachus eucerca*)
(Photo: MOEJ)

2.a.1.2.1. Temperature and precipitation

In the nominated property, which is located in the subtropical zone between the tropical and temperate zones, there are six to eight months in a year when the average temperature is over 20°C. Its annual average temperature is 21–24°C. In summer, the average temperature reaches 27–29°C; days with the minimum night-time temperature above 25°C continue for about three months partly because the diurnal range of temperature is small in these islands surrounded by the sea (Yamazaki et al. 1989). Even in winter, the climate is warm with the average temperature of 15–18°C. The annual range of temperature is also small in the nominated property area (Yamazaki et al. 1989). However there is a temperature gradient of 3.5°C between the northern and southern islands in the nominated property in the coldest month (Table 2-3 and Figure 2-6).

It rains all through the year in the nominated property, with the annual precipitation of 1,900 to 2,800 mm, which is greater than in mainland Japan (Tokyo: 1,528.8 mm). The rainfall is especially heavy in the rainy season (mid May to late June) and in the typhoon season (July to October); the total precipitation in the rainy and typhoon seasons accounts for about 60% of the annual precipitation (Okinawa Regional Headquaters, JMA (ed.) 1998). The annual average relative humidity is 74% in Amami-Oshima Island and 79% in Iriomote Island—more than 10 points higher than in mainland Japan (Tokyo: 62%) (Table 2-3 and Figure 2-6).

Table 2-3: Temperature and precipitation in the nominated property; comparison with mainland Japan (Tokyo)

	Amami-Oshima Island	Tokuno-shima Island	Northern part of Okinawa Island	Iriomote Island	Mainland Japan (Tokyo)
Altitude of observation site (m)	2.8	44	232	9.9	25.2
Annual average temperature (°C)	21.6	21.6	20.7	23.7	16.3
Average temperature in the hottest month (°C) *1	28.7	28.2	26.7	28.9	27.4
Average temperature in the coldest month (°C) *1	14.8	14.9	14.5	18.3	6.1
Annual average precipitation (mm)	2,837.7	1,912.3	2,501.5	2,304.9	1,528.8
Annual average relative humidity (%) *2	74	–	–	79	62

Source: Japan Meteorological Agency data (1981 to 2010)
*1: The hottest month is July in the nominated property and August in mainland Japan (Tokyo); the coldest month is January.
*2: Depending on the type of observatory, some observation items are not addressed.

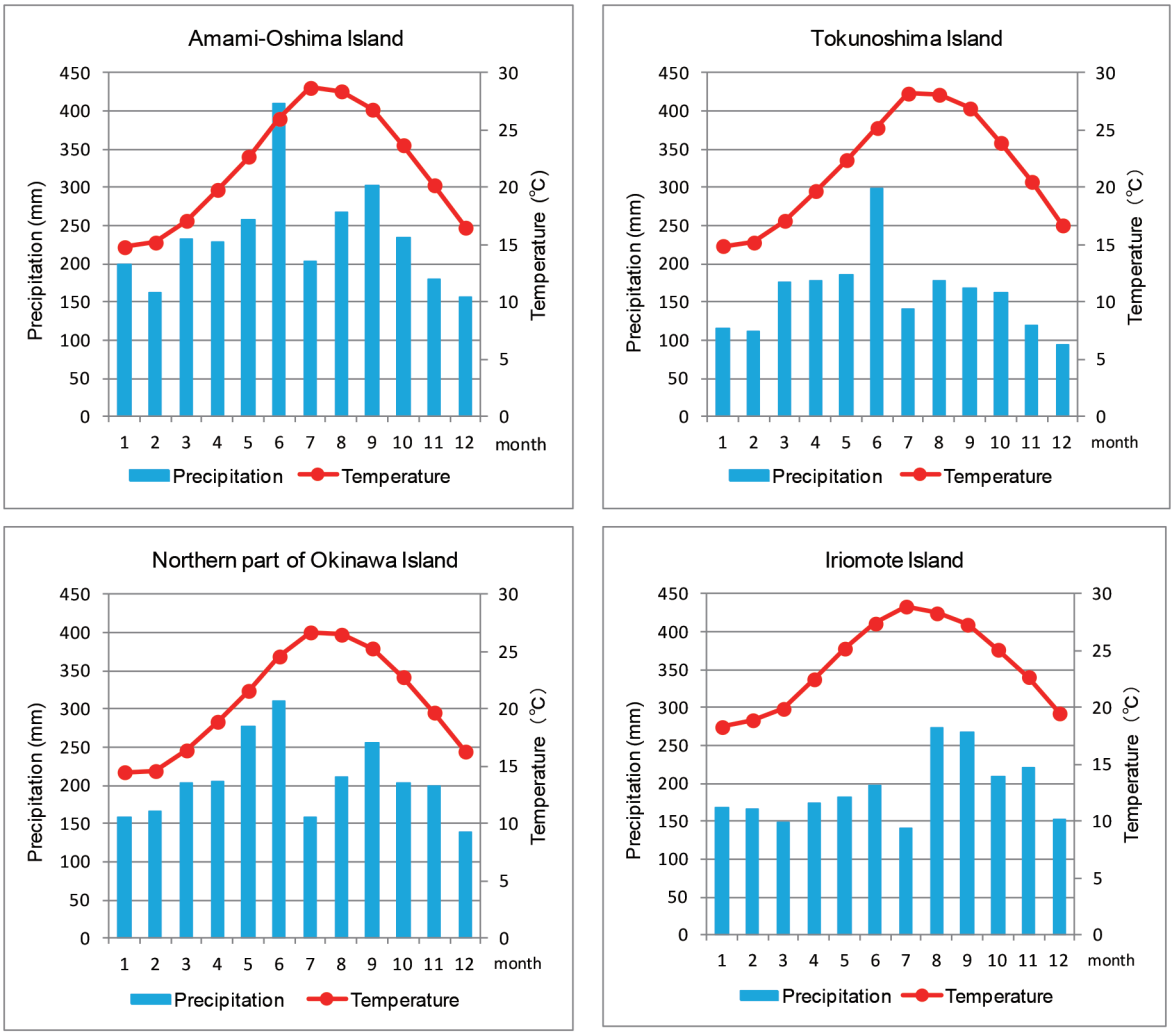


Figure 2-6: Average monthly temperature (line chart) and average monthly precipitation (bar chart) in the four regions
Source: Previous meteorological data (1981 to 2010) at http://www.jma.go.jp/jma/indexe.html

2.a.1.2.2. Typhoon

Figure 2-7 shows the birthplaces and tracks of all tropical depressions and storms in the world that have been recorded since the 1850s. The strongest tropical storms (scales 4–5) occur on the oceans east of the Philippines and around the Mariana Islands, and their tracks are focused on the ocean south of Japan. The nominated property is one of the areas prone to the strong tropical storms[2] (typhoon) in the world.

Figure 2-8 shows the annual number of typhoons occurring and those approaching Japan, and the percentage of those approaching the nominated property since 1951. Although the number of typhoons varies annually, the annual average is 26 (14 to 39) and 12 (4 to 19) of them approach Japan. On average, 7.6 (3 to 15) typhoons approach the nominated property annually—about 30% (13–52%) of the typhoons occurring.

2 Japan Meteorological Agency (JMA) calls tropical storms with the maximum wind speed near its center of 17.2 m/s (34 kn/s) or above *taifu* [typhoon]. Depending on regions of the world, tropical storms have various names but in any case, the maximum wind speed of 64 kn/s (32.9 m/s) or above is necessary. It is equivalent to what JMA calls "strong *taifu*."

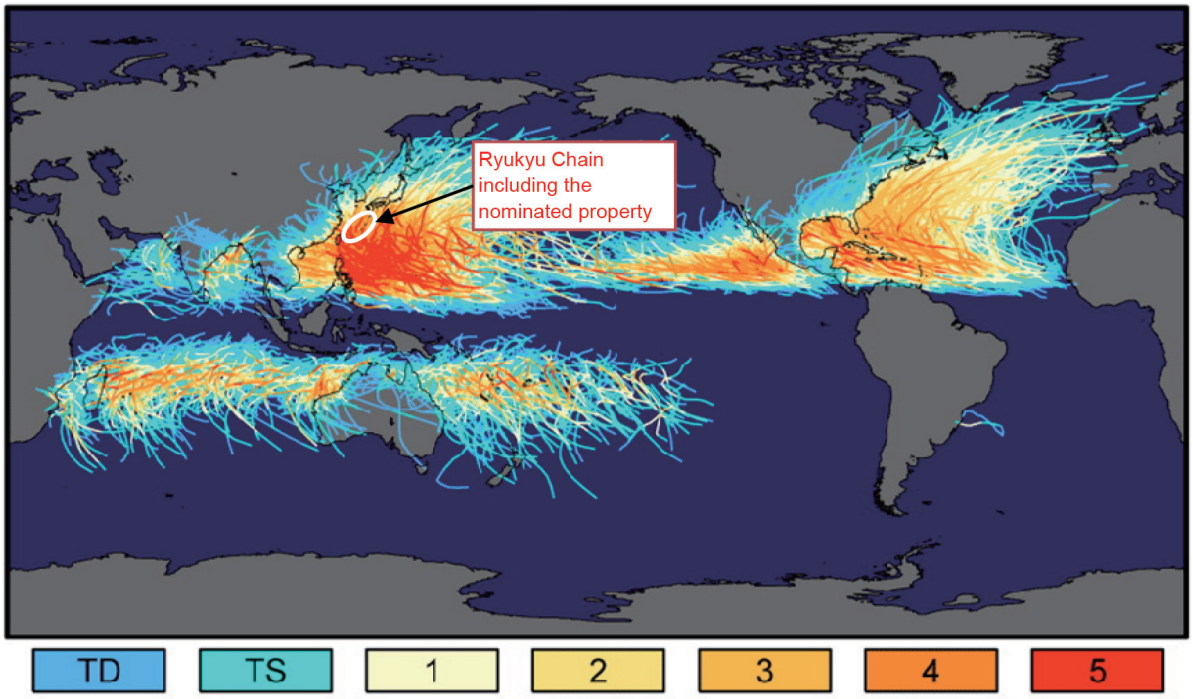


Figure 2-7: Birthplaces and tracks of all tropical storms in the world that have been recorded since the 1850s

Global Warming Art. Prepared on October 7, 2006. http://www.globalwarmingart.com/

Data on the tracks of tropical storms is based on National Hurricane Center (America) for the north Atlantic and the east Pacific; Joint Typhoon Warning Center (America) for the Indian Ocean and the northwest Pacific; and Gary Padgett's April 2004 Monthly Tropical Cyclone Summary and Roger Edson at University of Guam for Hurricane Katrina in the south Pacific.

Saffir-Simpson Hurricane Intensity Scale
TD (Tropical Depression): wind speed of 0–38 mph (0–17 m/s)
TS (Tropical Storm): 39–73 mph (17–33 m/s)
Category 1: 74–95 mph (33–42 m)
Category 2: 96–110 mph (33–49 m/s)
Category 3: 111–130 mph (49–58 m/s)
Category 4: 131–155 mph (58–69 m/s)
Category 5: 155 mph (69 m/s+)

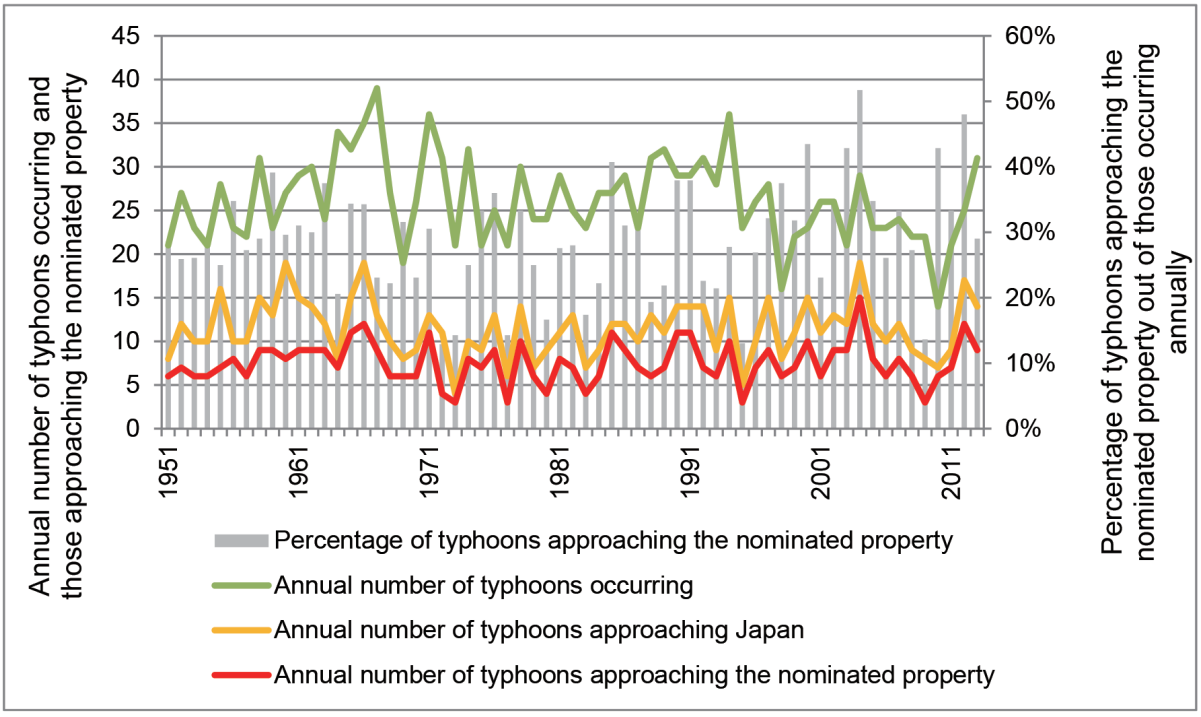


Figure 2-8: Annual number of typhoons occurring and those approaching Japan, and the percentage of those approaching the nominated property
Source: Statistics on typhoons at http://www.data.jma.go.jp/fcd/yoho/typhoon/statistics/index.html

Strong tropical storm (typhoon) (Photo: MOEJ)

2.a.1.3. Vegetation

The dominant natural vegetation of the nominated property is mountainous forests—evergreen broadleaved forests developed in the humid subtropical zone. Trees dominating the upper layer include oaks, Ryukyu pines (*Pinus luchuensis*) (Pinaceae), and camphor trees (Lauraceae); its vegetation landscape is similar to that of evergreen broadleaved forests in the warm temperate zone north of Yakushima Island (Aiba 2011). However it has diversed tree species, including tree ferns, marlberry species, some *Ardisia* species growing as tall as semi-tall trees, strangler figs, and palm trees, which are different from those found in forests in the warm temperate zone. On the other hand, the coasts of this area are home to tree species of coastal vegetation in tropical and subtropical regions, including mangroves, Tahitian screwpine (*Pandanus odoratissimus*), tropical almond (*Terminalia catappa*), *Argusia argentea*, powder-puff tree (*Barringtonia racemosa*), and *Hernandia nymphaeifolia* (Hotta 1974; Kira 1989). In this way, the lowlands contain species found in the tropical zone while the mountains contain diverse subtropical evergreen broadleaved trees, including Castanopsis (*Castanopsis sieboldii*) and oak (*Quercus miyagii*). This kind of mixed forest is called the subtropical rainforest in this document (Kira 1976; Aiba 2011).

Many of these southern plants in understory and coastal areas are dispersed relatively quickly; for example, their seeds and spores are carried by wind, ocean currents, and birds. Conversely, the mountainous tall trees like Castanopsis and *Quercus miyagii* are not good at spreading their seeds into distant areas across the sea. They are thought to date back to old times when this area was low in temperature and connected with the Continent and mainland Japan by land (Hotta 1974; Kira 1989; Ohno 1997).

2.a.1.3.1. Vegetation of the nominated property

1) Evergreen broadleaved forest

(Photo: MOEJ)

The largest vegetation in the nominated property is the natural and secondary evergreen broadleaved forests, whose tree layers are dominated by Castanopsis. According to Miyawaki (ed.) (1989), these forests are developed on the non-limestone region and classified phytosociologically as Psychotrio-Castanopsion sieboldii (alliance). The natural forests include Lasiantho-Castanopsietum sieboldii (association) that mainly occurs in Amami-Oshima Island and Tokunoshima Island, Illicio anisati-Castanopsietum sieboldii (association) that widely occurs in mountains in northern and central Okinawa Island, and Adinandro yaeyamensis-Castanopsietum sieboldii (association) seen in mountains in Iriomote Island. The secondary forests include Tarenno-Castanopsietum sieboldii (association). In mesic areas along the valleys, Quercetum miyagii (association) dominated by *Quercus miyagii* occurs in relatively wide areas. On the other hand, in the limestone region, subtropical coastal plants and species specific to the limestone land form another

unique plant community, including Fico microcarpae-Pongamietum pinnatae (association) on the raised coral reef as well as Macarango-Bischoffietum (association).

In the nominated property, periodic disturbances caused by frequent typhoon attacks (see Figure 2-7 and 2-8) and complex landform where small ridges and valleys occur (see 2.a.1.1.2) help promote the diversification of the environment, making component species in the forests more diversified (Kubota et al. 2004; Yoneda 2016). As an example, research conducted in the forests of the northern part of Okinawa Island dominated by Castanopsis shows that the forests in the nominated property have greater diversity of tree species (Ito 1997) and that the diversity and productivity of woody species is higher in ridges than in valleys and slopes (Kubota et al. 2004). That is probably because ridges are affected powerfully by frequent typhoons and fallen trees create canopy gaps. This helps avoid competition for light between tree species in tree layers and those in subtree layers, enabling various tree species to coexist (Kubota et al. 2004). According to research targeted at the natural forests in Tokunoshima Island, forest floor vegetation in valleys is characterized by herbaceous, fern and climbing plants rather than woody plants; it is thought that disturbances caused by typhoon rains are more intense in valleys than in ridges (Yoneda 2016).

2) Cloud forest

Mt. Yuwandake (694 m) in Amami-Oshima Island is the highest peak in the nominated property, and Tokunoshima Island has Mt. Inokawadake with an altitude of 644 m. The forests of these mountains that are located at the height of 500–600 m or more constitute cloud belts, where sunlight is limited and air humidity is high (Suzuki 1979; Miyawaki (ed.) 1989; Onishi et al. 2012) and Arisaemato heterocephali-Castanopsietum sieboldii (association) is found (Suzuki 1979; Miyawaki (ed.) 1989). On top of the trees are unique epiphytes such as an epiphytic fern (*Polypodium amamianum*), and orchid (*Liparis viridiflora*), and on the humid forest floors, fern plants such as *Bolbitis subcordata* and *Ctenitis subglandulosa* flourish (Miyawaki (ed.) 1989). Bryophytes are also rich in diversity; for example, there are over 120 species near the peak of Mt. Inokawadake (altitude of above 500 m) (Onishi et al. 2012).

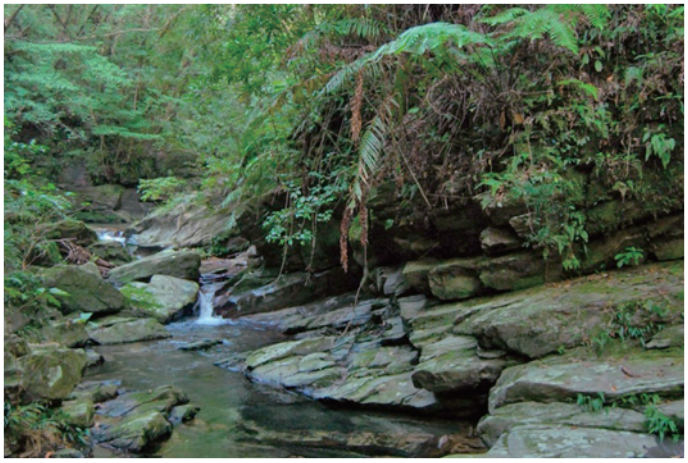
(Photo: JWRC)

Similarly, on the slopes located at an altitude above 450 m of Mt. Yonahadake (503 m), the highest peak in Okinawa Island, there are cloud forests whose abundant annual precipitation exceeds 3,000 mm, constituting the *Microlepia hookeriana-Castanopsis sieboldii* community (Niiro 2015). With the tree layers dominated by Castanopsis, these forests are rich with bryophytes, epiphytic and ground orchids, and fern plants, reflecting high air humidity (Miyagi 1990; Makita 1998). Near the peak of Mt. Komidake (469.5 m), the highest peak in Iriomote Island, the *Woodwardia harlandii-Pleioblastus linearis* community occurs. Swept by wind from the coasts, in this area develops *Pleioblastus linearis* forest, which is resistant to wind. The summit area is like a

cloud belt, home to *Skimmia japonica* var. *lutchuensis*, *Woodwardia harlandii*, *Goodyera foliosa* var. *commelinoides*, and Iriomote false holly (*Osmanthus heterophyllus* var. *iriomotensis*) (Niiro et al. 1974; Shimabukuro 2015).

3) Mountain stream zone

In humid tropical regions, high and low waters of rivers appear cyclically due to frequent rainfalls. At the upstream and midstream, riverbeds and riversides are flooded periodically for a certain time between high and low waters. These places are called mountain stream zones, with a difference in water level of 2–3 m in tropical regions. Although the nominated property consists of islands with relatively small water catchment areas, frequent rainfalls allow it to have mountain stream zones with a difference in water level as much as that in tropical regions (Kato 2003).



(Photo: JWRC)

Plants growing in this kind of environment are called rheophytes (Hotta 2002; Kato 2003). They adapt to the unusual environment where they are exposed to torrents during heavy rainfalls and dried during the low-water period (Hotta 2002). Some of them have slender or small leaves so as to reduce resistance to water flow; some stick to rocks with their roots or rhizomes; and some have leaves with fewer trichomes so that muddy water dries quickly (Yokota 1997).

As for the vegetation of mountain stream zones, in the northern part of Okinawa Island and Iriomote Island, the *Lindsaea odorata* var. *japonica-Salvia pygmaea* community is known, in which small and dwarf herbs stick to somewhat shaded rocks. Also, Pileo-Arundetum formosae is seen at waterfalls and cliffs in Iriomote Island, and the *Rhododendron scabrum-Farfugium japonicum* var. *luchuense* community consisting of ericaceous plants and evergreen low trees is seen on the rocks on the riversides in Kunigami Mountains (Miyawaki (ed.) 1989; Miyagi 1990).

At the upstream and midstream of the Sumiyo River in Amami-Oshima Island are communities dominated by *Rhododendron scabrum* on the rocks. In the nominated property, many rheophytes grow, including *Salvia pygmaea*, *Solenogyne mikadoi*, *Lysimachia liukiuensis*, and *Viola amamiana*. These include a number of threatened plants endemic to the Ryukyu Chain (Hotta 2002; Kawanishi 2016). Besides, *Platanthera sonoharae* found in the northern part of Okinawa Island is a relict endemic species, which survived only in this area after having been isolated from the Continent. Many of the rheophytes are thought to have newly evolved in this area, including *Polystichum hancockii* var. *yaeyamense*, *Farfugium japonicum* var. *luchuense*, *Ainsliaea macroclinidioides* var. *oblonga*, and *Eurya emarginata* var. *ryukyuensis* (Yokota 1997).

4) Mangrove forest

(Photo: MOEJ)

Mangroves mean groups of unique plants growing in muddy wetlands near sea shores or river mouths in tropical or subtropical regions that are affected by salt water (Nakasuga 1995). One of their major habitats is tropical Asia, from Southeast Asia to East Asia, the Central and South Ryukyus, which is the northern limit (Miyawaki (ed.) 1989). In Japan, mangrove forests covering a decent amount of space can be seen only in the Ryukyu Chain in which the nominated property is included. Among them, the mangrove forest at the mouth of the Sumiyo River in Amami-Oshima Island is the most northern. In Iriomote Island, mangrove forests are found at the mouths of the Nakama River, the Urauchi River, and the Shiira River, etc.

Mangrove forests are simpler in species composition and scrubbier in structure than those in tropical Asia (Miyawaki (ed.) 1989). Those in Amami-Oshima Island are comprised of *Kandelia obovata* and oriental mangrove (*Bruguiera gymnorhiza*), and Iriomote Island has four more species: Asiatic mangrove (*Rhizophora stylosa*), gray mangrove (*Avicennia marina*), black mangrove (*Lumnitzera racemosa*), and *Sonneratia alba*. The occurrence of species in the forests varies with frequency and intensity of tides, soil substrate, landform, and salinity (Miyawaki et al. 1983); from riversides toward inner lands, component species gradually change, forming zonal vegetation (Nakanishi 2005). As an example, the Urauchi River in Iriomote Island shows a zone comprising the *Sonneratia alba*, Asiatic mangrove, *Kandelia obovata*, and oriental mangrove communities that develop in this order from the riverside to inland (Nakanishi 2005).

The wetland on the landward side from the mangrove forests in Iriomote Island exhibits a mosaic sequence, in which *Barringtonia racemosa* forests are found in depressions where forest floors are flooded during high tides and rainfalls, and looking-grass tree (*Heritiera littoralis*) forests are found in slightly elevated places that are always above water (Miyawaki (ed.) 1989).

Back marsh of mangrove forest (Photo: MOEJ)

2.a.1.3.2. Vegetation of four regions of the nominated property

1) Amami-Oshima Island

In Amami-Oshima Island, an island with relatively high mountains, more than 80% of its whole area is covered with forests. The secondary forests of evergreen broadleaved trees, such as coppice forests of oaks, account for 61% of the island (Table 2-4). The Ryukyu pine community accounts for nearly 20%; half of it was created by planting after logging and the other half was regenerated naturally (Yoneda 2016).

Ilex dimorphophylla (Photo: MOEJ)

The nominated property corresponds to the mountainous backbone running from the Kinsakubaru national forest in the mid-island to Mt. Yuwandake in the southwest, the Kamiya national forest, Mt. Torigamine and Mt. Eboshidake in the southeast. Large, almost natural forests, including Castanopsis forests, are concentrated in this area. In the middle mountainsides is Lasiantho-Castanopsietum sieboldii while at the higher level (around 400 m) Arisaemato heterocephali-Castanopsietum sieboldii develops. The summit area of Mt. Yuwandake, the highest peak in Amami-Oshima Island, makes up wind-swept scrub forests, about 8 m tall, comprised of Ilici dimorphophyllae-Symplocosetum confusae specific to this region; on the mountainside, 300–600 m high, is Arisaemato heterocephali-Castanopsietum sieboldii, which is like a cloud forest. Furthermore, the rocky area with springs is home to the woody fern (*Cyathea lepifera*) community while *Quercus miyagii* is scattered around the mesic areas along the valleys and at the mountain foot.

2) Tokunoshima Island

Despite being an island with high mountains, Tokunoshima Island has a wealth of arable land, with its mountains full of Castanopsis forests surrounded by raised coral reef terraces. Forests and arable land divide the island area almost into two halves. Most of the forests are evergreen broadleaved forests or secondary Ryukyu pine forests. About 30% of the Ryukyu pine community was created by planting after logging and 70% was regenerated naturally. The *Quercus glauca* var. *amamiana* community is found on the raised limestones in the hilly area (Table 2-4) (Miyawaki (ed.) 1989; Kagoshima Prefecture 2012; Kyushu Regional Forest Office, Forestry Agency 2012).

Quercus miyagii (Photo: MOEJ)

The nominated property corresponds to the mountains ranging from Mt. Amagidake to Mt. Sasontsujidake in the north and the mountains ranging from Mt. Inokawadake to Mt. Tanpatsu, Mt. Hagedake and Mt.

Inutabudake in the south-central. These mountains are full of Castanopsis and other forests. As is the case with Amami-Oshima Island, Lasiantho-Castanopsietum sieboldii is present in the lower mountains while Arisaemato heterocephali-Castanopsietum sieboldii is seen at the higher level. The summit area of Mt. Inokawadake, the highest peak in the island, constitutes wind-swept scrub forests comprised of Ilici dimorphophyllae-Symplocosetum confusae; on the mountainside, 300–600 m high, is Arisaemato heterocephali-Castanopsietum sieboldii, which is like a cloud forest. Near Mt. Amagidake in the north and in Mt. Tanpatsu and Mt. Inutabudake in the south-central, a mature forest stand of *Quercus miyagii* is present (Miyawaki (ed.) 1989; Kyushu Regional Forest Office, Forestry Agency 2016).

3) Northern part of Okinawa Island

The northern part of Okinawa Island has been traditionally called by local residents "Yambaru," which is said to mean the mountainous region full of forests. Its area is not clearly defined, but this document calls Kunigami Village, Ogimi Village, and Higashi Village in the northern part of Okinawa Island three Yambaru villages, which keep in relatively healthy condition the forests where Okinawa rails (*Gallirallus okinawae*) and many other endemic plant and animal species occur. Both tree species characteristic of the temperate zone and those characteristic of the tropical zone coexist in the forests of these three villages, with Castanopsis being dominant (Table 2-4). In the mountains of three Yambaru villages, especially in the backbone area, forests of over 50 years old with many endemic plants widely occur, providing a unique landscape.

Schima wallichii ssp. *liukiuensis* (Photo: JWRC)

Forests comprise about 80% of the vegetation in three Yambaru villages. Illicio anisati-Castanopsietum sieboldii (evergreen broadleaved plants of natural vegetation) accounts for 41.6% in terms of area; it especially prevails in Kunigami Village, the largest in area of the three villages. Then it is followed by Tarenno-Castanopsietum sieboldii (secondary vegetation of evergreen broadleaved forest) (18.9%) and the Ryukyu pine community (secondary evergreen conifer forest) (12.3%).

Illicio anisati-Castanopsietum sieboldii widely occurs in the mountain areas with an altitude of above 200 m of Mt. Nishimedake, Mt. Ibudake, Mt. Terukubi and Mt. Yonahadake, all of which are located in the nominated property. The summit area of Mt. Yonahadake constitutes a cloud forest filled with bryophytes, epiphytic and ground orchids, and fern plants. In the summit areas, wind-swept sites around the ridges, and south-facing dry sites of Mt. Nishimedake and Mt. Ibudake, Ainsliaeo okinawaensis-Pasanietum (association), a scrub forest not more than 6 m tall, is occurring (Miyawaki (ed.) 1989). In the mountains whose bedrocks include palaeozoic limestones of about 200 million years old, such as Mt. Nekumachijidake and Mt. Shioya-Fuji in Ogimi Village, mixed forests comprising both evergreen broadleaved trees such as *Quercus glauca* var. *amamiana*, *Acer oblongum* var. *itoanum*, *Elaeocarpus sylvestris* var. *ellipticus*, *Schefflera octophylla*, and *Daphniphyllum teijsmannii* and deciduous broadleaved trees such as *Fraxinus floribunda*, *Rhus succedanea*, *Euonymus tanakae*,

Fraxinus griffithii, and *Celtis boninensis* exist (Board of Education, Ogimi Village 1997).

4) Iriomote Island

Forests comprise about 90% of the island. It is the most untamed in the four regions containing the nominated property, with a lot of mountain stream zones and mangroves growing on it.

Iriomote Island is widely covered with evergreen broadleaved forests. Adinandro yaeyamensis-Castanopsietum sieboldii accounts for 67% in terms of area. Taking also into account the mangrove forests at the river mouths, about 70% of the island is covered with natural vegetation of evergreen broadleaved trees (Table 2-4).

Barringtonia racemosa (Photo: MOEJ)

In the non-limestone region spreading from hills to mountains in the nominated property, Adinandro yaeyamensis-Castanopsietum sieboldii widely occurs while the mesic areas next to the valleys occur Quercetum miyagii. In some places along the Nakama River where raised limestones are exposed, Macarango-Bischoffietum, etc. is observed and Castanopsis is not dominant. The vale areas downstream of the Nakama River have humid forests dominated by looking-grass tree and powder-puff tree; on the natural banks, riparian forests comprised of Melicopo triphyllae-Perseetum thunbergii, etc. develop. At the mouths of the Nakama River and the Shiira River, there are the largest mangrove forests in Japan. Hernandietum sonorae (association) dominated by *Gettarda speciosa* is found on the coastal dunes, and Planchonello-Litseetum japonicae is seen in the wind-swept areas on the coastal cliffs. The valley in the upstream Urauchi River has variously sized waterfalls and cliffs, where the mountain stream side vegetation like Pileo-Arundetum formosae is found (Miyawaki (ed.) 1989). Around the summit area of Mt. Komidake, the highest peak in Iriomote Island, the *Woodwardia harlandii-Pleioblastus linearis* community exhibits a wind blown form, 2.5–3 m tall. On the lower mountainside, cloud forests are formed where tall trees such as Castanopsis and epiphytes prevail.

Nipa palm (*Nypa fruticans*) (Photo: MOEJ)

Table 2-4: Percentage of area by vegetation type in the four regions containing the nominated property

	Area (ha)	Percentage (%) of area by vegetation type										Year of vegetation map prepared
		Natural evergreen broadleaved forest	Mangrove forest	Secondary evergreen broadleaved forest	Ryukyu pine community	Secondary deciduous broadleaved forest	Secondary grass-land	Bamboo/ dwarf-bamboo community	Planted forest	Arable land	Other	
Amami-Oshima Island	71,235	6.0	0.1	55.1	19.8	4.8	0.6	0.0	1.0	6.5	6.1	2009
Tokuno-shima Island	24,785	3.5	0.0	25.1	16.4	0.9	0.1	0.0	0.2	45.0	8.8	2009
Northern part of Okinawa Island	34,023	41.6	0.0	21.8	12.1	5.8	1.6	0.0	0.9	11.3	4.8	2000-01
Iriomote Island	28,961	67.6	3.0	8.2	9.3	3.4	0.3	0.3	0.3	4.6	3.0	2006

Area of the islands/region is based on the statistical reports on the land area by prefectures and municipalities in Japan, 2015 by the Geospatial Information Authority of Japan. The area of the northern part of Okinawa Island represents the total of three Yambaru villages (Kunigami, Ogimi, and Higashi).
Percentage of area by vegetation type is calculated based on the vegetation surveys in the Sixth and Seventh Rounds of the National Survey on the Natural Environment (1999–) by the Ministry of the Environment, using GIS.

Evergreen broadleaved forest (Photo: MOEJ)

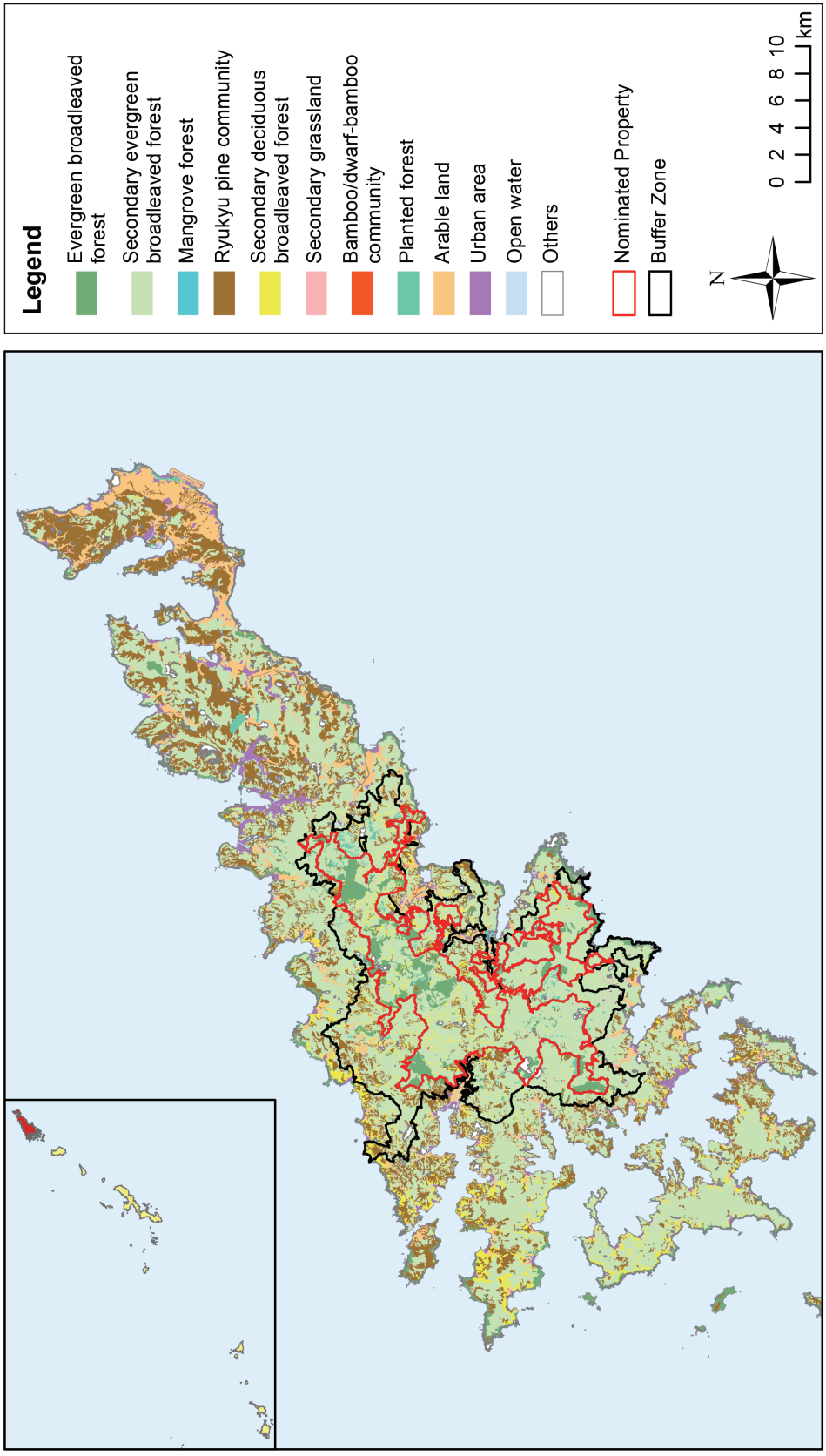


Figure 2-9: Vegetation of the nominated property (Amami-Oshima Island)
The Sixth and Seventh Rounds of the National Survey on the Natural Environment (vegetation surveys) by the Ministry of the Environment

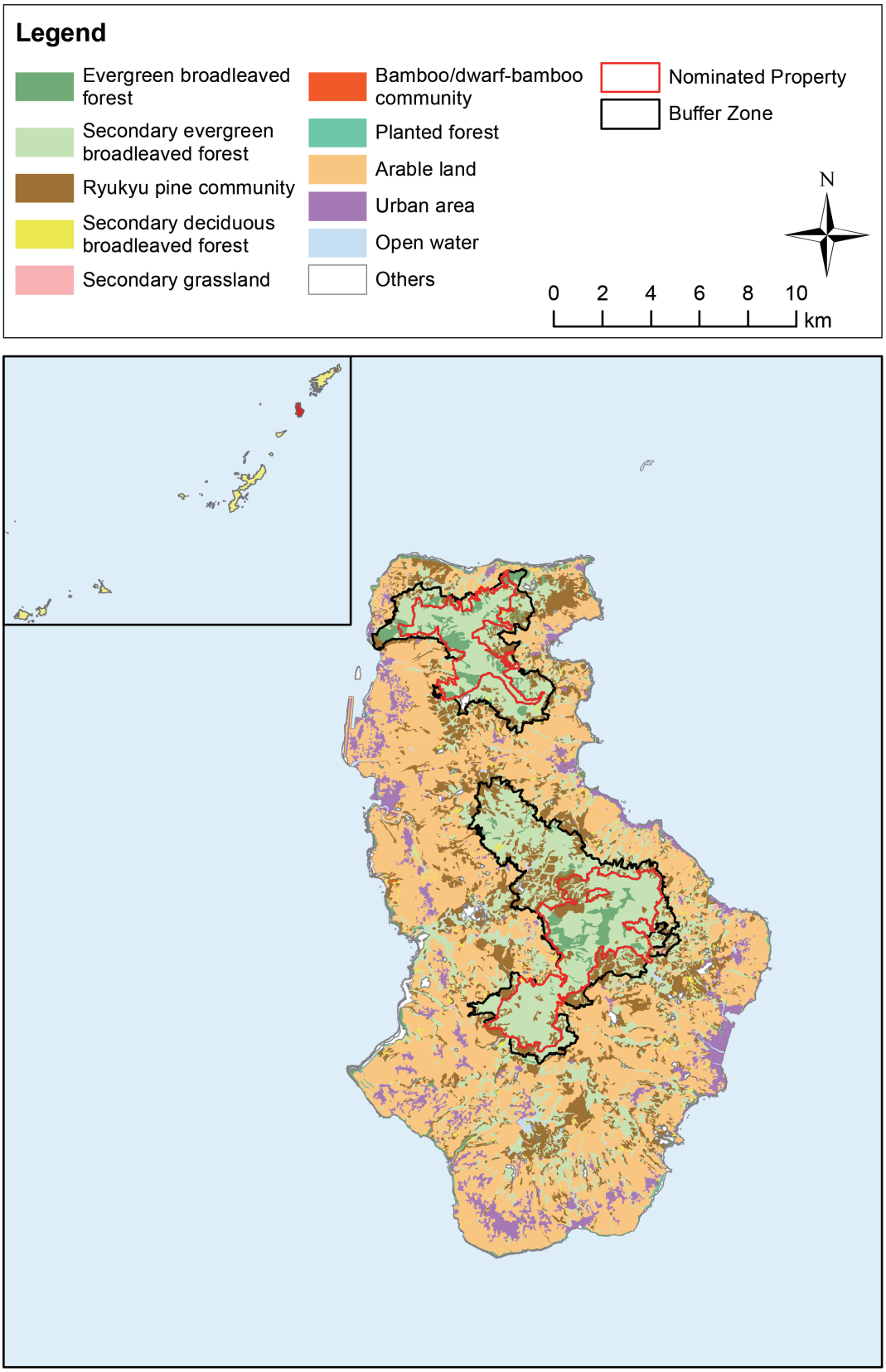


Figure 2-10: Vegetation of the nominated property (Tokunoshima Island)
The Sixth and Seventh Rounds of the National Survey on the Natural Environment (vegetation surveys) by the Ministry of the Environment

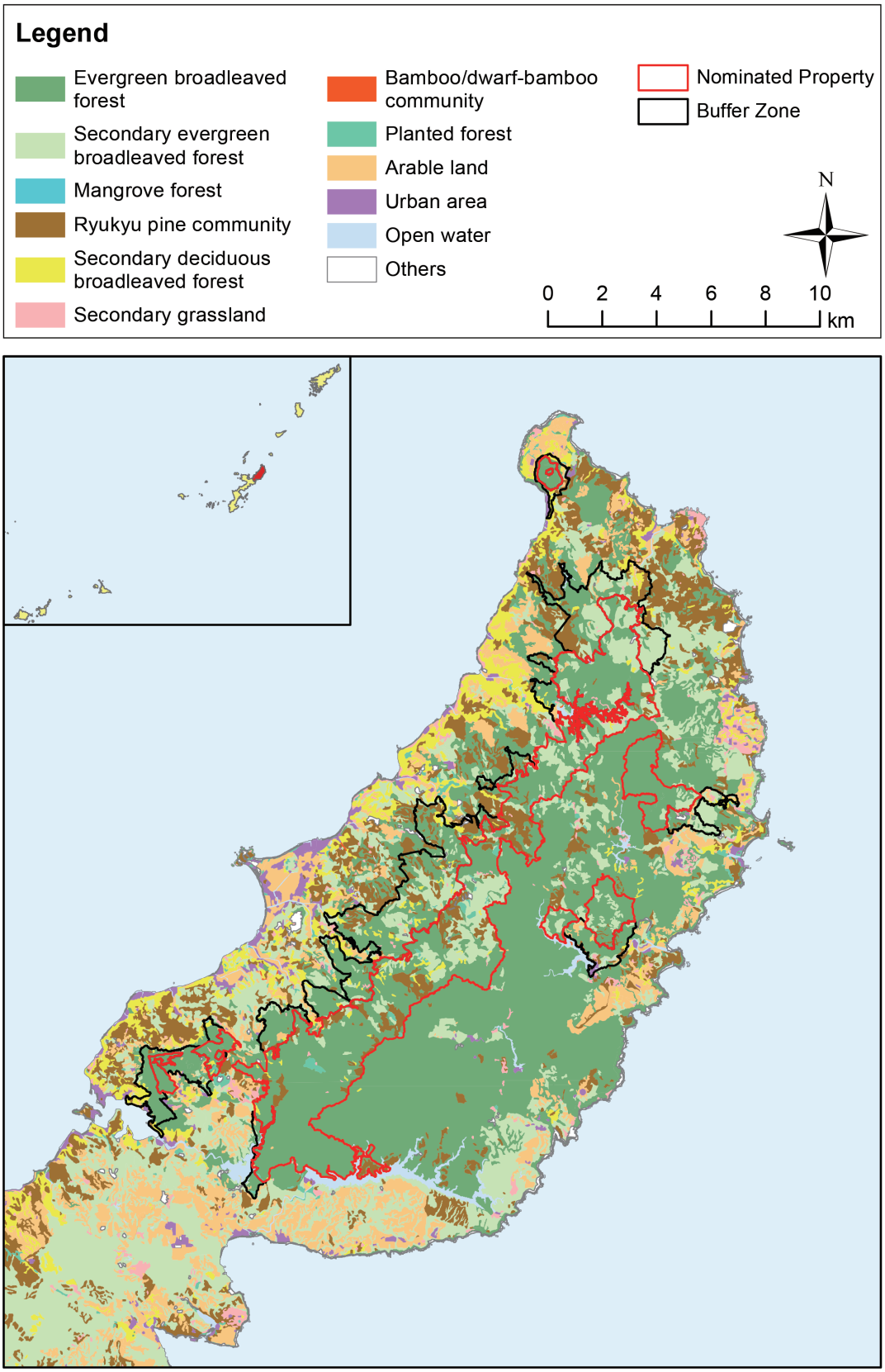


Figure 2-11: Vegetation of the nominated property (Northern part of Okinawa Island)
The Sixth and Seventh Rounds of the National Survey on the Natural Environment (vegetation surveys) by the Ministry of the Environment

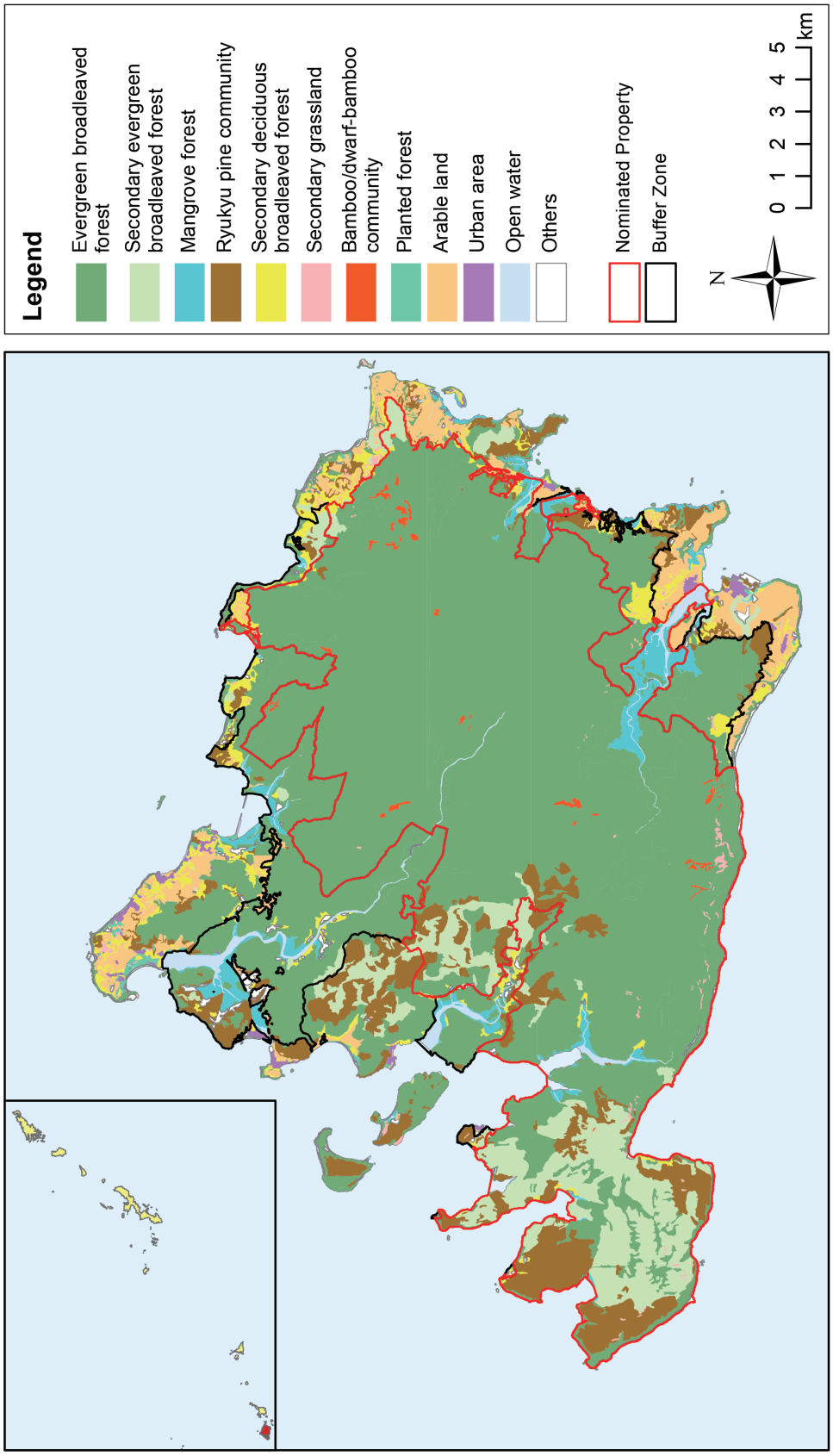


Figure 2-12: Vegetation of the nominated property (Iriomote Island)
The Sixth and Seventh Rounds of the National Survey on the Natural Environment (vegetation surveys) by the Ministry of the Environment

2.a.2. Biota

The Ryukyu Chain is home to a particularly large number of endemic species and subspecies of non-avian vertebrates, reflecting the formation process of the continental islands, namely, separation and isolation from the Continent caused by plate motions, followed by the formation of a land bridge and subsequent fragmentation into islands as a result of periodic sea-level fluctuations between the glacial and interglacial periods (to be detailed in "2.a.3. Geological History and Speciation"). Studies on distribution patterns of amphibians and reptiles have shown that the herpetofauna in the Central Ryukyus is closer to that of the South Ryukyus and southward than to that of the North Ryukyus (Ota 2000), but the Central and South Ryukyus exhibit different patterns of endemism (Hikida and Ota 1997; Ota 1998; Okamoto 2017). Therefore, many of the non-avian terrestrial vertebrate species inhabiting the Central and South Ryukyus are considered to be of subtropical origin and have many evolutionary sister groups and stem groups in Taiwan and the southeastern part of the Eurasian Continent (Ota 2009).

In addition, the Ryukyu Chain also exhibits characteristics similar to those of the establishment of organisms observed in oceanic islands and its biota is composed of plants and animals that arrived via various routes and processes, reflecting various geographic and climatic characteristics which include the following: it is a chain of islands located in the northwestern Pacific Ocean, lying like stepping stones over a stretch of waters extending approximately 1,200 km in parallel to the east coast of the Eurasian Continent; it is washed by the Kuroshio Current, one of the world's major warm ocean currents, which flows northward in the East China Sea; strong typhoons formed over the ocean east of the Philippines frequently hit the archipelago; and it is situated along a migration route for birds travelling a long distance between the Northern and Southern Hemispheres (Figure 2-13 and Table 2-5).

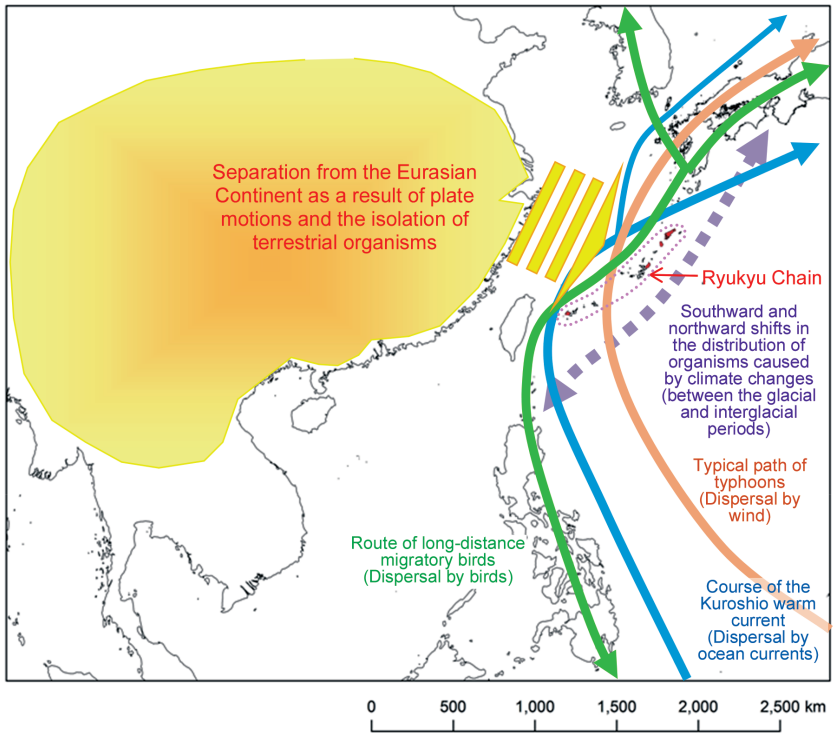


Figure 2-13: Diverse processes of biota development in the nominated property (Image)

Table 2-5: Patterns of biological dispersal, etc. associated with biota development in the Ryukyu Chain and examples

Patterns of biological dispersal, etc. in the Ryukyu Chain	Examples
Separation and isolation from the Eurasian Continent caused by plate motions and the speciation of species	Detailed in 2.a.3. Geological History and Speciation
Migratory birds that stopped over while travelling from the south along the archipelago lost their flight ability and evolved into endemic species	Okinawa rail (*Gallirallus okinawae*) (Matsuoka 2003; Ozaki 2005; Kirchman 2012)
Southward and northward shifts in the distribution of organisms caused by climate changes (between the glacial and interglacial periods) and refuges	・Relicts of temperate species of organisms that migrated southward during the glacial period Asahina's skipper (*Ochlodes asahinai*) (Chiba and Tsukiyama 1996) *Dendranthema crassum, Euphorbia sieboldiana* (Hotta 2003b), etc. ・Safe refuges for plants of tropical origin that had migrated northward before the glacial period *Begonia fenicis* (Nakamura et al. 2014)
Dispersal by ocean currents such as the Kuroshio	Weevil (*Pachyrhynchus infernalis*) (Kohama 2015) Stick insect (*Megacrania tsudai adan*) (Yamasaki 1991) Nipa palm (*Nypa fruticans*) (Sugai et al. 2015) Asiatic mangrove (*Rhizophora stylosa*) (Ng W. L. et al. 2015) *Kandelia obovata* (Giang et al. 2006) *Entada phaseoloides* (Wakita et al. 2008; Tateishi et al. 2008)
Dispersal by wind such as typhoons	Common rose (*Pachliopta aristolochiae interposita*), striped blue crow (*Euploea mulciber barsine*), crimson marsh glider (*Trithemis aurora*), amber-winged glider (*Hydrobasileus croceus*) (Kohama 2015)
Dispersal by birds such as migratory birds	*Solenogyne mikadoi* (Nakamura et al. 2012) *Lobelia loochooensis* (Kokubugata et al. 2012)

As a result, the four regions containing the nominated property together account for only 0.4% of the total land area of Japan, a biodiversity hotspot by Conservation International, are home to 26% of vascular plant species of Japan, 7% of the endemic species of Japan, 20% of those listed as threatened (on the MOEJ Red List). They are also a habitat for 58% of all of the vertebrates in Japan, 44% of endemic species of Japan (excluding inland water fish), and 30% of species listed as threatened (on the IUCN Red List). Also, 20% of the insect species inhabiting Japan and 53% of those threatened as well as 64% of the inland decapod crustacean species inhabiting Japan and 39% of endemic species are found in the regions (Table 2-6).

Dendranthema crassum (Photo: MOEJ)

*Lobelia loochooensi*s (Photo: JWRC)

Table 2-6: Numbers of species inhabiting the four regions containing the nominated property and the rates of endemic and threatened species

Taxonomic group	Number of species in Japan	Number of species endemic to Japan*	Rate of endemic species to total species in Japan	Number of threatened species in Japan (IUCN-RL)*1	Number of threatened species in Japan (MOEJ-RL)	Number of species inhabiting the nominated property (Rate to total species in Japan)	Number of species endemic to the nominated property (Rate to total endemic species in Japan)	Rate of endemic species to total species in the nominated property	Number of threatened species inhabiting the nominated property (IUCN-RL) (Rate to total endangered species in Japan)	Number of threatened species inhabiting the nominated property (MOEJ-RL) (Rate to total endangered species in Japan)	Sources
Vascular plants*2	Approx. 7,000	Approx. 2,800	Approx. 40%	43	1,779	1,808 (26%)	185 (7%)	10%	24 (56%)	334 (19%)	1)
Terrestrial mammals	109	42	39%	24*1	33	22 (20%)	13 (31%)	59%	10 (42%)	13 (39%)	2)
Birds*3	633	11	2%	58	97	394 (62%)	4 (36%)	1%	12*3 (65.5%)	36*3 (37%)	3)
Terrestrial reptiles	72	47	65%	9	36	36 (50%)	23 (49%)	64%	5 (56%)	13 (36%)	4)
Amphibians	71	61	86%	20	22	21 (30%)	18 (30%)	86%	12 (60%)	10 (45%)	4)
Inland water fishes	Approx. 400	–	–	41*1	167	267 (68%)	13 (?%)	5%	6 (15%)	64 (38%)	5)
Vertebrates*4	Approx. 1,285	161*4	13%*4	152	355	740 (58%)	71 (36%)*4	10%	45 (30%)	136 (38%)	–
Insects	Approx. 30,000	–	–	36*1	358	6,148 (20%)	1,062 (?%)	17%	19 (53%)	36 (10%)	6)
Inland decapod crustaceans	73	38	52%	2	22	47 (64%)	15 (39%)	32%	0 (0%)	5 (23%)	7)

Source: 1) Kagoshima University (2012), Ministry of the Environment (2014a), and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture (2014);
2) Abe (2008) and Odachi et al. (2015);
3) Takagi (2007) and Ornithological Society of Japan (2012)
4) Herpetological Society of Japan (2015);
5) Yoshigo (2014) and Ministry of the Environment (2014b);
6) Azuma (2002) and Biodiversity Center of Japan, Ministry of the Environment (2010); and
7) Hayashi (2011)

*1: The numbers of species for the IUCN Red List are based on species-level assessments. However, the Iriomote cat and the Steller sea lion, which are subspecies of mammals, as well as the Ryukyu ayu-fish and Japanese rosy bitterling, which are subspecies of inland water fishes, are counted as species as they have been assessed at a subspecies level and there are no other threatened subspecies belonging to the same species in Japan. Likewise, each subspecies of insects is counted as one species because insects are assessed only at the level of subspecies, not at the level of species.

*2: The numbers of plant species include subspecies, varieties, and hybrids (excluding those listed on the IUCN Red List).

*3: The numbers of threatened species of birds inhabiting the nominated property do not include those recorded as vagrants.

*4: For vertebrates, the number of species endemic to Japan, the rate of endemic species to total species in Japan, and the rate of species endemic to the nominated property to total endemic species in Japan do not include inland water fishes.

2.a.2.1. Flora

The four regions containing the nominated property are home to 1,808 indigenous species of vascular plants (including subspecies, varieties, and hybrids; hereinafter the same), consisting of 300 species of ferns and 1,508 species of seed plants (calculated based on Kagoshima University (2012) and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture (2014)) (Table 2-7).

Table 2-7: Numbers of indigenous species of vascular plants (including subspecies, varieties, and hybrids) in the four regions containing the nominated property

	Four regions containing the nominated property	Amami-Oshima Island[*1, 2]	Tokunoshima Island[*2]	Northern part of Okinawa Island	Iriomote Island
Psilotales	1	1	1	1	1
Lycopodiales	11	9	6	6	7
Selaginellales	9	6	5	4	7
Equisetales	1	1	0	0	0
Ophioglossales	6	5	2	2	4
Marattiales	2	2	2	1	2
Filicales	267	180	139	179	167
Marsileales	2	2	2	1	2
Salviniales	1	1	0	1	1
Cycadales	1	1	1	1	1
Coniferales	4	4	4	4	3
Magnoliales	28	21	18	20	20
Piperales	4	3	4	3	3
Aristolochiales	18	12	5	1	4
Rafflesiales	1	1	1	0	1
Ranunculales	22	19	14	13	15
Guttiferales	31	19	16	21	23
Malvales	17	14	10	12	14
Papaverales	13	11	8	9	8
Violales	18	11	8	6	9
Cucurbitales	9	8	4	6	5
Caryophyllales	26	12	17	16	20
Polygonales	28	23	12	15	12
Hamamelidales	19	14	9	8	9
Sarraceniales	2	1	1	1	2
Rosales	95	62	54	48	65
Geraniales	3	3	1	1	1
Rutales	22	16	10	14	17
Sapindales	12	9	8	5	8
Celastrales	29	25	19	20	20
Rhamnales	16	14	11	9	13
Oleales	11	9	7	7	6
Umbelliflorae	29	22	16	21	16
Sapindales	34	24	18	20	23
Urticales	50	35	29	31	37
Myricales	1	1	1	1	1
Fagales	10	7	6	6	2
Proteales	1	1	1	1	1
Santalales	5	4	4	2	4
Balanophorales	3	2	2	1	2

	Four regions containing the nominated property	Amami-Oshima Island[*1, 2]	Tokunoshima Island[*2]	Northern part of Okinawa Island	Iriomote Island
Euphorbiales	37	26	24	28	28
Haloragales	5	4	1	3	3
Primulales	15	15	13	11	11
Plumbaginales	3	2	2	1	3
Ericales	18	13	6	8	7
Ebenales	19	13	13	16	14
Gentianales	27	17	18	14	15
Rubiales	66	48	41	44	42
Solanales	136	101	66	68	93
Campanulales	8	8	6	5	4
Asterales	91	68	51	50	57
Alismatales	4	3	4	2	3
Hydrocharitales	16	14	6	2	11
Helobiae	15	13	5	2	11
Principes	5	2	2	2	4
Pandanales	5	1	1	1	5
Spathiflorae	19	11	9	8	11
Typhales	2	2	1	1	1
Triuridales	3	3	0	3	1
Liliiflorae	41	34	24	21	21
Iridales	6	5	1	4	2
Microspermae	126	78	47	38	68
Scitamineae	5	3	1	3	3
Commelinales	12	10	8	9	7
Eriocaulales	8	6	4	6	2
Juncales	6	3	2	5	1
Cyperales	114	82	55	64	79
Restionales	1	0	1	1	1
Graminales	134	106	68	91	98
Total	1,808	1,306	956	1,029	1,162

The numbers are based on Kagoshima University (2012) and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture (2014).

*1: The numbers for the Amami-Oshima Island include those found on islands in the neighboring area (Kakeroma Island, Ukejima Island, and Yoro Island) because they cannot be distinguished from those of the Amami-Oshima Island based on data contained in source documents.

*2: Those for whose area of distribution is defined simply as the "Amami Island Group" in the source documents are regarded as inhabiting all of the Amami Island Group.

The flora of these regions is considered to have the historical backgrounds and components shown in Table 2-8, reflecting their geological history, climate changes in the past, and geographic conditions such as how the islands are positioned relative to ocean currents (Hatsushima 1975). It is believed that the mountain floras of the regions have a high degree of affinity to those of the Eurasian Continent and the main islands of Japan, whereas the floras found in the regions' forest floors, lowlands, and coastal areas are closely related to those found in tropical Asia (Tateishi 1998). The Ryukyu Chain containing the nominated property is located in a subtropical zone, i.e., in between tropical and temperate zones, with a chain of islands extending about 1,200 km from north to south. Therefore, the distribution pattern of plants is influenced by the temperature gradient between the islands located in the northern part of the archipelago and those in the southern part (see 2.a.1.2.1 and Column 1), and many species have their northern or southern limits in the archipelago (Hotta 2003).

Table 2-8: Factors influencing the floras of the Central and South Ryukyus

Components	Description	Proportion	Examples
(1) Ryukyu-indigenous components that have been in existence since before the formation of the islands	Believed to have been in existence since the age when the present Central and South Ryukyus were part of the east coast of the Eurasian Continent. Many of them are relict endemic species.	Large	*Elatostema oshimense* (Urticaceae); *Vaccinium emarginanum* (Ericaceae); *Platanthera sonohara*e (Orchidaceae); *Polystichum obae* (Dryopteridaceae); Genus *Asarum* (Aristolochiaceae); *Arisaema heterocephalum* (Araceae); etc. (Hatsushima 1975: 1980)
(2) Components originated from the southeastern part of the Eurasian Continent	Believed to have travelled from southern China, through Taiwan, to enter the regions.	Large	*Ophiorrhiza japonica* (Rubiaceae) (Nakamura et al. 2010) Genus *Pieris* (Setoguchi et al. 2008) Genus *Lysimachia* Sect, *Nummularia* (Kokubugata et al. 2010) Genus *Lysionotus* (Kokubugata et al. 2011)
(3) Components of Palearctic origin	Believed to have survived the last glacial period after arriving the regions by traveling southward from the main islands of Japan during the glacial period from the late Pliocene to the early Pleistocene.	Rather small	*Chrysanthemum crassum*, *Sigesbeckia glabrescens* (Asteraceae); *Diplomorpha phymatoglossa* (Thymelaeaceae); *Stachyurus praecox* var. *lancifolia* (Stachyuraceae); *Securinega suffruticosa* var. *amamiensis* (Phyllanthaceae); *Sapium japonicum*, *Euphorbia sieboldiana* var. *amamiana* (Euphorbiaceae); *Solidago yokusaiana* (Asteraceae); *Desmodium podocarpum* subsp. *oxyphyllum* (Fabaceae); *Adenophora triphylla* (Campanulaceae); *Rhamnella franguloides* var. *inaequilatera*, *Berchemia racemosa* f. *stenosperma* (Rhamnaceae); *Lilium alexandrae* (Liliaceae); etc. (Hatsushima 1975; Hotta 2003b; Okuyama 2016)
(4) Components originated from Malaysia	Believed to have arrived the regions after traveling northward from Malaysia along the east coast of Taiwan. It is believed that most of them were carried in by ocean currents, birds, or winds.	Rather small	*Begonia fenicis* (Begoniaceae); *Nypa fruticans* (Arecaceae); *Rhizophora stylosa*, *Kandelia obovata* (Rhizophoraceae); *Vitex trifolia* var. *bicolor* (Verbenaceae); *Ixeris laevigata* (Asteraceae); *Fimbristylis umbellaris* (Cyperaceae); *Macodes petola* (Orchidaceae); etc. (Nakamura et al. 2014; Sugai et al. 2015; Ng W. L. et al. 2015; Sheue et al. 2003; Giang et al. 2006; Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture 2006)
(5) Components originated from the Pacific Islands	Believed to have been carried in by ocean currents, birds, or winds.	Very small	*Limnophila fragrans* (Scrophulariaceae) (Hsu et al. 2009)
(6) Components originated from Australia	Believed that seeds have been carried in and dispersed by migratory birds	Very small	*Solenogyne mikadoi* (Asteraceae); *Lobelia loochooensis* (Campanulaceae); etc. (Nakamura et al. 2012; Kokubugata et al. 2012)

Examples of the flora of the Central and South Ryukyus.
Numbers correspond to Table 2-8.

(1) *Platanthera sonoharae* (Photo: MOEJ)

(2) *Ophiorrhiza japonica* var. *amamiana* (Photo: JWRC)

(3) *Euphorbia sieboldiana* (Photo: MOEJ)

(4) *Begonia fenicis* (Photo: MOEJ)

(5) *Limnophila fragrans* (Photo: Masatsugu Yokota)

(6) *Solenogyne mikadoi* (Photo by MOEJ)

Table 2-9: Numbers of endemic and threatened species of vascular plants (including subspecies, varieties, and hybrids) in the four regions containing the nominated property

	Four regions containing the nominated property	Amami- Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Number of indigenous species	1,808	1,306	956	1,029	1,162
Number of endemic species	185	124	79	71	58
Rate of endemic species (%)	10	9	8	7	5
Number of species listed on IUCN-RL (2016)	24	13	7	6	5
Number of species listed on MOEJ-RL (2015)	335	194	105	122	176
Rate of species listed on MOEJ-RL (%)	20	15	11	12	15

The numbers and calculations are based on: Kagoshima University (2012); and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture (2014).

Table 2-9 shows the numbers of endemic and threatened species of vascular plants in the four regions containing the nominated property. Out of a total of 1,808 species (including subspecies, varieties, and hybrids) of vascular plants, 185 species (10%) are endemic. The rate of endemic species is not so high, for instance, compared to oceanic islands such as Hawaii and the Galápagos Islands, where the rate of endemic plant species ranges from 40% to nearly 80% (Ito 1996). However, as explained in the geological history of the regions, in the Central and South Ryukyus, which were an eastern margin of the Eurasian Continent and hence inherited the rich flora of the continent, some of the inherited species have survived only in the regions under isolation (relict endemism) or differentiated into an entirely new endemic species (new endemism) (Hotta 2003a).

Among the vascular plant species found in the nominated property, 24 species are listed as globally threatened on the IUCN Red List (Tables 2-9 and 2-10). Meanwhile, approximately 7,000 species (including subspecies and varieties) of vascular plants in Japan were assessed for the MOEJ Red List (2015), and 1,779 species (approximately 25%) were determined as threatened. In the four regions containing the nominated property, 355 species (including subspecies and varieties) are listed as endangered (Table 2-9), meaning that 20% of threatened plant species in Japan are found in the four regions that together represent only 0.4% of the total land area of Japan (Table 2-6).

A joint study conducted by the Ministry of the Environment, the National Institute for Environmental Studies, Kyushu University, and other research groups, in which they assessed the extinction risks of species listed on the MOEJ Red List, cited the nominated property along with two of Japan's listed natural heritage sites—the Ogasawara Islands and Yakushima—as areas that are highly non-substitutable in terms of conserving Japanese vascular plant species and have conservation priority (Ministry of the Environment 2011; Kadoya et al. 2014) (Figure 2-14).

Table 2-10: Globally threatened vascular plant species in the four regions containing the nominated property

	Threatened species	Distribution	IUCN	MOEJ
Dryopteridaceae	*Dryopteris hasseltii*	Northern part of Okinawa Island	EN	–
Aristolochiaceae	*Asarum gusk*	Amami-Oshima Island	CR	CR
	A. monodoriflorum	Iriomote Island	CR	CR
	A. pellucidum	Amami-Oshima Island	CR	CR
	A. tabatanum	Amami-Oshima Island	CR	CR
	A. celsum	Amami-Oshima Island	EN	EN
	A. hatsushimae	Tokunoshima Island	EN	EN
	A. lutchuense	Amami-Oshima Island, Tokunoshima Island	EN	EN
	A. nazeanum	Amami-Oshima Island	EN	EN
	A. trinacriforme	Amami-Oshima Island	EN	EN
	A. fudsinoi	Amami-Oshima Island	VU	VU
	A. simile	Tokunoshima Island	VU	VU
Violaceae	*Viola amamiana*	Amami-Oshima Island	CR	CR
Saxifragaceae	*Cardiandra amamiohsimensis*	Amami-Oshima Island	EN	EN
	Deutzia yaeyamensis	Iriomote Island	EN	EN
Leguminosae	*Intsia bijuga*	Iriomote Island	VU	CR
Aquifoliaceae	*Ilex liukiuensis*	Amami-Oshima Island, Tokunoshima Island, Northern part of Okinawa Island, Iriomote Island	EN	–
Combretaceae	*Terminalia nitens*	Iriomote Island	VU	CR
Compositae	*Aster miyagii*	Amami-Oshima Island, Tokunoshima Island, Northern part of Okinawa Island	VU	VU
Araceae	*Arisaema kawashimae*	Tokunoshima Island	CR	CR
	A. heterocephalum	Amami-Oshima Island Tokunoshima Island	EN	–
Burmanniaceae	*Oxygyne shinzatoi*	Northern part of Okinawa Island	CR	CR
Orchidaceae	*Eulophia taiwanensis*	Northern part of Okinawa Island	EN	CR
Cyperaceae	*Carex collifera*	Northern part of Okinawa Island	CR	CR

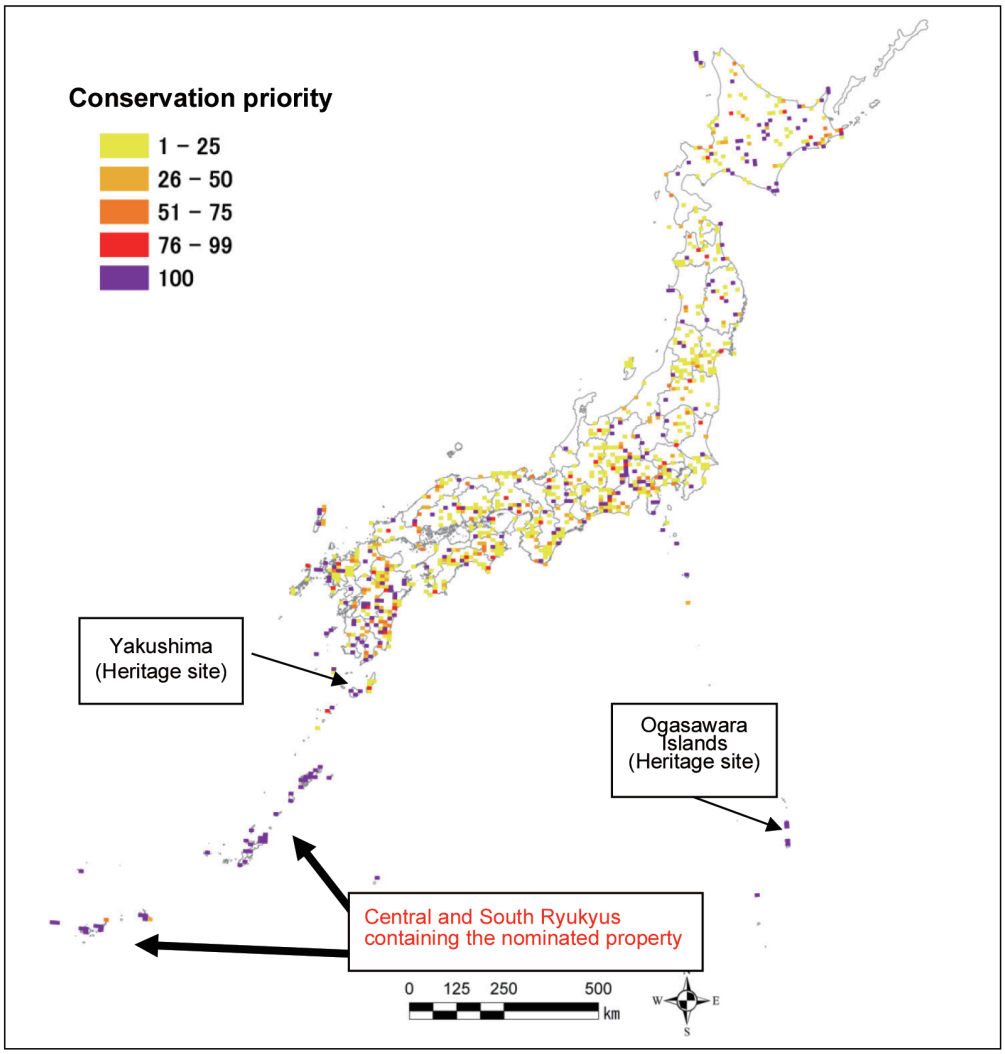


Figure 2-14: Priority areas for conservation of the threatened vascular plant species in Japan (Ministry of the Environment 2011)

Conservation priority: The number of times each area was selected as a priority conservation area in a complementary analysis performed 100 times on the 1,219 vascular plant species listed on the MOEJ Red List for which distribution data are available. The value of each grid cell of 10km x 10km represents how many times the corresponding area was selected. The greater the value (closer to purple), the more difficult is it to find a substitute for the area and the more critical is it to the efficient conservation of target species.

Viola amamiana (Photo: MOEJ)

Cardiandra amamiohsimensis (Photo: MOEJ)

Dendrobium okinawense (Photo: MOEJ)

Colum 1. Mangrove forests in the northern and southern parts of the Ryukyu Chain are quite different in species composition

The influence of the temperature gradient between the northern and southern parts of the Ryukyu Chain on the distribution of plants is typically observed in differences in the species composition of mangrove forests formed by tropical trees and shrubs that are dispersed by ocean currents.

In Asia, the Ryukyu Chain containing the nominated property is about the northern limit of mangrove species. Within the archipelago, the most extensive mangrove forests are found on Iriomote Island. Table 2-11 shows seven major species found in mangroves in the Ryukyu Chain.

All of the seven species are distributed on Iriomote Island. However, the more northerly the island, the less species are found with only one species found on Yakushima Island. The difference in temperature between the northern and southern ends of the archipelago is believed to be the biggest factor preventing seeds from taking root on the northerly islands even if they manage to get carried by the Kuroshio current all the way up there (Shimabukuro 1990).

Table 2-11: Major islands of the Ryukyu Chain and the distribution of major species composing mangrove forests

	Iriomote Island	Miyako Island	Okinawa Island	Amami-Oshima Island	Yakushima
Latitude	N24°30′	N24°45′	N26°	N28°	N30°
Kandelia obovata	○	○	○	○	○
Bruguiera gymnorhiza	○	○	○	○	–
Rhizophora stylosa	○	○	○	–	–
Lumnitzera racemosa	○	○	○	–	–
Avicennia marina	○	○	–	–	–
Sonneratia alba	○	–	–	–	–
Nypa fruticans	○	–	–	–	–

Source: Shimabuku (1990) with some information added.

Rhizophora stylosa
(Photo: MOEJ)

2.a.2.2. Fauna

From the biogeographic viewpoint, the Watase Line, which coincides with the Tokara Strait, has been proposed as a boundary between the Palearctic and Indomalaya ecozones for the distribution of mammals, reptiles, and amphibians (Tokuda 1969), while the Hachisuka Line at the Kerama Gap has been proposed as a boundary for the distribution of birds (Yamashina 1955). Thus, from a phylogeographical point of view, the nominated property is located in-between the two areas that retain very different faunas and can be defined as a geographical transition zone (Motokawa 2000; Ota 2000; Takagi 2009).

2.a.2.2.1. Terrestrial mammals

It has been confirmed that 22 species of indigenous terrestrial mammals inhabit the nominated property (Table 2-12), accounting for 20% of the total 109 indigenous species found across Japan (calculated based on Abe 2008 and Ohdachi et al. 2015).

Since the four islands containing the nominated property are small with the Okinawa Island, the largest among them, having a land area of 120,696 ha, there are only few species of large- and medium-sized indigenous mammals, i.e., only one species from each of the orders Carnivora, Artiodactyla, and Lagomorpha, and none from Primates. As such, the relatively large proportion of small-sized species such as those belonging to Chiroptera and Rodentia thanks to the limited presence of apex predators and large- and medium-sized species is one of the characteristics of the mammalian fauna of the nominated property.

Table 2-12: Numbers of indigenous terrestrial mammal species in the nominated property

(The numbers in the parentheses include subspecies)	Nominated property	Component parts			
		Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Insectivora					
Soricidae	3	3	3	2	1
Chiroptera					
Pteropodidae	1 (2)	0	0	1	1
Rhinolophidae	3	1	1	1	1
Hipposideridae	1	0	0	0	1
Vespertilionidae	5	5	5	4	2
Molossidae	1	1	0	0	0
Carnivora					
Felidae	1	0	0	0	1
Artiodactyla					
Suidae	1	1	1	1	1
Rodentia					
Muridae	5	2	2	3	0
Lagomorpha					
Leporidae	1	1	1	0	0
Total	22 (23)	14	13	12	8

The numbers are based on Abe (2008) and Ohdachi et al. (2015).
*: The numbers include Ryukyu mouse (*Mus caroli*), a possible alien species (Suzuki 2016).

Out of the 22 species of terrestrial mammals found in the nominated property, 13 species (59%) are endemic. When endemic subspecies such as the Iriomote cat (*Prionailurus bengalensis iriomotensis*) and Ryukyu wild boar (*Sus scrofa riukiuanus*) are included, there are a total of 23 species and subspecies, of which 18 (78%) are endemic to the nominated property, showing a very high rate of endemic species (Table 2-13).

Among the terrestrial mammals found in the nominated property, a total of 10 species and subspecies (45%) are listed on the IUCN Red List as globally threatened (three categorized as CR and seven as EN) (Tables 2-12 and 2-13). Also, a total of 13 species and subspecies (57%) are listed on the MOEJ Red List as Japanese threatened species, three categorized as CR, nine as EN, and one as VU (Tables 2-13 and 2-14), of which five are classified as Evolutionarily Distinct and Globally Endangered (EDGE) species[3] by the Zoological Society of London (Table 2-14).

Table 2-13: Numbers of endemic and threatened species of terrestrial mammals in the nominated property

(The numbers in the parentheses include subspecies)	Nominated property	Component parts			
		Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Number of indigenous species	22 (23)	14	13	12	8
Number of endemic species	13 (18)	8 (10)	8 (10)	7 (9)	3 (6)
Rate of endemic species (%)	59 (78)	57 (71)	62 (77)	58 (75)	38 (75)
Number of species listed on IUCN-RL (2016) *	10	7	7	5	2
Rate of species listed on IUCN-RL (%)	45	50	54	42	25
Number of species listed on MOEJ-RL (2015) *	13	8	8	6	3
Rate of species listed on MOEJ-RL (%)	57	57	62	50	38

The numbers are based on Abe (2008) and Ohdachi et al. (2015).

*: The numbers of those listed on the IUCN Red List are, in principle, based on species-level assessments. However, the Iriomote cat, which has been assessed at a subspecies level, is counted as one species as there are no other subspecies belonging to the same species in the nominated property.

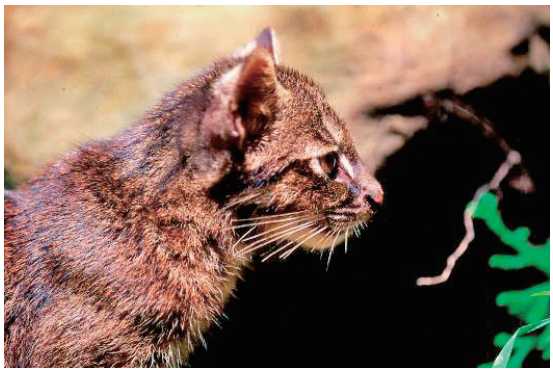
Yanbaru whiskered bat (*Myotis yanbarensis*)
(Photo: MOEJ)

3 Species ranked and selected in the order of conservation priority based on scores calculated according to their unique evolutionary history (Evolutionary Distinctiveness: ED) and conservation status (Global Endangerment: GE) under the EDGE of Existence program of the Zoological Society of London. EDGE species have no or very few close evolutionary relatives, and the extinction of these species means that there will be no similar species left on the globe.

Table 2-14: Globally threatened terrestrial mammal species inhabiting the nominated property

Threatened species	Distribution	IUCN	MOEJ	EDGE rank
Yanbaru whiskered bat (*Myotis yanbarensis*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island	CR	CR	–
Iriomote cat (*Prionailurus bengalensis iriomotensis*)	Iriomote Island	CR	CR	–
Okinawa spiny rat (*Tokudaia muenninki*)	Northern part of Okinawa Island	CR	CR	48
Orii's shrew (*Crocidura orii*)	Amami-Oshima Island, Tokunoshima Island	EN	EN	–
Ryukyu bent-winged bat (*Miniopterus fuscus*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island, Iriomote Island	EN	EN	306
Ryukyu tube-nosed bat (*Murina ryukyuana*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island	EN	EN	–
Amami spiny rat (*T. osimensis*)	Amami-Oshima Island	EN	EN	214
Tokunoshima spiny rat (*T. tokunoshimensis*)	Tokunoshima Island	EN	EN	–
Ryukyu long-haired rat (*Diplothrix legata*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island	EN	EN	282
Amami rabbit (*Pentalagus furnessi*)	Amami-Oshima Island, Tokunoshima Island	EN	EN	42

Amami rabbit (*Pentalagus furnessi*) (Photo: MOEJ)



Iriomote cat (*Prionailurus bengalensis iriomotensis*) (Photo: MOEJ)

Ryukyu long-haired rat (*Diplothrix legata*) (Photo: MOEJ)

Okinawa spiny rat (*Tokudaia muenninki*) (Photo: MOEJ)

2.a.2.2.2. Birds

A total of 394 species of birds from 71 families and 22 orders are recorded as inhabiting the four regions containing the nominated property (Table 2-15). With those accounting for 62% of all avian species in Japan, a total of 633 species from 81 families and 24 orders (Table 2-6), it is fair to say that the nominated property can be described as having a very rich avifauna (calculated based on Ornithological Society of Japan (2012) and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture et al. (2015)).

Table 2-15: Numbers of indigenous species of birds in the four regions containing the nominated property*

(The numbers in the parentheses include subspecies.)	Nominated property	Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Anseriformes	30 (32)	26 (28)	14	18	26 (27)
Podicipediformes	4	4	2	2	3
Phaethontiformes	2	1	0	0	1
Columbiformes	7 (10)	5	3	4 (5)	6 (8)
Gaviiformes	2	2	2	0	0
Procellariiformes	9	7	3	1	5
Ciconiiformes	2	1	1	1	2
Suliformes	7 (8)	7 (8)	3	2 (7)	5
Pelecaniformes	25	19 (20)	12 (13)	15	22 (23)
Gruiformes	16 (17)	11 (12)	8 (9)	7	10 (11)
Otidiformes	1	0	0	1	0
Cuculiformes	6	3	3	4	5
Caprimulgiformes	1	1	1	1	1
Apodiformes	3	3	3	3	3
Charadriiformes	91 (92)	83 (84)	58	36	70 (69)
Accipitriformes	21 (22)	16	8	8 (10)	18 (19)
Strigiformes	8 (10)	6 (8)	4	2 (3)	7 (8)
Bucerotiformes	1	1	1	1	1
Coraciiformes	6	4	3	3	6
Piciformes	4 (6)	3	1	2	1
Falconiformes	6 (7)	4	2	4	6 (7)
Passeriformes	142 (171)	108 (123)	64 (69)	80 (88)	114 (128)
Total	394 (437)	315 (338)	196 (203)	195 (207)	312 (333)

The numbers are based on Ornithological Society of Japan (2012) and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture et al. (2015).

*: Information on the distribution of species and subspecies by island is not necessarily consistent because the preciseness of the information varies depending on the literature (e.g., species level versus subspecies level).

As for the migratory status of birds recorded in the four regions containing the nominated property, migratory birds—i.e., summer visitors, winter visitors, and other passage migrants—and vagrants make up the vast majority of the avifauna. Meanwhile, resident birds, totaling 49 species (63 species and subspecies), account for approximately 11% (Figure 2-15). Factors behind this include that the Central and South Ryukyus, which are a chain of islands lying like stepping stones over a stretch of water extending approximately 1,200 km from the southern tip of Kyushu to Taiwan, serve as a safe route for migratory birds traveling between the Northern and Southern Hemispheres, and that the archipelago, which has a subtropical climate and is warm even in winter, is abundant in insects and amphibians, providing sufficient food for birds (Okinawa Wild Bird Research Association 2002).

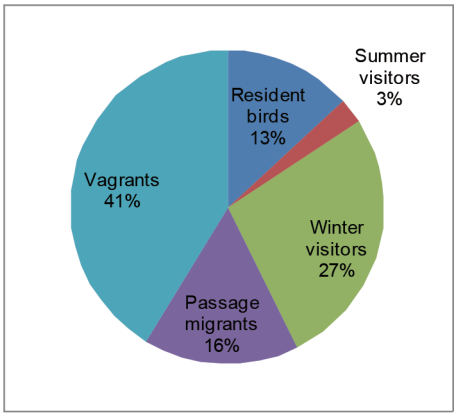


Figure 2-15: Migratory status of birds recorded in the four regions containing the nominated property

Japan has a total of 11 endemic species of birds (Takagi 2007) and five of them inhabit the nominated property. Among them, the Ryukyu robin (*Luscinia komadori*) is also found on the Danjo Islands, Nagasaki Prefecture (Kyushu), but the remaining four—i.e., the Amami jay (*Garrulus lidthi*), the Amami woodcock (*Scolopax mira*), the Okinawa woodpecker (*Sapheopipo noguchii*), and the Okinawa rail—are endemic to Central and South Ryukyus containing the nominated property (Table 2-16). However, some including BirdLife International believe that the white-backed woodpecker (*Dendrocopos leucotos owstoni*), a subspecies endemic to the Amami-Oshima Island, should be recognized as a separate species and thus referred to as Amami woodpecker (*Dendrocopos owstoni*) (Hoyo and Collar 2014). Based on this classification, the number of species endemic to the Central and South Ryukyus is five. Because of the inhabitation of those endemic species of birds, all islands lying between Kyushu and Taiwan, including the nominated property, are listed as Endemic Bird Area (EBAs) by BirdLife International under the name of "Nansei Shoto."

Among the species of birds found in the four regions containing the nominated property, 12 species are globally threatened species listed on the IUCN Red List (2016), two as CR, five as EN, and five as VU, while 36 species and subspecies are Japanese threatened species listed on the MOEJ Red List, four categorized as CR, 11 as EN, and 21 as VU (Table 2-16). All of the four species that are endemic to the nominated property are globally threatened species listed on the IUCN Red List, of which three are classified as EDGE species by the Zoological Society of London (Table 2-17).

Table 2-16: Numbers of endemic and threatened species of birds in the four regions containing the nominated property*1

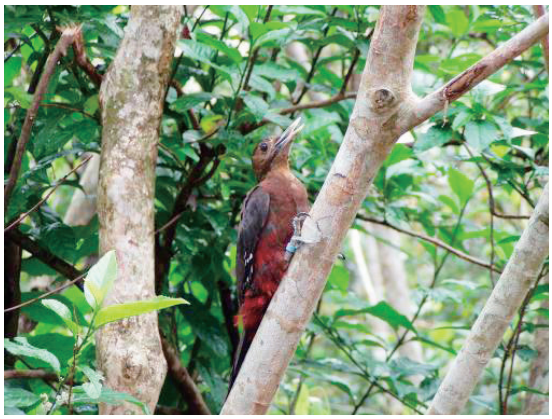
(The numbers in the parentheses include subspecies)	Four regions containing the nominated property	Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Number of species	394 (437)	315 (338)	196 (203)	195 (207)	312 (333)
Resident birds	49 (63)	42	38 (36)	38 (40)	44 (46)
Migratory birds (summer/ winter visitors and passage migrants)	167 (178)	158 (166)	127 (134)	97 (106)	155 (165)
Vagrants	178 (196)	115 (130)	31 (33)	60 (61)	112 (122)
Number of endemic species*2	4 (30)	2 (12)	1 (7)	3 (12)	0 (17)
Rate of endemic species (%)*2	8 (48)	5 (29)	3 (19)	8 (30)	0 (37)
Number of species listed on IUCN-RL (2016)	12	10	6	4	8
Rate of species listed on IUCN-RL (%)	6	5	4	7	4
Number of species listed on MOEJ-RL (2015)	36	25	15	19	29
Rate of species listed on MOEJ-RL (%)	15	12	9	13	14

The numbers are based on the Ornithological Society of Japan (2012) and Nature Conservation Division, Department of Environmental Affairs, Okinawa Prefecture et al. (2015).

*1: Information on the distribution of species and subspecies by island is not necessarily consistent because the preciseness of the information varies depending on the literature (e.g., species-level versus subspecies level, inconsistent migratory status between species- and subspecies levels).

*2: The numbers and rates of endemic species are those of resident birds.

Okinawa rail (*Gallirallus okinawae*) (Photo: MOEJ)



Okinawa woodpecker (*Sapheopipo noguchii*) (Photo: MOEJ)

Table 2-17: Globally threatened species of birds inhabiting or visiting the four regions containing the nominated property

Species	Distribution	IUCN	MOEJ	EDGE rank	Migratory status*1
Okinawa woodpecker (*Sapheopipo noguchii**2)	Northern part of Okinawa Island	CR	CR	–	Rb
Okinawa rail (*Gallirallus okinawae**3)	Northern part of Okinawa Island	EN	CR	409	Rb
Amami woodcock (*Scolopax mira*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island	VU	VU	586	Rb*4
Amami jay (*Garrulus lidthi*)	Amami-Oshima Island	VU	–	620	Rb
Spoon-billed sandpiper (*Eurynorhynchus pygmeus*)	Amami-Oshima Island, Iriomote Island	CR	CR	–	Pm/Wv
Black-faced spponbill (*Platalea minor*)	Amami-Oshima Island, Tokunoshima Island, Iriomote Island	EN	EN	–	Wv
Japanese night heron (*Gorsachius goisagi*)	Amami-Oshima Island, northern part of Okinawa Island, Iriomote Island	EN	VU	–	Wv/Pm
Far Eastern curlew (*Numenius madagascariensis*)	Amami-Oshima Island, Tokunoshima Island, Iriomote Island	EN	VU	–	Wv
Great knot (*Calidris tenuirostris*)	Amami-Oshima Island, Tokunoshima Island, Iriomote Island	EN	–	–	Pm
Saunders's gull (*Larus saundersi*)	Amami-Oshima Island, Tokunoshima Island, Iriomote Island	VU	VU	–	Wv
Common pochard (*Aythya ferina*)	Amami-Oshima Island, Tokunoshima Island, Iriomote Island	VU	–	–	Wv
Chinese egret (*Egretta eulophotes*)	Amami-Oshima Island, Iriomote Island	VU	–	–	Pm

*1: Migratory status: Rb = resident birds (which inhabits the area throughout the year); Wv = winter visitor (which overwinters in the area); Pm = passage migrant (which visits the area on the way of migrating between breeding and wintering grounds). The migratory status is assessed for the whole Central and South Ryukyus and does not necessarily correspond to each island.

*2: Following Ornithological Society of Japan (2012), *Sapheopipo noguchii* is provided as the scientific name of the Okinawa woodpecker but *Dendrocopos noguchii* (Hoyo and Collar 2014) is used on the IUCN Red List.

*3: Likewise, *Gallirallus okinawae* is provided as the scientific name but *Hypotaenidia okinawae* (Hoyo and Collar 2014) is used on the IUCN Red List.

*4: The Amami woodcock, which has been confirmed to be breeding in the Amami-Oshima Island and its nearby islands as well as in the Tokunoshima Island, visits the Kikai Island, the Okinoerabu Island, the Okinawa Island, and the Kerama Islands in winter.

Amami jay (*Garrulus lidthi*) (Photo: MOEJ)

Amami woodcock (*Scolopax mira*) (Photo: MOEJ)

2.a.2.2.3. Terrestrial reptiles

A total of 72 indigenous species (82 species and subspecies) of terrestrial reptiles from 15 families and two orders are distributed across Japan. The nominated property is home to 36 species (38 species and subspecies) or 50% of the national total (Tables 2-6 and 2-18), serving as a major habitat for terrestrial reptiles in Japan.

Table 2-18: Numbers of indigenous species of terrestrial reptiles in the nominated property

(The numbers in the parentheses include subspecies)	Nominated property	Component parts			
		Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Testudines					
Geoemydidae	3	0	0	1	2
Squamata					
Lacertilia					
Eublepharidae	2	0	1	1	0
Gekkonidae	4	3	3	3	2
Agamidae	1 (2)	1	1	1	1
Scincidae	7	3	3	3	3
Lacertidae	2	1	1	1	1
Serpentes					
Typhlopidae	1	1	1	1	1
Pareatidae	1	0	0	0	1
Xenodermatidae	2	1	1	1	1
Colubridae	8	3	3	3	5
Elapidae	2 (3)	1	1	1	1
Viperidae	3	2	2	2	1
Total	36 (38)	16	17	18	19

The numbers are based on Herpetological Society of Japan (2015).

The nominated property is very rich in endemic species of terrestrial reptiles. Out of the total 36 species of terrestrial reptiles distributed in the nominated property, 23 species (64%) are endemic. As those terrestrial reptiles are under an ongoing process of differentiation and speciation among different islands, the nominated property hosts extremely rich endemism with a total of 33 species and subspecies (87%) endemic to the nominated property (Table 2-18).

Among those distributed in the nominated property, five species (14%) are globally threatened species listed on the IUCN Red List (2016), four categorized as EN and one as VU (Table 2-19). Meanwhile, a total of 13 species and subspecies (34%) are listed as threatened on the MOEJ Red List (2015), one species categorized as EN and 12 species and subspecies as VU (Tables 2-19 and 2-20). Many of those threatened species primarily inhabit relatively moist evergreen broadleaved forests (Ota 2000), and such environments are preserved in good conditions in the nominated property.

Table 2-19: Numbers of endemic and threatened species of terrestrial reptiles in the nominated property

(The numbers in the parentheses include subspecies)	Nominated property	Component parts			
		Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Number of indigenous species	36 (38)	16	17	18	19
Number of endemic species	23 (33)	10 (11)	11 (12)	13 (14)	8 (16)
Rate of endemic species (%)	64 (87)	63 (69)	65 (71)	72 (78)	42 (84)
Number of species listed on IUCN-RL (2016)	5	1	2	3	2
Rate of species listed on IUCN-RL (%)	14	6	12	17	11
Number of species listed on MOEJ-RL (2015)	13	3	4	6	3
Rate of species listed on MOEJ-RL (%)	34	19	24	33	16

Table 2-20: Globally threatened species of terrestrial reptiles inhabiting the nominated property

Threatened species	Distribution	IUCN	MOEJ
Asian brown pond turtle (*Mauremys mutica*)	Iriomote Island	EN	–
Yellow-margined box turtle (*Cuora flavomarginata*)	Iriomote Island	EN	VU*1
Ryukyu black-breasted leaf turtle (*Geoemyda japonica*)	Northern part of Okinawa Island	EN	VU
Kuroiwa's ground gecko (*Goniurosaurus kuroiwae*)	Northern part of Okinawa Island	EN*2	VU*3
Ryukyu odd-scaled snake (*Achalinus werneri*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island	VU	–
Banded ground gecko (*Goniurosaurus splendens*)	Tokunoshima Island	EN*2	EN

*1: One of its subspecies, the Yaeyama yellow-margined box turtle (*C. flavomarginata evelynae*) is categorized as VU.
*2: The banded ground gecko (*G. splendens*), which is treated as a separate species in Honda et al. (2014), is included.
*3: One of its subspecies (*G. kuroiwae kuroiwae*) is categorized as VU. Other subspecies inhabiting some islands near the Okinawa Island, other than the nominated property—i.e., *G. k. toyamai* and *G. k. yamashinae* are categorized as CR, and *G. k. orientalis* as EN.

2.a.2.2.4. Amphibians

A total of 71 species (76 species and subspecies) of amphibians from nine families and two orders have been recorded as inhabiting Japan (calculated based on Herpetological Society of Japan (2015)). The nominated property is home to 21 species (22 species and subspecies) or 30% of the national total. Those belonging to the order Anura include one species from the family Hylidae, 11 species from the family Ranidae, two species from the family Dicroglossidae, four species (five species and subspecies) from the family Rhacophoridae, and one species from the family Microhylidae, together accounting for more than half (54%) of those indigenous to Japan, i.e., 39 species from seven families within the order Anura. Meanwhile, those belonging to the order Caudata include only two species from the family Salamandridae and none from the family Hynobiidae, which has an extremely large number of species on the main islands of Japan (Table 2-21).

Because of the scarcity of inland water bodies, small islands in general do not provide a desirable habitat for amphibians, which require sizable water bodies to breed (in egg-laying and larval stages). However, the Central and South Ryukyus harbor a rich amphibian fauna thanks to the formation and presence of moist, subtropical rainforests, which is attributable to the influence of the monsoon climate, typhoons, ocean currents, and other unique conditions not seen in other regions located at the same latitude.

Table 2-21: Numbers of indigenous species of amphibians found in the nominated property

(The numbers in the parentheses include subspecies)	Nominated property	Component parts			
		Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Caudata					
Salamandridae	2	2	1	2	0
Anura					
Hylidae	1	1	1	1	0
Ranidae	11	4	2	4	3
Dicroglossidae	2	0	0	1	1
Rhacophoridae	4 (5)	2	2	2	3
Microhylidae	1	1	1	1	1
Total	21 (22)	10	7	11	8

The numbers are based on the list of amphibians and reptiles of Japan (Herpetological Society of Japan 2015).

Amphibians inhabiting the nominated property show extremely high endemism with 18 species (19 species and subspecies) or 86% of the total species being endemic to the nominated property (Table 2-22).

Out of the total 21 species (22 species and subspecies) of amphibians inhabiting the nominated property, 12 species (55%) are listed as EN on the IUCN Red List (2016). Three of them are also classified as EDGE species by the Zoological Society of London (Table 2-23). Meanwhile, 10 species (43%) are listed on the MOEJ Red List (2015), six categorized as EN and four as VU. As is the case with reptiles, the nominated property is serving as a major habitat for those threatened species of amphibians, as it preserves evergreen broadleaved forests with relatively moist floors, an ideal habitat for most of the species (Ota 2000).

Table 2-22: Numbers of endemic and threatened species of amphibians in the nominated property

(The numbers in the parentheses include subspecies)	Nominated property	Component parts			
		Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Number of indigenous species	21 (22)	10	7	11	8
Number of endemic species	18 (19)	9	6	10	5
Rate of endemic species (%)	86 (8)	90	86	91	63
Number of species listed on IUCN-RL (2016)	12	5	2	6	3
Rate of species listed on IUCN-RL (%)	55	45	25	50	38
Number of species listed on MOEJ-RL (2015)	10	4	2	5	2
Rate of species listed on MOEJ-RL (%)	43	36	25	42	25

Table 2-23: Globally threatened species of amphibians inhabiting the nominated property

Threatened species	Distribution	IUCN	MOEJ	EDGE rank
Anderson's crocodile newt (*Echinotriton andersoni*)	Amami-Oshima Island, Tokunoshima Island, northern part of Okinawa Island	EN	VU	263
Sword-tailed newt (*Cynops ensicauda*)	Amami-Oshima Island, northern part of Okinawa Island	EN	–	313
Amami tip-nosed frog (*Odorrana amamiensis*)	Amami-Oshima Island, Tokunoshima Island	EN	VU	–
Amami Ishikawa's frog (*Odorrana splendida*)	Amami-Oshima Island	EN	EN	–
Greater tip-nosed frog (*Odorrana supranarina*)	Iriomote Island	EN	–	–
Okinawa Ishikawa's frog (*Odorrana ishikawae*)	Northern part of Okinawa Island	EN	EN	–
Utsunomiya's tip-nosed frog (*Odorrana utsunomiyaorum*)	Iriomote Island	EN	EN	–
Okinawa tip-nosed frog (*Odorrana narina*)	Northern part of Okinawa Island	EN	VU	–
Otton frog (*Babina subaspera*)	Amami-Oshima Island	EN	EN	–
Holst's frog (*Babina holsti*)	Northern part of Okinawa Island	EN	EN	–
Yaeyama harpist frog (*Nidirana okinavana**)	Iriomote Island	EN	VU	–
Namie's frog (*Limnonectes namiyei*)	Northern part of Okinawa Island	EN	EN	291

*: On the IUCN Red List, the scientific name of the Yaeyama harpist frog is given as "*Babina okinavana*" and it is stated that the species also inhabits Taiwan. However, it is treated as "*Nidirana okinavana*" that belongs to a separate genus in Herpetological Society of Japan (2015).

Herpetofauna of the nominated property

Ryukyu black-breasted leaf turtle (*Geoemyda japonica*)
(Photo: MOEJ)

Amami Ishikawa's frog (*Odorrana splendida*)
(Photo: MOEJ)

Yellow-margined box turtle (*Cuora flavomarginata*)
(Photo: JWRC)

Namie's frog (*Limnonectes namiyei*) (Photo: MOEJ)

Kuroiwa's ground gecko (*Goniurosaurus kuroiwae*)
(Photo: MOEJ)

Anderson's crocodile newt (*Echinotriton andersoni*)
(Photo: MOEJ)

2.a.2.2.5. Inland water fish

A total of 567 indigenous species of fish from 99 families and 25 orders have been recorded as inhabiting the inland waters of the four islands containing the nominated property (Yoshigo 2014). However, more than half of these species are marine vagrants, which accidentally entered the area. Those include the following (Table 2-24):

- Freshwater fish, which are confined to freshwater throughout their lives: nine species (1%)
- Diadromous fish, which regularly migrate between rivers and the sea during certain periods of their life cycle: 53 species (9%)
- Brackish water fish, which spend their lives in and around brackish water bodies except for the planktonic stage: 130 species (23%)
- Peripheral freshwater fish, which mainly inhabit the sea but spend part of their lives in inland waters: 75 species (13%)
- Marine vagrants, which typically inhabit the sea but accidentally enter freshwater habitats: 301 species (53%)

Thus, it is considered that a total of 267 species from 57 families and 18 orders, which exclude marine vagrants, represent the true ichthyofauna of the inland waters of the four islands containing the nominated property.

Table 2-24: Number of indigenous species of fish in the inland waters of the four islands containing the nominated property (classified by life form)*

	Four islands containing the nominated property	Amami-Oshima Island	Tokunoshima Island*2	Okinawa Island	Iriomote Island
Freshwater fish	9	7	2	9	5
Diadromous fish	53	38	14	44	48
Brackish water fish	130	68	18	85	120
Peripheral freshwater fish	75	41	0	63	73
Marine vagrants	301	67	4	177	226
Total	568	221	38	378	472

The numbers are based on Yoshigo (2014).
*: The species inhabiting the Tokunoshima Island have not been fully surveyed and considered as lacking sufficient information.

Only nine species of freshwater fish inhabit the four islands containing the nominated property. In contrast to the main islands of Japan, Taiwan, the Philippines, and Indonesia where large populations of freshwater fish—such as those belonging to the families of Cyprinidae, Siluridae, and Cobitidae—are found in inland waters, the nominated property is characteristic in that while it has few such species, many species of brackish water and marine fish are found in freshwater bodies (Table 2-24).

One reason behind the formation of this unique ichthyofauna of inland waters is the characteristics of rivers in the nominated property, which are mostly short and steep. When swollen, those rivers flow rapidly in their entire length, making it difficult for freshwater fish species—those that do not tolerate any salinity—to inhabit. Also, in the Central and South Ryukyus, rivers with tidal areas forested by mangroves as well as seagrass beds and coral reefs in adjacent sea areas are preserved in relatively good conditions, providing secure habitats for many species of diadromous fish, peripheral freshwater fish, brackish water fish, and so forth (Tachihara 2003).

Although diadromous fish and brackish water fish can disperse through the sea, they require freshwater in certain stages or periods of their life cycle. Therefore, they are able to inhabit only those islands with sizable rivers. It is assumed that the smaller the number of inhabitable islands, the greater is the distance between habitats and the more likely are those species to be geographically isolated from one another (Mukai 2010). In the four islands containing the nominated property, a total of 14 endemic species and subspecies are distributed, namely, the Ryukyu ayu-fish (*Plecoglossus altivelis ryukyuensis*), one species each from the genera *Carassius* and *Monopterus*, and 11 species of gobies (Sakai et al. 2001; Nakabo (ed.) 2013).

Among the inland water fish inhabiting the four islands containing the nominated property, six species and subspecies are listed on the IUCN Red List (2016) as globally threatened species (Tables 2-25 and 2-26). Meanwhile, a total of 64 species and subspecies—37 species and subspecies categorized as CR, 14 species as EN, and 13 species as VU—are listed on the MOEJ Red List (2015), accounting for 38% of the total 167 threatened species of inland water fish in Japan (Tables 2-6 and 2-25). In particular, 54% of those categorized as CR inhabit the four islands containing the nominated property, making those islands home to large populations of many rare species of inland water fish.

Swamp eel (*Monopterus* sp.) (Photo: MOEJ)

Freshwater goby (*Rhinogobius* sp. BB) (Photo: MOEJ)

Table 2-25: Numbers of endemic and threatened species of inland water fish in the four islands containing the nominated property*1

(The numbers in the parentheses include subspecies)	Four islands containing the nominated property	Amami-Oshima Island	Tokunoshima Island	Okinawa Island	Iriomote Island
Number of indigenous species	267	154	34	201	246
Number of endemic species*2	13 (14)	9 (10)	2	10	9
Rate of endemic species (%)	5	6	6	5	4
Number of species listed on IUCN-RL (2016)*2	6	5	1	4	5
Number of species listed on MOEJ-RL (2015)	64	35	3	38	58
Rate of species listed on MOEJ-RL (%)	24	23	9	19	24

*1: Marine vagrants are excluded.
*2: Assessments for the IUCN Red List are conducted at a species level. However, the Ryukyu ayu-fish, which has been assessed at a subspecies level, is counted as one species because there are no other subspecies belonging to the same species in the nominated property.

Table 2-26: Globally threatened species of inland water fish inhabiting the four islands containing the nominated property

Threatened species	Distribution	IUCN	MOEJ	Life cycle*1
Japanese eel (*Anguilla japonica*)	Amami-Oshima Island, Tokunoshima Island, Okinawa Island, Iriomote Island	EN	EN	D
Ryukyu ayu-fish (*Plecoglossus altivelis ryukyuensis*)	Amami-Oshima Island, Okinawa Island*2	EN	CR	D
Spotted seahorse (*Hippocampus kuda*)	Amami-Oshima Island, Okinawa Island, Iriomote Island, Ishigaki Island	VU	–	B
Okinawa seabream (*Acanthopagrus sivicolus*)	Amami-Oshima Island, Okinawa Island, Iriomote Island	VU	–	P
Stiphodon imperiorientis	Amami-Oshima Island, Okinawa Island	VU	CR	D
Pink whipray (*Himantura fai*)	Iriomote Island	VU		P

*1: D = diadromous fish, B = brackish water fish, P = peripheral freshwater fish
*2: The distribution on the Okinawa Island is a result of the reintroduction of the species from the Amami-Oshima Island.

Ryukyu ayu-fish (*Plecoglossus altivelis ryukyuensis*)
(Photo: MOEJ)

2.a.2.2.6. Insects

Azuma et al. (eds.) (2002) provides a comprehensive view of the insect fauna of the Central and South Ryukyus. However, a number of species and subspecies have been described and recorded after its publication. There are some insect groups that are yet to be studied taxonomically, while some areas remain unsurveyed and offer only limited information. Thus, the number of insect species in the nominated property is expected to increase as relevant studies make progress.

A total of 6,148 species (6,447 species and subspecies) of insects inhabit the four islands containing the nominated property[4] (Table 2-27). Among the insect fauna, the order Coleoptera (beetles) has the largest number of indigenous species totaling 1,924 species (2,122 species and subspecies), followed by the order Lepidoptera (moths and butterflies) at 1,221 species (1,239 species and subspecies), together accounting for roughly half of the total indigenous species (Table 2-27).

Based on a survey on the distribution of some 7,500 species of insects in the Central and South Ryukyus, Azuma (2013) showed that those of Indomalayan origin are the largest group accounting for 39.8%, followed by those indigenous to the Central and South Ryukyus at 26.7% and those indigenous to Japan and found also in the main islands at 13.2%, while those of Palearctic origin account for only 5.5%. This tendency is particularly conspicuous in butterflies as well as in beetles (Kohama 2015).

Yanbaru long-armed scarab beetle (*Cheirotonus jambar*) (Photo: MOEJ)

Stag beetle (*Neolucanus okinawanus*) (Photo: MOEJ)

4 Among the species listed in Azuma et al. (eds.) (2002), those for which the definition of the geographic area of distribution does not provide the names of islands (simply stating the Amami Island Group, the Okinawa Island Group, the Yaeyama Island Group, etc.) are excluded. Therefore, the actual numbers of species are greater than those listed on Table 2-27.

Table 2-27: Numbers of insect species on the four islands containing the nominated property*1

(The numbers in the parentheses include subspecies)	Four islands containing the nominated property	Amami-Oshima Island	Tokunoshima Island*2	Okinawa Island	Iriomote Island
Archaeognatha	4	4	0	3	1
Thysanura	7	4	0	6	2
Ephemeroptera	14	6	0	11	9
Odonata	84 (92)	46 (48)	35	49 (50)	64 (66)
Plecoptera	15	5	4	10	4
Blattaria	33 (35)	17	9	17	25
Mantodea	7	4	5	7	7
Isoptera	14 (17)	5 (6)	2	10 (11)	10 (12)
Orthoptera	149 (153)	94	51	99 (101)	95 (96)
Phasmida	10	6	4	6	6
Dermaptera	11	4	0	8	4
Psocoptera	10 (16)	7 (9)	0	5 (8)	5 (7)
Mallophaga	3	3	0	0	0
Anoplura	2	2	0	2	2
Thysanoptera	58 (70)	23 (25)	0	43 (52)	27 (31)
Homoptera	467 (476)	223 (224)	86 (88)	359 (363)	262 (267)
Heteroptera	384 (389)	195 (196)	97	278 (282)	280 (283)
Neuroptera	56	17	4	35	28
Coleoptera	1,924 (2,122)	1,085 (1,119)	372 (385)	1,041 (1,073)	869 (899)
Strepsiptera	8	3	1	2	7
Hymenoptera	752 (785)	410 (414)	138 (140)	455 (460)	313 (316)
Mecoptera	1	1	0	0	0
Diptera	872 (874)	436 (438)	50	545	295
Trichoptera	41	15	1	31	5
Lepidoptera	1,221 (1,239)	637 (640)	150 (151)	802 (804)	747 (751)
Total	6,148 (6,447)	3,252 (3,304)	1,009 (1,027)	3,824 (3,887)	3,067 (3,123)

*1: Among those listed in Azuma et al. (eds.) (2002), three orders (Collembola, Diplura, and Protura) in the class Entognatha are excluded. Data from other sources were used to supplement data on the distribution of those taxa that have been subjected to major reclassification (e.g., Odonata) and that of the alien species. The numbers provided above do not include those for which the definition of the geographic area of distribution does not include the names of islands (simply stating the Amami Island Group, the Okinawa Island Group, the Yaeyama Islands, etc.). Therefore, the actual numbers of species are greater than those listed above.

*2: The species inhabiting the Tokunoshima Island have not been fully surveyed and considered as lacking sufficient information.

The four islands containing the nominated property are home to a total of 1,602 endemic insect species, accounting for 26% of the total insect species inhabiting the islands. Those insect species are under an ongoing process of differentiation and speciation among different islands, resulting in the significant presence of subspecies endemic to each island, which is one of the characteristics of the Central and South Ryukyus. The number of species and subspecies totals 1,997, accounting 31% of total species and subspecies (Table 2-28).

Table 2-28: Numbers of endemic and threatened insect species on the four islands containing the nominated property*1

(The numbers in the parentheses include subspecies)	Four islands containing the nominated property	Amami-Oshima Island	Tokunoshima Island	Okinawa Island	Iriomote Island
Number of indigenous species	6,148 (6,447)	3,252 (3,304)	1,009 (1,027)	3,824 (3,887)	3,067 (3,123)
Number of endemic species	1,602 (1,997)	693 (836)	173 (242)	740 (906)	647 (789)
Rate of endemic species (%)	26 (31)	21 (25)	17 (24)	19 (23)	21 (25)
Number of species listed on IUCN-RL (2016)*2	19	4	2	9	7
Number of species listed on the MOEJ-RL (2015)*3	36	19	13	18	18

*1: Among the species listed in Azuma et al. (eds.) (2002), those for which the definition of the geographic area of distribution does not include the names of islands (simply stating the Amami Island Group, the Okinawa Island Group, the Yaeyama Islands, etc.) are excluded. Therefore, the actual numbers of species are greater than those listed above.

*2: Assessments for the IUCN Red List are, in principle, conducted at a species level. However, no species-level assessment data are available for some dragonflies and damselflies, as they have been assessed only at a subspecies level. Therefore, the numbers of species shown above are the numbers of subspecies. Meanwhile, the assessment of *Rhipidolestes okinawanus* was conducted in 1996 and the geographic area of distribution is simply defined as "Nansei Shoto." Therefore, it is believed that this includes three species and two subspecies, which were subdivided from *Rhipidolestes okinawanus* in and after 2005.

*3: The numbers represent the sum of threatened species categorized as CR, EN, and VU. Assessments for the MOEJ Red List are, in principle, conducted at a subspecies level.

Six insect species—the Yanbaru long-armed scarab beetle (*Cheirotonus jambar*) and five species of stream dragonflies and damselflies—are listed on the IUCN Red List (2016) and the number goes up to 19 when those assessed at a subspecies level are included[5] (Tables 2-28 and 2-29). Meanwhile, the MOEJ Red List (2015), for which some 32,000 species (including subspecies) of insects in Japan have been assessed, lists 358 species (approximately 1%) as threatened (Table 2-6). Among those inhabiting the four islands containing the nominated property, 36 species and subspecies of insects are designated as threatened (Tables 2-6 and 2-28), meaning that those islands, which together represent only 0.4% of the total land area of Japan, are home to 10% of the national total.

Matrona basilaris japonica (Photo: MOEJ)

5 Assessments for the IUCN Red List are conducted at a species level. However, no species-level assessment data are available for some dragonflies and damselflies (e.g., *Chlorogomphus brunneus brunneus*, *Coeliccia ryukyuensis ryukyuensis*, *C. ryukyuensis amamii*), as they have been assessed only at a subspecies level, while the results of species- and subspecies-level assessments are inconsistent for some others (e.g., the species *Asiagomphus amamiensis* is categorized as NT, but both of its known subspecies, *A. amamiensis amamiensis* and *A. amamiensis okinawanus*, are categorized as EN).

Table 2-29: Globally threatned species of insects inhabiting the four islands containing the nominated property

Threatened species	Distribution	IUCN	MOEJ	Remarks
Chlorogomphus brunneus brunneus	Okinawa Island	EN	–	*2
Matrona basilaris japonica	Amami-Oshima Island, Tokunoshima Island, Okinawa Island	EN	–	*1
Rhinocypha uenoi	Iriomote Island	EN	–	
Rhipidolestes okinawanus	Amami-Oshima Island, Tokunoshima Island, Okinawa Island, Iriomote Island	EN	–	*3
Coeliccia flavicauda masakii	Iriomote Island	EN	–	*1
C. ryukyuensis amamii	Amami-Oshima Island, Tokunoshima Island	EN	–	*2
C. ryukyuensis ryukyuensis	Okinawa Island	EN	–	*2
Asiagomphus amamiensis amamiensis	Amami-Oshima Island	EN	–	*1
A. amamiensis okinawanus	Okinawa Island	EN	–	*1
A. yayeyamensis	Iriomote Island	EN	–	
Stylogomphus ryukyuanus asatoi	Okinawa Island	EN	–	*2
S. shirozui watanabei	Iriomote Island	EN	–	*2
Chlorogomphus okinawensis	Okinawa Island	EN	VU	
Planaeschna ishigakiana ishigakiana	Iriomote Island	EN	–	*2
P. ishigakiana nagaminei	Amami-Oshima Island	EN	–	*2
P. risi sakishimana	Iriomote Island	EN	–	*1
Hemicordulia mindana nipponica	Iriomote Island	EN	VU	*1
Macromia kubokaiya	Okinawa Island	EN	–	
Cheirotonus jambar	Okinawa Island	EN	EN	

*1: Assessed at a subspecies level for the IUCN Red List (categorized as LC at a species level).
*2: Assessed only at a subspecies level for the IUCN Red List.
*3: The distribution is simply defined as "Nansei Shoto" and the assessment was conducted in 1996. It may include the following species and subspecies that were subdivided from *Rhipidolestes okinawanus* in and after 2005: *Rhipidolestes aculeatus*, *R. shozoi*, *R. amamiensis amamiensis*, and *R. amamiensis tokunoshimensis*.

Damselfly (*Rhinocypha uenoi*) (Photo: MOEJ)

2.a.2.2.7. Inland water decapod crustaceans

A total of 73 indigenous species of inland water decapod crustaceans have been recorded in Japan (Hayashi 2011). The four islands containing the nominated property harbor 47 species of them, accounting for 64% of the national total (calculated based on Kagoshima University (2014)) (Tables 2-6 and 2-30).

Table 2-30: Numbers of indigenous species of inland water decapod crustaceans in the four islands containing the nominated property

	Four islands containing the nominated property	Amami-Oshima Island	Tokunoshima Island	Okinawa Island	Iriomote Island
Atyidae	18	6	6	13	14
Palaemonidae	14	2	2	11	11
Alpheidae	1	0	0	1	0
Potamidae	10	3	3	5	3
Varunidae	4	3	1	3	3
Total	47	14	12	33	31

The numbers are based on Kagoshima University (2014).

Out of the total of 47 indigenous species of inland water decapod crustaceans found in the four islands containing the nominated property, 15 species or 32% are endemic. In particular, those of the family Potamidae are endemic, which inhabit freshwater and land, are unable to disperse through the sea because their eggs and larvae cannot survive in seawater (Shokita 1996), and thus all of the 10 species (100%) belonging to this family are endemic. Five of the Potamidae species are listed as threatened on the MOEJ Red List (2015) (Tables 2-6 and 2-31).

Table 2-31: Numbers of endemic and threatened species of inland decapod crustaceans in the four islands containing the nominated property

(Potamidae species in the parentheses)	Four islands containing the nominated property	Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
Number of indigenous species	47 (10)	14 (3)	12 (3)	33 (5)	31 (3)
Number of endemic species	15 (10)	3 (3)	3 (3)	6 (5)	7 (3)
Rate of endemic species (%)	32 (100)	21 (100)	25 (100)	18 (100)	23 (100)
Number of species listed on IUCN-RL (2016)	0	0	0	0	0
Number of species listed on MOEJ-RL (2015)*	5	1	1	4	0
Rate of species listed on MOEJ-RL (%)	11	7	8	12	0

2.a.3. Geological history and speciation

2.a.3.1. Geological history

The current landform of the nominated property is considered to have been developed through the processes described below (Figure 2-16).

1) Period when it was part of the Eurasian Continent: Before middle Micene (before 11.63 Ma)

During the Cretaceous and Palaeogene, the current Ryukyu Arc was located at the eastern edge of the Eurasian Continent and formed a part of the continent. The subduction of the oceanic Pacific plate beneath the Eurasian plate from the southeast caused the formation of accretionary complex (Machida et al. 2001) and metamorphic rocks and the intrusion of granite (Kawano and Nishimura 2010; Nishiyama 2010). Then, in the Eocene, the spreading of the Philippine Basin eventually brought the Philippine Sea plate and the Eurasian plate together. Yet, no plate subduction had occurred at that time and crustal movements are considered to have been inactive (Machida et al. 2001).

2) Formation of Island Arc—Separation from Continent: late Micene to early Pleistocene (11.63 to around 2 Ma)

During this period, a series of large-scale crustal movements occurred, which transformed an area on the Continent's margin into an island arc. First, around 6 Ma or 10 Ma, the Philippine Sea plate, which had made no major movements until then, began to subduct beneath the Ryukyu Trench (Kamata and Kodama 1993; Machida et al. 2001). This subduction caused the Okinawa Trough to start opening between the late Miocene and the early Pleistocene, leading to the formation of the Ryukyu Arc (Miki et al. 1990; Kamata and Kodama 1993; Machida et al. 2001; Iryu and Matsuda 2010; Gungor et al. 2012; Osozawa et al. 2012; Gallagher et al. 2015). It is considered that in this process, the Tokara Strait and the Kerama Gap were formed and the Central Ryukyus isolated. Furthermore, it is supposed that the Yonaguni Strait was created, separating the South Ryukyu from Taiwan. However, there are a number of different theories, primarily from biogeographical perspectives (Kizaki and Oshiro 1977, 1980; Ota 1998, 2002, 2005, 2009, 2012; Ota and Takahashi 2006; Koizumi et al. 2014; Yoshikawa et al. 2016; Okamoto 2017), as to when and in what order these individual events occurred, which have yet to be clarified sufficiently.

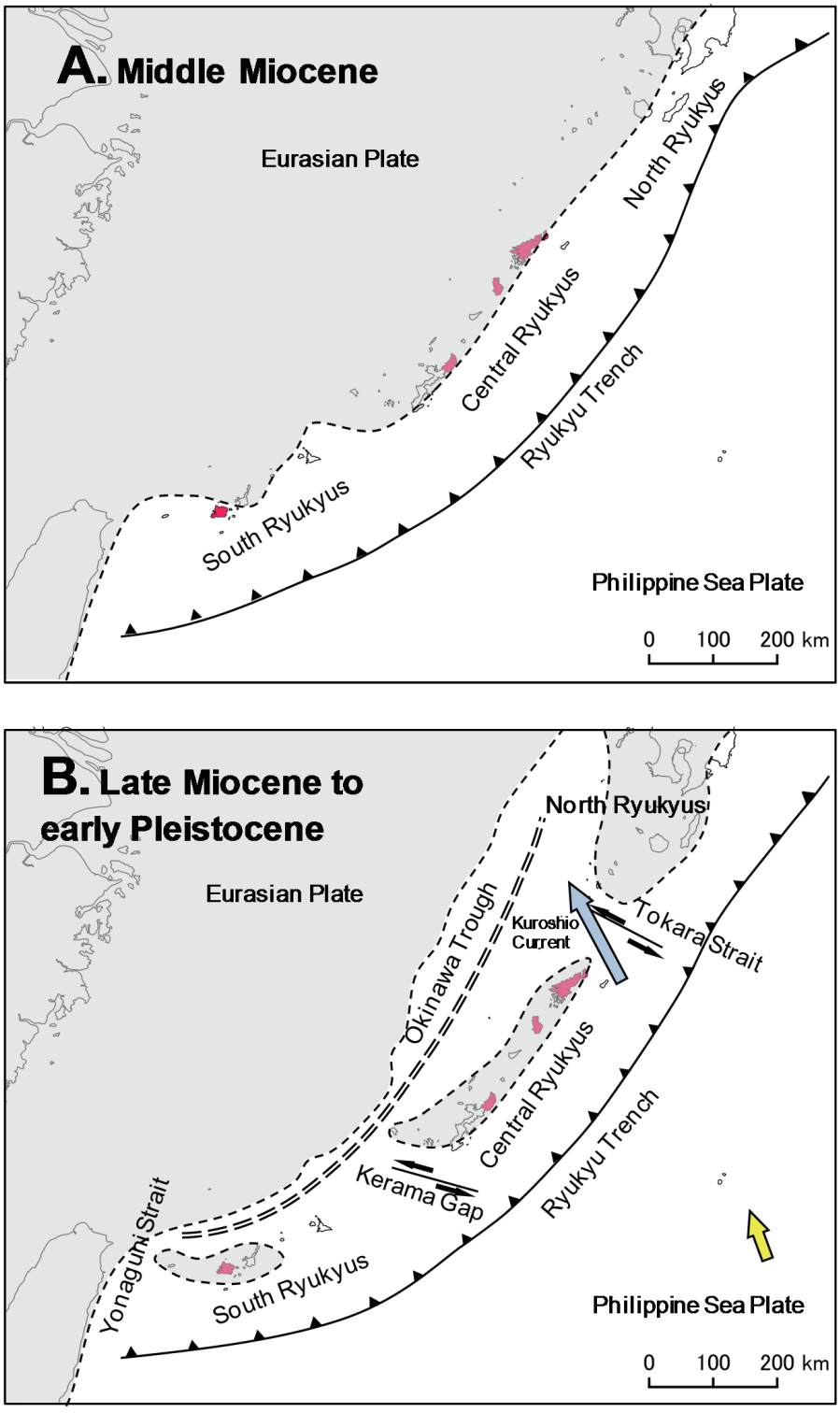
3) Period of repetitive conjunctions and separations of neighbouring islands due to changes in sea surface: early Pleistocene to late Pleistocene (around 2 million to 1.2 thousand years ago)

A group of neighbouring islands that constitute the Ryukyu Chain were repeatedly joined together and separated from each other during the Pleistocene due to sea surface changes associated with the glacial-interglacial cycles of the period.

At around 1.8 Ma, the Kuroshio Current began to flow into the back arc side of the Ryukyu Arc through the

Yonaguni Strait (Iryu et al. 2006) and then into the Pacific Ocean through the Tokara Strait. Consequently, the Central and South Ryukyus became isolated from Taiwan and the North Ryukyus by the fast-flowing Kuroshio Current. At the same time, the effect of the warm Kuroshio Current, as well as the discontinuation of the sedimentation of clastics from the continent as a result of the opening of the Okinawa Trough, resulted in the formation coral reefs around many islands of the Central and South Ryukyus from around 1.71 to 1.39 Ma (Iryu et al. 2006; Saito 2009; Iryu and Matsuda 2010).

Ria coast of the Oshima Strait, Amami-Ohisma Island (Photo: JWRC)


A. Middle Miocene
Eurasian Plate
North Ryukyus
Central Ryukyus
Ryukyu Trench
South Ryukyus
Philippine Sea Plate
0 100 200 km
B. Late Miocene to early Pleistocene
Eurasian Plate
North Ryukyus
Okinawa Trough
Kuroshio Current
Tokara Strait
Central Ryukyus
Ryukyu Trench
Kerama Gap
Yonaguni Strait
South Ryukyus
Philippine Sea Plate
0 100 200 km
Legend
Direction of motion of Philippin sea plate
Trough axis
Coastal line in a glacial period
Nominated property
Plate boundary
Slip fault
Direction of Kuroshio current

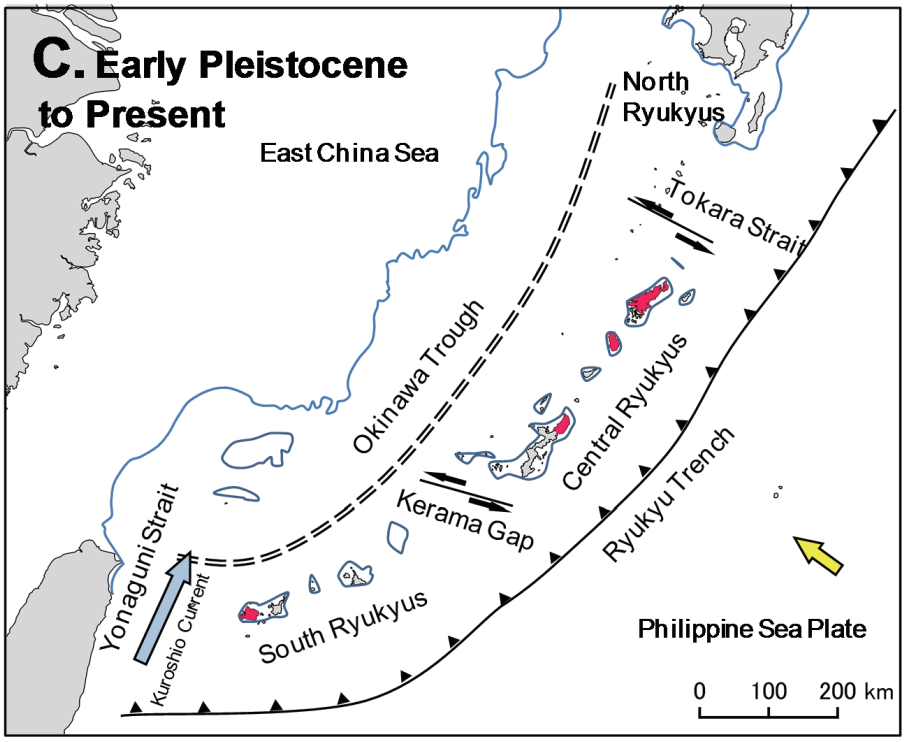


Figure 2-16: Historical development of Ryukyu Arc

The Figure was prepared by referring to the following: Koba, 1992; Kamata and Kodama, 1994; Park et al., 1998; Kamata, 1999; Machida et al., 2001; Inoue, 2007; Sato et al., 2009; Hase, 2010; Nishiyama, 2010; Kawano and Nishimura, 2010; Sakai, 2010 a, b; Takeuchi, 2010; Isozaki et al., 2011; Iryu and Matsuda, 2011; Gungor et al., 2012; Gallagher et al., 2015, and Iryu's personal communications 2016.

A: Before middle Miocene (Before 11.63 Ma)
From the Cretaceous to early Miocene, the Ryukyu Arc was located on the eastern margin of the Eurasian Continent and formed a part of the continent. The subduction of the plate led to the formation of accretionary complex and metamorphic rocks, as well as intrusion of granite providing the bedrock of the Ryukyu Arc. The current Ryukyu Arc was located on the eastern margin of the continent. While the North and Central Ryukyus were subaerial, the South Ryukyus were partly subaerial and surrounded by shallow water.

B: Late Miocene to early Pleistocene (around 11.63 to 2 Ma)
The Philippine Sea plate moved north-northwest and began to subduct in the Ryukyu Trench. This opened the Okinawa Trough and resulted in the formation of the island arc. Furthermore, the Tokara Strait, Kerama Gap, and Yonaguni Strait formed, and the Central and South Ryukyus were separated from the continent. The Yonaguni Strait was not as wide as it would later become and the Kuroshio Current began to flow into the back arc side through the Tokara Strait around 4.0 Ma or later.

C: Early Pleistocene to Present (around 2 Ma onwards)
The Philippine Sea plate changed its direction to the northwest. Expansion of the Yonaguni Strait allowed the Kuroshio Current to flow into the back arc side. As a result, coral reefs grew around a number of Central and South Ryukyu islands starting from around1.71 to 1.39 Ma.
In addition, the glacial-interglacial cycles caused repetitive sea regressions and transgressions.

2.a.3.2. Geological history and speciation of terrestrial fauna

The Ryukyu Chain is considered to have once been part of the edge of the Eurasian Continent and later divided into the North Ryukyus, Central Ryukyus, and South Ryukyus by channels, straits, etc. The terrestrial biota of the North Ryukyus (Palearctic) is distinctly different from those of the Central and South Ryukyus, which are separated by the Tokara Strait. There is also more than a slight difference in biota between the Central Ryukyus and the South Ryukyus.

The terrestrial biota of the nominated property has two characteristics. The first is the richness of its relict endemic species that have ancestor species once widely distributed across the continent and the mainland of Japan, but which can now be found only on the Ryukyu Chain. Their speciation reflects the nominated property's geological history of being formed as continental islands. There are also the new endemic species that have further speciated after having been isolated on the Ryukyu Chain. The second charcteristic is the difference in the pattern of endemism between the Central Ryukyus and the South Ryukyus on individual islands or island groups. Table 2-32 shows the speciation patterns on Amami-Oshima Island, Tokunoshima Island, and the northern part of Okinawa Island (Central Ryukyus) and on Iriomote Island (South Ryukyus) within the nominated property based on molecular phylogenetic analyses of typical terrestrial species and the distribution of closely-related species.

1) The Central Ryukyus—High relict endemism

(Amami-Oshima Island, Tokunoshima Island, and the northen part of Okinawa Island)

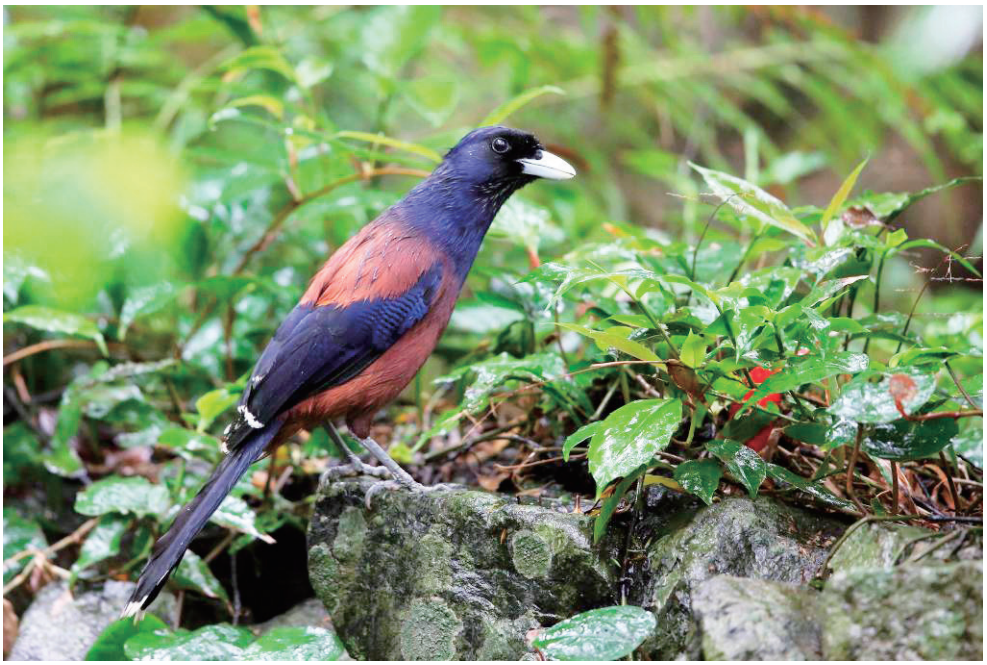
1)-1. Relict endemic species

In view of the results of molecular phylogenetic analyses and the distribution of closely-related species, it is considered that the terrestrial fauna of the Central Ryukyus became isolated from those of the Eurasian Continent, the North Ryukyus, and the South Ryukyus at least by the late Miocene (11.63–5.33 Ma) during the course of the transformation of the continent's eastern periphery into a group of islands, and continued to remain in the isolated state (Okamoto 2017). In the fauna of the Central Ryukyus, some species and their closely-related species, which had initially been distributed on the continent and neighbouring areas, gradually became extinct due to the emergence of new predators and competitors, making the remaining species endemic to the Central Ryukyus. These species are relict endemic species in that they do not have any conspecific or congeneric species in the neighbouring Northern and South Ryukyus, but only in remote places such as the Eurasian Continent. This relict endemism is particularly evident in flightless terrestrial animals. Representative species of this pattern including the Amami rabbit (*Pentalagus furnessi*) on Amami-Oshima and Tokunoshima Islands are listed in Table 2-32.

While most of the listed species became isolated on the Central Ryukyus during the late Miocene, the ground geckoes (*Goniurosaurus*; described below) on Tokunoshima Island, Okinawa Island, and other neighbouring islands and the Ryukyu black-breasted leaf turtle (*Geoemyda japonica*) in the northern part of Okinawa Island have more ancient origins and are considered to have already been separated from their relatives on the continent species due to geographical and environmental reasons in the period from the Palaeocene to the Eocene (56.4–33.9 Ma), before the separation of the Central Ryukyus from the continent

(Honda et al. 2014; Okamoto 2017).

The relict endemism is also seen among avian species with flight ability. Some molecular phylogenetic analyses and morphological analyses have shown that the Amami jay (*Garrulus lidthi*), a species endemic to Amami-Oshima Island, is remotely related to the Eurasian jay (*G. glandarius*) occurring in a vast region from mainland Japan to the Eurasian Continent, and its closest relative is the black-headed jay (*G. lanceolatus*) found in a narrow area around the Himalayas (Kajita et al. 1999). It is considered that the common ancestor of the Amami jay and the black-headed jay had once been distributed in a wider area than today, but in later days, its distribution became limited to Amami-Oshima Island and the Himalayan region for some reason, and the populations that remained and survived in these two regions have evolved in their own way (Kajita et al. 1999). This theory is supported by the fact that the fossils of the Amami jay have been found in a wider area of the Ryukyu Chain (Matsuoka, 2000).



Amami jay (*Garralus lidthi*) (Photo: MOEJ)

Column 2. Amami rabbit (*Pentalagus furnessi*)

The Amami rabbit, a member of the rabbit family (Leporidae), is a monotypic genus endemic to Amami-Oshima Island and Tokunoshima Island. The lack of its closely related species (or genus) seems attributable to its early phylogenetic differentiation. Fossils of the genus *Pentalagus* have also been found in Okinawa Island from the 1.7 to 1.3 Ma and 0.4 Ma strata (Ozawa, 2009).

The subfamily Leporinae has 11 genera in the world, including the Amami rabbit. Matthee et al. (2004) estimates that the Amami rabbit and its allied genera (*Oryctolagus, Bunolagus*, etc.) diverged from each other approximately 9.44 Ma ± 1.15 Ma (Figure 2-17). This is consistent with the palaeogeography explanation that Amami-Oshima Island and Tokunoshima Island had been part of the Eurasian Continent during the middle- to late Miocene, but became separated from the continent in the Pliocene. From a palaeontological point of view, the ancestor of this species is considered to be the fossil species (genus) *Pliopentalagus*, whose fossils were previously found in Eastern Europe but recently in the Eurasian Continent's Yangtze River basin (Tomida and Jin 2002).

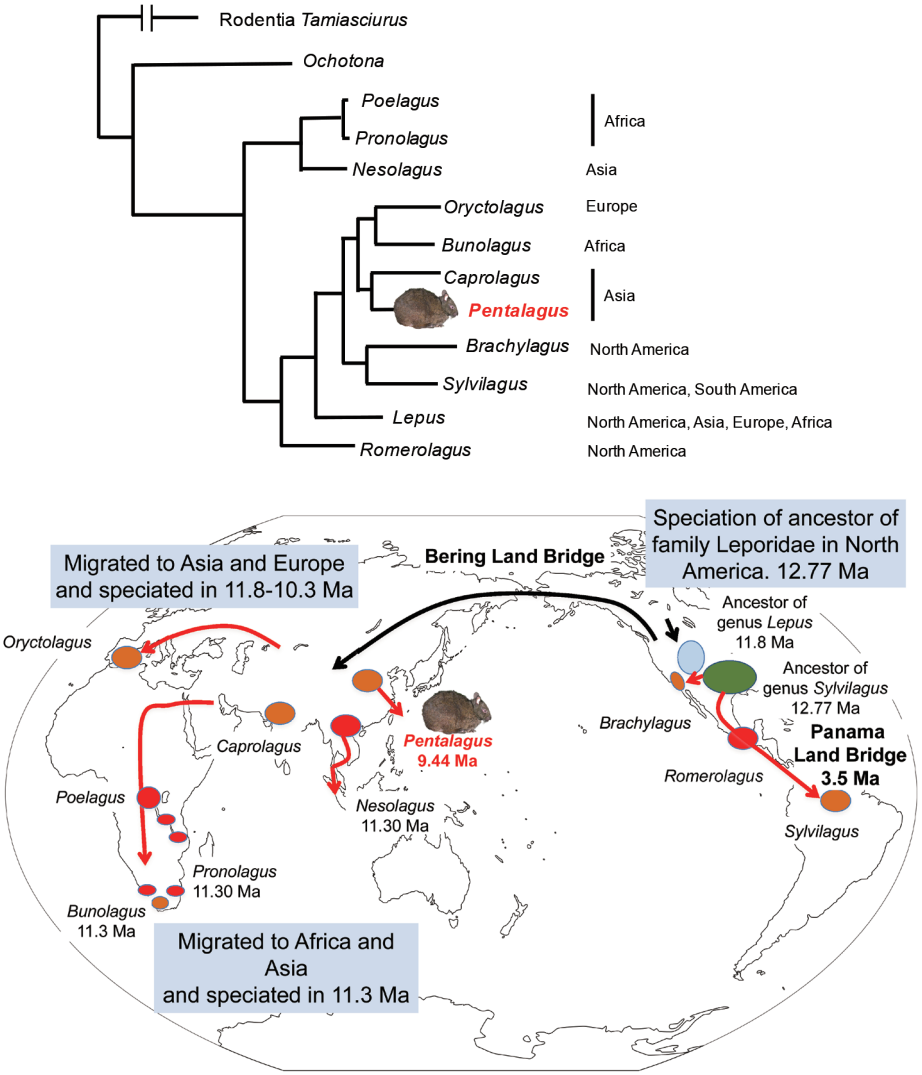


Figure 2-17: Phylogenetic tree of Leporidae based on the molecular phylogenetic analyses with morphological and biogeographic information (above), and the origin and speciation processes of *Oryctolagus* (below). (based on Yamada 2017. Illustrated from Matthee et al. 2004; Robinson and Matthee 2005).

1)-2. Relict endemic and new endemic lineages

It is considered that climate changes and associated sea surface changes from around the late Pliocene (3.6-2.58 Ma) to the Pleistocene (2.58–0.012 Ma) caused repeated connections and separations of the neighbouring islands, resulting in a divided distribution of organisms and advances in speciation on individual islands, which facilitated evolution to new endemic species and subspecies. In particular, some relict endemic lineages in the Central Ryukyus diverged further and evolved into different new endemic species between the Amami Island Group and Okinawa Island Group. Table 2-32 shows three species in the spiny rats (*Tokudaia*) and other typical species in the aforementioned category.

It should be noted that the divergence of the ground geckoes (*Goniurosaurus*) in the Central Ryukyus dates back even further; as a result of molecular phylogenetic analyses, it was found that their ancestor species had already diverged from a group of related continental species due to geographical and environmental reasons at least by the Eocene (65 to 40 Ma), when the Ryukyu Chain had still been part of the Eurasian Continent. In the Miocene (20 Ma to 10 Ma), when most of the Central Ryukyu species are considered to have been isolated from their continental kin, the banded ground gecko (*Goniurosaurus splendens*) on Tokunoshima Island and the Kuroiwa's ground gecko (*G. kuroiwae*) on the Okinawa Island Group diverged from each other, resulting in the differentiation of subspecies on Okinawa Island and surrounding islands from late Miocene to around Pliocene (6 to 3.9 Ma) (Honda et al. 2014; Okamoto 2017).

Such advances in speciation of relict endemic lineages among different islands suggest that the biota of the Central Ryukyus has been segregated for an extended period of time.

Otton frog (*Babina subaspera*), Amami-Oshima Island (Photo: MOEJ)

Holst's frog (*Babina holsti*), Northern part of Okinawa Island (Photo: MOEJ)

Column 3. Three spiny rat species belonging to the genus *Tokudaia*

The genus *Tokudaia* has only three species—the Amami spiny rat (*T. osimensis*) on Amami-Oshima Island, the Tokunoshima spiny rat (*T. tokunoshimensis*) on Tokunoshima Island, and the Okinawa spiny rat (*T. muenninki*) in the northern part of Okinawa Island. All of these three species are endemic to their respective islands (Ohdachi et al. 2015). They were initially described as a single species of spiny rat under the name of *T. osimensis* (Abe 1933), and later classified into different species according to their range island, based on the results of morphology, karyology, and molecular phylogeny (Tsuchiya et al. 1989; Suzuki et al. 1999; Kaneko 2001; Endo and Tsuchiya 2006).

Phylogenetic analyses of IRBP genes suggest that the genus *Tokudaia* diverged from the allied genus *Apodemus* and other species of the Murinae linage around 8 Ma to 6.5 Ma (Sato and Suzuki 2004) and evolved into a distinct taxon as a result of being isolated on the Central Ryukyus and becoming a relict species endemic to the group of islands.

At the same time, differences exist within these three species in terms of karyotype and karyomorph. For example, the karyotype of Tokunoshima spiny rats, Amami spiny rats, and Okinawa spiny rats is 2n=45, 2n=25, and 2n=44, respectively (Tsuchiya et al. 1989). As to their divergence dates, it was found that Okinawa spiny rats diverged from the ancestral lineage about 2.5 Ma, while Tokunoshima spiny rats and Amami spiny rats branched out from the lineage about 1 Ma (Murata et al. 2010, 2012). Based on the study results, it appears that these three new endemic species speciated as they were isolated from each other, along by the separation of Okinawa and Tokunoshima Islands and following separation of Tokunoshima and Amami-Oshima Islands, on the three islands within the Central Ryukyus.

In addition, the genus *Tokudaia* has a unique sex-determining mechanism. Usually, mammals have either XX or XY sex chromosomes. However, Amami spiny rats and Tokunoshima spiny rats do not have a Y chromosome, and have the XO/XO sex chromosome type in both sexes (Honda et al. 1977, 1978). Okinawa spiny rats are thought to have an XX/XY system, but their X and Y chromosomes are not clearly distinct from each other (Tsuchiya et al. 1989). Furthermore, Tokunoshima spiny rats and Amami spiny rats have lost their Sry gene along with the Y chromosome (Murata et al. 2010, 2012; Figure 2-18). The Y chromosome of these two species is considered to have been lost when a new sex-determining gene appeared and a part of the Y chromosome was translocated to the X chromosome (Murata and Kuroiwa 2011). Because of their sex-chromosome structure differerent from that of normal mammalian, their sex-determining mechanism has received a great deal of interest from researchers and a number of studies have been initiated.

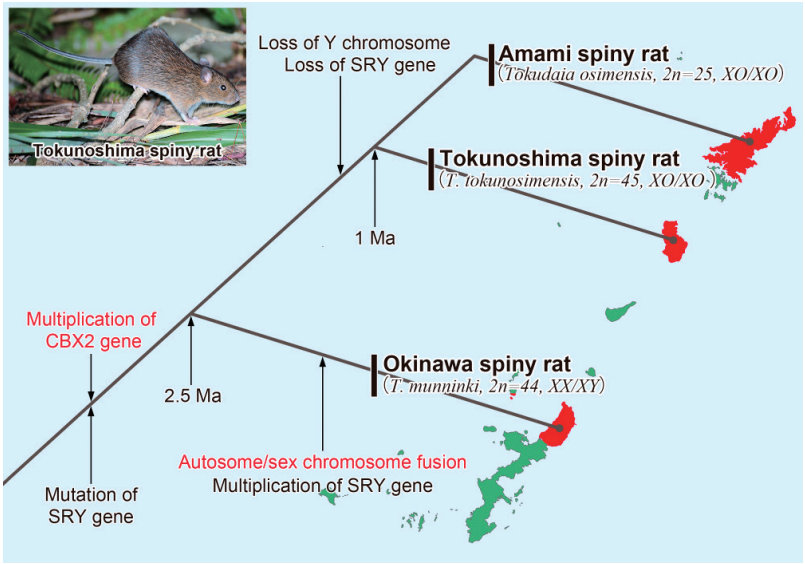


Figure 2-18: Genus *Tokudaia's* speciation and evolution of sex chromosomes and Sry/CBX2 genes (Prepared based on Murata et al. 2012)

2) South Ryukyus—New endemic lineages between Taiwan and the Eurasian Continent

(Iriomote Island)

As described in 1) above, considering the results of molecular phylogenetic analyses and the distribution of closely-related species, the terrestrial fauna on the South Ryukyus appear to have been formed after having been isolated from their counterpart in Taiwan and the Eurasian Continent during the Pliocene (5.33–2.58 Ma) after the South Ryukyus was separated from the Central Ryukyus in the late Miocene (Okamoto 2017). This explains the reason why the South Ryukyus' fauna does not have their relatives on the Central Ryukyus but have very closely-related species and subspecies mostly in Taiwan and the eastern part of the continent (Ota 1998, 2012; etc.). Table 2-32 shows typical species.

Molecular phylogenetic analyses indicate that, unlike other terrestrial animals on the South Ryukyus, the Iriomote cat (*Prionailurus bengalensis iriomotensis*) diverged from related subspecies (*P. b. Chinensis*) distributed in Taiwan and southern China during the relatively recent period of the late Pleistocene (90,000 years ago) (Tamada et al. 2008), and then migrated into Iriomote Island via Taiwan in the era when the exposed land in the South Ryukyus extended closer to Taiwan and the continent due to the lowering of sea levels during a glacial period (Yasuma 2016).

3) New endemic lineages across Central and South Ryukyus

(Amami-Oshima Island, Tokunoshima Island, the northern part of Okinawa Island, and Iriomote Island)

On the Central and South Ryukyus, there are a number of lineages of endemic species that have speciated within the respective regions. Table 2-32 shows such typical species including the group of tip-nosed frogs that belong to the genus *Odorrana*. These species represent a combination of geographic variations of speciation described above in 1) and 2). The existence of these speciation variations explains well that the biota of the South Ryukyus was isolated from that of the Central Ryukyus in older times and isolated from those of Taiwan and the eastern part of the Eurasian Continent in more recent times.

This suggests that in the late Miocene (11.63–5.33 Ma), common ancestor species that had been distributed across the entire Central and South Ryukyus, Taiwan, and the continent became isolated on the Central Ryukyus. Later, ancestor species were separated from Taiwan and the continent, and became isolated on the South Ryukyus during the Pliocene (5.33–2.58 Ma). They gradually speciated and became endemic to each region (Okamoto 2017). As a result, no relict endemic species like those on the Central Ryukyus are found among the endemic species and subspecies on the South Ryukyus.

As an exception, Ishigaki blue-tailed skink (*Plestiodon stimpsonii*) on the South Ryukyus has closely-related species on the North Ryukyus (Kuchinoshima Island, the Tokara Island Group). Molecular phylogenetic analyses found that this case was a long-distance dispersal event driven by the Kuroshio Current during the early period of the Pleistocene (1.8–1.4 million year ago) (Kurita and Hikida 2014; Okamoto, 2017).

Column 4. Tip-nosed frogs (*Odorrana*)

Endemic species of frogs belonging to the genus *Odorrana* include the Amami tip-nosed frog (*Odorrana amamiensis*) on Amami-Oshima Island and Tokunoshima Island (Central Ryukyus), the Okinawa tip-nosed frog (*O. narina*) on Okinawa Island, and the Utsunomiya's tip-nosed frog (O. utsunomiyaorum) and the greater tip-nosed frog (*O. supranarina*) on Iriomote Island and Ishigaki Island (South Ryukyus). In Taiwan, the Taiwan odorous frog (*O. swinhoana*), a species that is morphologically similar to the frogs above, is distributed (Figure 2-19).

Mitochondrial DNA (mtDNA) analyses showed that tip-nosed frogs' ancestral species, which had been distributed in the Continent, including Taiwan and the Ryukyu Chain, were separated from the continent during the late Miocene (12.3–5.4 Ma). They then divided into the two groups of the Central Ryukyu population and the Southern Ryukyu/Taiwan population from the late Miocene through the early Pliocene (9.3–4.1 Ma) (Matsui et al. 2005). It is considered that greater tip-nosed frogs diverged from the Central Ryukyus pupoulation in the early Pliocene, and that Amami tip-nosed frogs and Okinawa tip-nosed frogs speciated from the same population in later days. In the meantime, the South Ryukyus' Utsunomiya's tip-nosed frogs and Taiwan odorous frogs appear to have speciated from the Southern Ryukyus/Taiwan population in the Pleistocene (Matsui et al. 2005). Greater tip-nosed frogs are considered to have entered the South Ryukyus, where Utsunomiya's tip-nosed frogs had already existed, in the Pleistocene. While Utsunomiya's tip-nosed frogs occur in mountain and forest stream areas, greater tip-nosed frogs' habitat extends to downstream areas, up to near the border between mountains and plains (Toyama and Ota 1990; Ministry of the Environment 2014). It is estimated that the coexistence of these two species on the South Ryukyus is made possible by the absence of ecological competition due to the differences in their body size and entry age and by the segregation of their habitats (Matsui 1994).

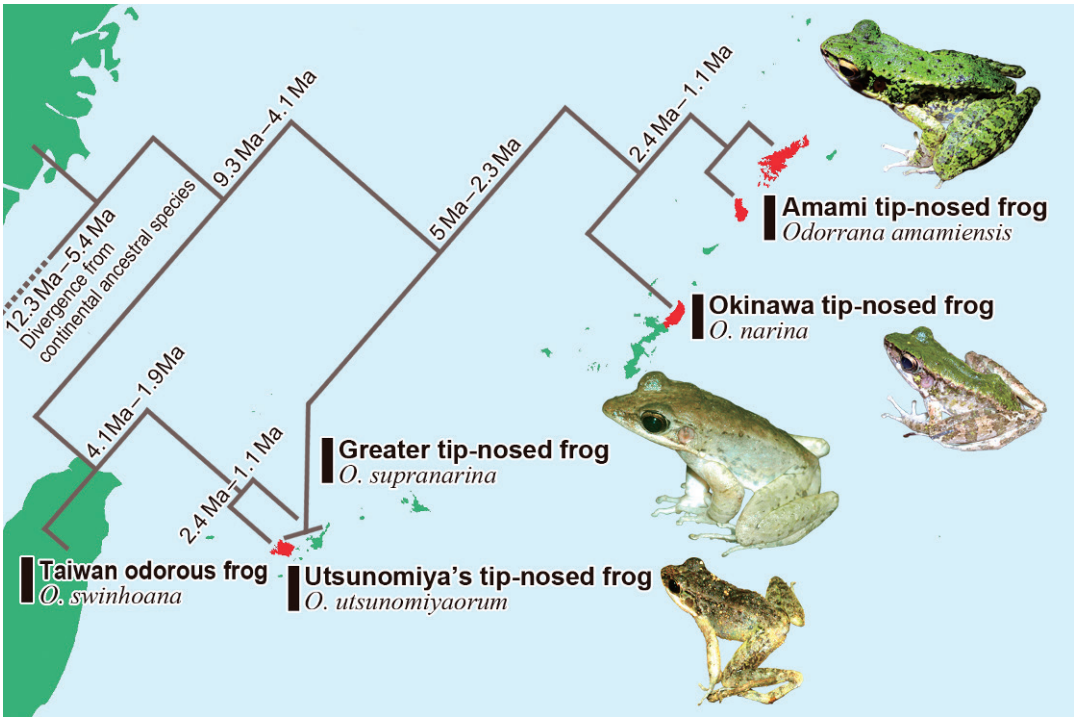


Figure 2-19 Distribution and phylogenetic relationships of Okinawa tip-nosed frogs prepared based on Matsui et al. 2005.

Figure 2-20 shows the Ryukyu Chain's position in the palaeogeographical map and biological dispersion estimated from the nominated property's geological history (see 2.a.3.1.) and the speciation patterns of terrestrial animals on the Central and South Ryukyus.

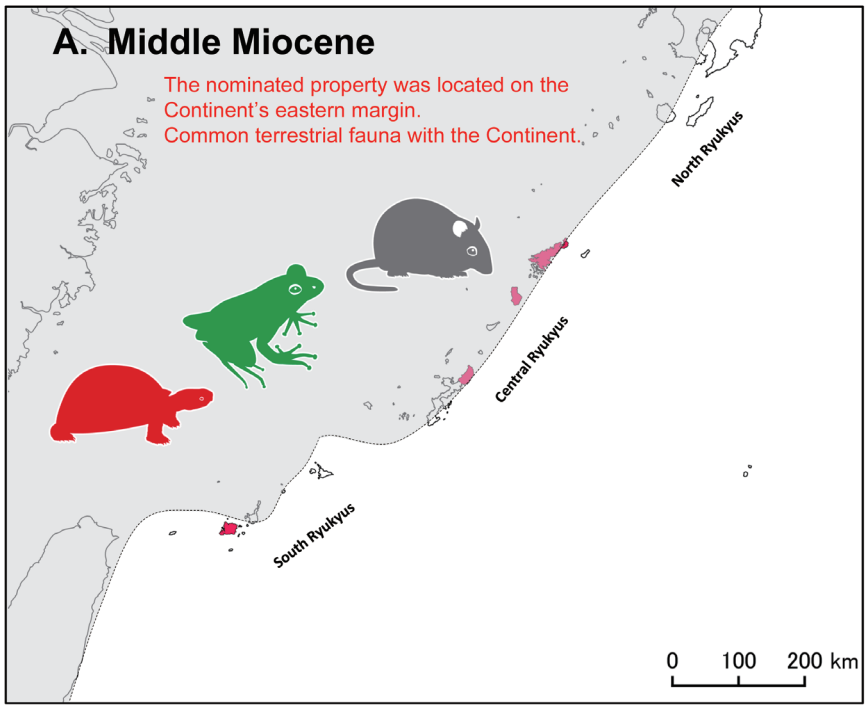
As to a link between the flora and the geological history of these islands, analysis of 1,815 species of seed plants on the Ryukyu Chain identified floristic speciation between the North, Central, and South Ryukyus on the whole (Nakamura et al. 2009; Nakamura 2012), and it is suggested that not only the geological history of the formation of the gaps (straits) between the islands but also modern environmental factors such as the influence of the distance between the islands and their different sizes must be taken into account in understanding the floristic speciation patterns on the Central and South Ryukyus (Nakamura et al. 2009). Furthermore, analyses of 513 species of woody plants within the Ryukyu Chain indicated that, when the phylogenetic relationships between the islands are considered, the most significant impact on the inter-island differences in species composition is the geographical distance between the Tokara Strait and the islands, and that such differences are reflected in the phylogenetic structure of the present-day flora of the individual islands (Kubota et al. 2011).

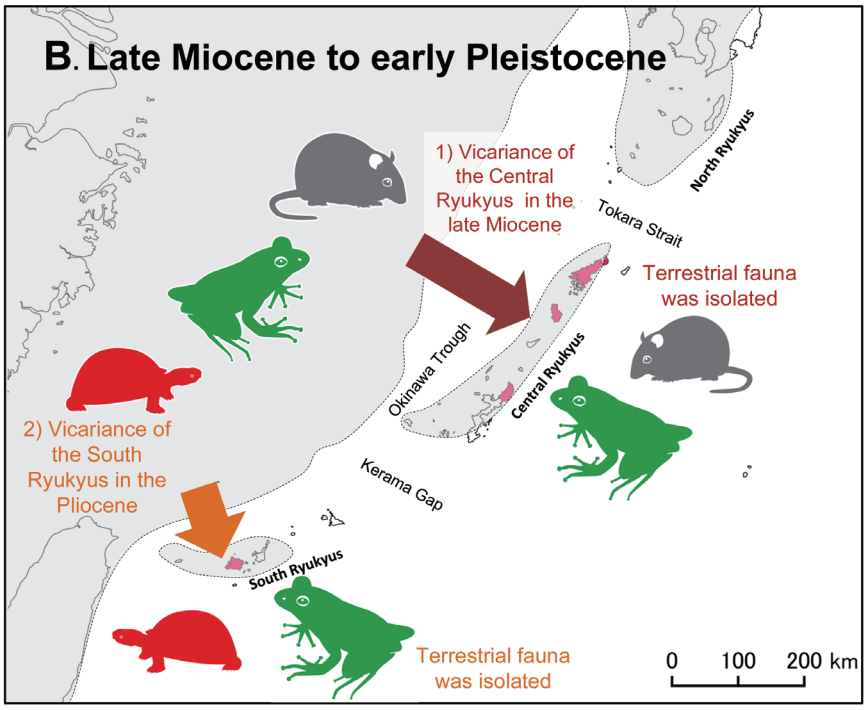
Habu viper (*Protobothrops flavoviridis*) (Photo: Hidetoshi Ota)

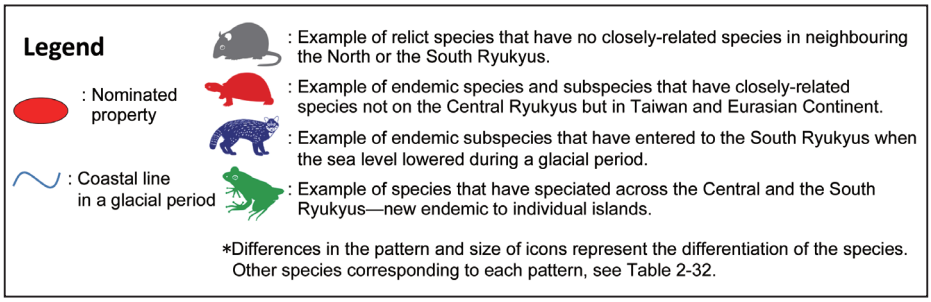
Table 2-32: Central and South Ryukyus' speciation patterns and typical terrestrial animal species on nominated property

Central Ryukyus				
Amami Oshima Island	**Tokunoshima Island**	**Northern part of Okinawa Island**	**Distribution of closest sister lineage**	**Period of divergence from sister lineage** (1 Ma=one million years ago)
1)-1. Relict endemic species				
Amami rabbit (*Pentalagus furnessi*)		–	Eurasia	10.6–8.3Ma (*Oryctolagus* and *Bunolagus*)
Ryukyu long-haired rat (*Diplothrix legata*)			Eurasia	3–4 Ma (*Rattus*)
Amami jay (*Garrulus lidthi*)	–	–	Himalayas	Unknown
–	–	Ryukyu black-breasted leaf turtle (*Geoemyda japonica*)	Southern China	56.4–33.9 Ma
Hime habu viper (*Ovophis okinavensis*)			Taiwan	14–5 Ma
Barbour's blue-tailed skink (*Plestiodon barbouri*)			Mainland Japan	14–5.5 Ma
Sword-tailed newt (*Cynops ensicauda*)	–	Sword-tailed newt (*C. ensicauda*)	Mainland Japan	10–6.4 Ma
Anderson's crocodile newt (*Echinotriton andersoni*)			Southern China	8.5–5.5Ma
–	–	Namie's frog (*Limnonectes namiyei*)	Taiwan	Unknown
–	–	Yanbaru long-armed scarab beetle (*Cheirotonus jambar*)	Southern China	Unknown
1)-2. Relict endemic AND new endemic lineages				
Amami spiny rat (*Tokudaia osimensis*)	Tokunoshima spiny rat (*T. tokunoshimensis*)	Okinawa spiny rat (*T. muenninki*)	Eurasia	8–6.5 Ma (*Apodemus*)
–	Banded ground gecko (*Goniurosaurus splendens*)	Kuroiwa's ground gecko (*G. kuroiwae*) (3 subspecies in nearby islands)	Southern China	65–40 Ma (Congeneric species)
Amami coral snake (*Sinomicrurus japonicus japonicus*)	Okinawa coral snake (*S. japonicus boettgeri*)		Taiwan	Unknown
Amami Ishikawa's frog (*Odorrana splendida*)	–	Okinawa Ishikawa's frog (*O. ishikawae*)	Eurasia	18–7.9 Ma (Other species on the continent)
Otton frog (*Babina subaspera*)	–	Holst's frog (*Babina holsti*)	Unknown	Unknown
Amami brownn frog (*Rana kobai*)		Okinawa brown frog (*R. ulma*)	Tsushima	Unknown
2) New endemic lineages between Taiwan and the Continent				
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
3) New endemic lineages across the entire Central and South Ryukyus				
Amami tip-nosed frog (*Odorrana amamiensis*)		Okinawa tip-nosed frog (*O. narina*)	South Ryukyus	12.3–5.4 Ma (Central/South/Taiwan vs. Continent)
Habu viper (*Protobothrops flavoviridis*) (South Tokara: Tokara habu viper (*P. tokarensis*))			South Ryukyus, Taiwan, Southern China	17–6 Ma (Central vs. South/Taiwan)
Pryer's keelback (*Hebius pryeri*)			South Ryukyus	7.5–12 Ma (Central/Miyako vs. Yaeyama/Taiwan)
Oshima blue-tailed skink (*Plestiodon oshimensis*)		Okinawa blue-tailed skink (*P. marginatus*)	South Ryukyus	7.3–3 Ma (Central vs. South)
Okinawa tree lizard (*Japalura polygonata polygonata*)			South Ryukyus	Unknown
Green grass lizard (*Takydromus smaragdinus*)			South Ryukyus	18–5 Ma (Central vs. South/Taiwan/Continent)
Stag beetle (*Neolucanus protogenetivus protogenetivus*) (Ukejima Is.: *N. protogenetivus hamaii*)		Stag beetle (*N. okinawanus*)	South Ryukyus	Unknown
Funnel web spider (*Macrothele amamiensis*)		–	South Ryukyus	ca. 10.4 Ma (Central/South/Taiwan vs. Continent) ca. 9.3 Ma (Central vs. South/Taiwan)

South Ryukyus			Literature
Iriomote Island	**Distribution of closest sister lineage**	**Period of divergence from sister lineage** (1 Ma=one million years ago)	
1)-1. Relict endemic species			
–	–	–	Matthee et al. (2004), Robinson and Matthee (2005)
–	–	–	Suzuki et al. (2000)
–	–	–	Kajita et al. (1999)
–	–	–	Okamoto (2017)
–	–	–	Okamoto (2017)
–	–	–	Okamoto (2017)
–	–	–	Tominaga et al. (2014)
–	–	–	Honda et al. (2012)
–	–	–	Emerson and Berrigan (1993)
–	–	–	Hosoya and Araya (2010)
1)-2. Relict endemic AND new endemic lineages			
–	–	–	Sato and Suzuki (2004), Murata et al. (2012)
–	–	–	Okamoto (2017)
–	–	–	Okamoto (2017)
–	–	–	Kuramoto et al. (2011)
–	–	–	Tominaga et al. (2014)
–	–	–	Matsui (2011), Eto and Matsui (2014)
2) New endemic lineages between Taiwan and the Continent			
Iriomote cat (*Prionailurus bengalensis iriomotensis*)	Taiwan and Southern China	0.09 Ma	Tamada et al. (2008)
Yaeyama pond turtle (*Mauremys mutica kami*)	Taiwan and Southern China	7.3–4.4 Ma	Okamoto (2017)
Yaeyama yellow-margined box turtle (*Cuora flavomarginata evelynae*)	Taiwan and Southern China	3–1.8 Ma	Okamoto (2017)
Sakishima beauty snake (*Elaphe taeniura schmackeri*)	Taiwan and Southern China	Unknown	Okamoto (2017)
Kishinoue's giant skink (*Plestiodon kishinouyei*)	Taiwan and Southern China	5–1.5 Ma	Okamoto (2017)
Sakishima smooth skink (*Scincella boettgeri*)	Taiwan	8–4.1 Ma	Okamoto (2017)
Iwasaki's slug snake (*Pareas iwasakii*)	Taiwan	4.2-1.6 Ma	Ota, from You et al. (2015)
Owston's green treefrog (*Rhacophorus owstoni*)	Taiwan	Unknown	Ota (1998)
3) New endemic lineages across the entire Central and South Ryukyus			
Utsunomiya's tip-nosed frog (*Odorrana utsunomiyaorum*) Greater tip-nosed frog (*O. supranarina*)	Taiwan	9.3–4.1 Ma (Central vs. South/Taiwan)	Matsui (1994)
Sakishima habu viper (*Protobothrops elegans*)	Taiwan/Southern China	ca. 3 Ma (South vs. Taiwan)	Okamoto (2017)
Yaeyama keelback (*Hebius ishigakiense*) (Miyako Is.: Miyako keelback (*H. concelarum*))	Taiwan(Undescribed species)	3–6 Ma (Yaeyama vs. Taiwan)	Kaito and Toda (2016)
Ishigaki blue-tailed skink (*Plestiodon stimpsonii*) (Kuchinoshima Is.: Kuchinoshima blue-tailed skink (*P. kuchinoshimensis*))	Taiwan/Southern China North Tokara	5–1.5 Ma (South vs. Taiwan/Continent) 1.4–1.8 (South vs. Tokara)	Brandley et al. (2011, 2012)
Sakishima tree lizards (*Japalura polygonata ishigakiensis*) (Yonaguni tree lizard (*J. polygonata donan*))	Taiwan	Unknown	Okamoto (2017)
Yaeyama grass lizard (*Takydromus dorsalis*) (Miyako Is.: Miyako grass lizard (*T. toyamai*))	Southern China	9–2.9 Ma (South vs. Continent)	Okamoto (2017)
Stag beetle (*Neolucanus insulicola insulicola*) (Yonaguni Is.: *N. insulicola donan*)	Taiwan/Southern China	Unknown	Hosoya and Araya (2006)
Funnel web spider (*Macrothele yaginumai*)	Taiwan	ca. 8.3 Ma (South vs. Taiwan)	Su et al. (2016)


A. Middle Miocene
The nominated property was located on the Continent's eastern margin.
Common terrestrial fauna with the Continent.
North Ryukyus
Central Ryukyus
South Ryukyus
0 100 200 km


B. Late Miocene to early Pleistocene
1) Vicariance of the Central Ryukyus in the late Miocene
Tokara Strait
North Ryukyus
Terrestrial fauna was isolated
Okinawa Trough
Central Ryukyus
2) Vicariance of the South Ryukyus in the Pliocene
Kerama Gap
South Ryukyus
Terrestrial fauna was isolated
0 100 200 km


Legend
: Nominated property
: Coastal line in a glacial period
: Example of relict species that have no closely-related species in neighbouring the North or the South Ryukyus.
: Example of endemic species and subspecies that have closely-related species not on the Central Ryukyus but in Taiwan and Eurasian Continent.
: Example of endemic subspecies that have entered to the South Ryukyus when the sea level lowered during a glacial period.
: Example of species that have speciated across the Central and the South Ryukyus—new endemic to individual islands.
*Differences in the pattern and size of icons represent the differentiation of the species. Other species corresponding to each pattern, see Table 2-32.

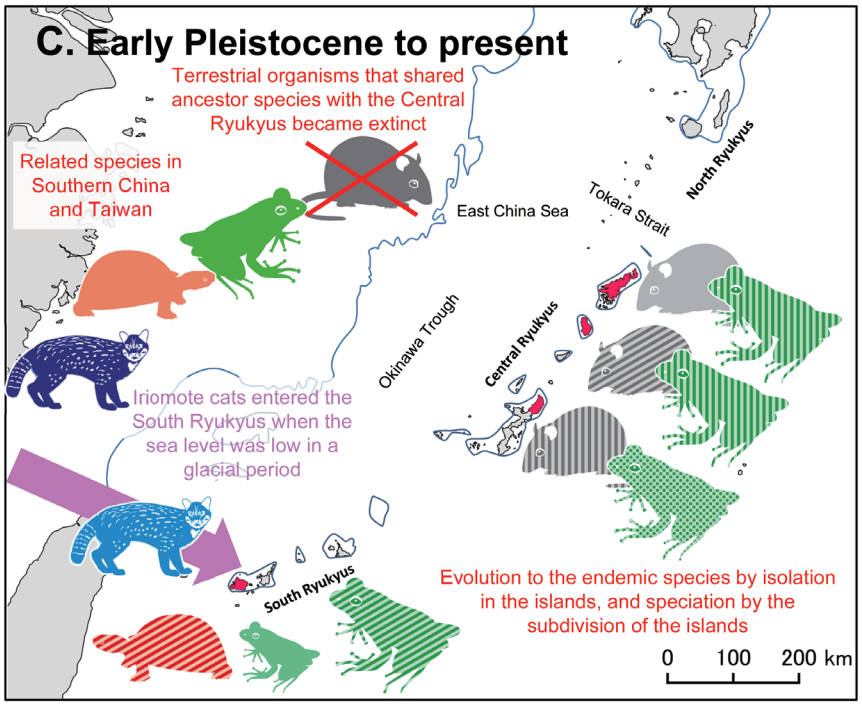


Figure 2-20: Ryukyu Archipelago's ancient geography and biological trends (Estimates)

The figures were prepared based on the following: Hypothesis established by Kizaki and Oshiro (1977), which is based on the geology and biological fossil information; hypothetical paleogeographic maps of the Nansei-Shoto Islands, which were estimated based on the comprehensive information about the phylogeography of the reptile and amphibian lineages (Ota 1998); findings of recent molecular biology (Tokuda 1969; Sato and Suzuki 2004; Koizumi et al. 2014; Yoshikawa et al. 2016; Okamoto 2017), findings of fossilology (Ota 2013, Ikeda et al. 2016; Nishioka et al. 2016), and findings of geology (Koba 1992; Kamata and Kodama 1994; Park et al. 1998; Kamata 1999; Machida et al. 2001; Inoue 2007; Sato et al. 2009; Kawano and Nishimura 2010; Hase 2010; Iryu and Matsuda 2010; Nishiyama 2010; Sakai 2010 a, b; Takeuchi, 2010; Isozaki et al. 2011; Gungor et al. 2012; Gallagher et al. 2015; and Iryu's personal communications 2016).

A: Before middle Miocene (Before 11.63 Ma)

The current Ryukyu Archipelago including the nominated site was apparently located on the eastern margin of the Eurasian Continent and shared a common terrestrial biota.

B: Late Miocene to early Pleistocene (11.63 to 2 Ma)

The Okinawa Trough began to expand. Tokara Strait and Kerama Gap were formed.

The fauna on the Central and South Ryukyus started to follow a unique evolution process after the former group of islands had been separated from the continent with their terrestrial biota consisting of Amami rabbits, spiny rats, ground geckoes, habu vipers, tip-nosed frogs, etc. in the late Miocene (11.63–5.33 Ma). The latter group of islands had been isolated from Taiwan and the continent with its terrestrial biota consisting of Yaeyama yellow-margined box turtles, Kishinoue's giant skinks, Sakishima habu vipers, tip-nosed frogs, etc. in the Pliocene (5.33–2.58 Ma).

C: Early Pleistocene to present (2 Ma onwards)

The terrestrial organisms that shared ancestor species with those on the Central Ryukyus became extinct gradually on the continent, leaving a relict and endemic terrestrial biota on the Central Ryukyus.

Sea level changes associated with climate changes (glacial-interglacial cycles) caused repeated connections and separations among neighbouring islands. As a consequence, these islands' biological distribution was fragmented and island-specific speciation was accelerated. When the sea level lowered during a glacial period and the distance between the South Ryukyus and the Eurasian Continent/Taiwan was shortened to a minimal level, Iriomote cats seem to have entered the South Ryukyus (0.09 Ma).

2.a.4. Adaptive evolution of animals in island ecosystems

In the nominated property, the Central and South Ryukyus have certain differences in the existence of high-level predators as a component of the islands' ecosystems. High-level predators, such as carnivorous mammals and large-sized resident raptors, have not existed at all or been absent for a long period of time on Amami-Oshima Island, Tokunoshima Island and northern Okinawa Island of the Central Ryukyus. The biological communities, which contain a number of relict endemic species, have created a unique ecosystem topped by large-sized snakes, with animals having evolved in an adaptive way to the ecosystem. On the other hand, Iriomote Island of the South Ryukyus has Iriomote cats, the only carnivore in the nominated property. The scale of the Island's environment is considered to be too small to allow medium-sized carnivores to live for a long period of time, but it is observed the cats have evolved to adapt to such a small-scale island environment.

1) Central Ryukyus—Mammals, birds, and reptiles adapted to ecosystems without high-level predators and evolved in a unique way

On Amami-Oshima Island, Tokunoshima Island, and the northen part of Okinawa Island in the Central Ryukyus, the absence of carnivores and large raptors has helped habu vipers (*Protobothrops flavoviridis*), which grow up to about two meters long, and Ryukyu odd-tooth snakes (*Dinodon semicarinatum*) to establish themselves as the apex predators in the ecosystem by growing to the largest body size in their genus (Mori and Moriguchi 1988; Hamanaka et al. 2014). Nocturnal animals living on the ground, the Amami rabbit (endemic to Amami-Oshima Island and Tokunoshima Island) and three species of the spiny rats (endemic to Amami-Oshima Island, Tokunoshima Island, and northern part of Okinawa Island) are highly exposed to the risk of encountering a habu, but have adapted in a way to avoid such risk of the habu (Hattori, 2002). For example, Amami rabbits excavate a birthing burrow on a steep slope, and feed themselves and defecate feces in a rocky field or riverside with a good and wide view of surrounding areas. Spiny rats jump a vertical distance of approximately 50 centimetres to dodge an attack of a habu. Thanks to this ability, spiny rats are rarely included in habus' prey animals (Hattori 2002). On the other hand, Ryukyu odd-tooth snakes, a species that has a nocturnal habit similar to habus, rarely prey on mammals, as is the case with other species of the genus *Dinodon*. However, their stomach contents often consist of a variety of other reptiles (including habus) and birds (Mori and Moriguchi 1988; Hamanaka et al. 2014). Further, on sandy beaches on the northern part of Okinawa Island and peripheral remote islands, the Ryukyu odd-tooth snakes exhibit a distinctive behavior; they eat hatchlings and eggs of sea turtles that come up to the beach for oviposition. This quite exceptional conduct for a snake constitutes a part of the food web and material cycle that is unique to the islands (Mori et al. 1999; Sato 2015).

The Okinawa rail (*Gallirallus okinawae*), a species endemic to northern part of Okinawa Island, is considered to be almost flightless from an anatomical perspective in view of their wings' structure and muscles (Kuroda 1993; Kuroda 1995). In Okinawa Island, fossils of rails have been found in geological strata from ca. 18,500 years ago, indicating that these rails had shorter legs and might have had higher flight ability than modern Okinawa rails (Matsuoka 2000; Ozaki 2005). Considering the fact that the barred rail (*G. torquatus*), a relative species distributed in the Philippines and Indonesia, has flight ability, it is believed that ancestral species that flew to Okinawa Island from the south tens of thousands of years ago may have gradually acquired the ability to run on the ground and ultimately transformed themselves into the

current-day Okinawa rails (Matsuoka 2003; Ozaki 2005; Kirchman 2012). Factors that facilitated this process include the lack of indigenous carnivores on Okinawa Island who could have acted as a dominant predator, the diversisty of organisms in subtropical evergreen broadleaved forests, the abundance of small animals on the ground that can provide a prey, and other conditions that have made it possible to have enough food even for flightless birds (Ozaki 2005).

Ryukyu odd-tooth snake (*Dinodon semicarinatum*), one of the apex predators of the Central Ryukyus, including Amami-Oshima, Tokunoshima Islands and the northern part of Okinawa Island (Photo: Hidetoshi Ota)

The Okinawa woodpecker (*Sapheopipo noguchii*), a species endemic to northern part of Okinawa Island, flies down to the ground and digs arthropods lurking from the ground to feed their chicks (Kinjo 1997; Kotaka et al. 2006). There have been a number of reports concerning woodpeckers that have adapted to capture ants and forage on the ground. However, no woodpeckers other than the Okinawa woodpecker, have been reported to dig up and peck underground arthropods as their main diet. This is considered to be one of the most critical adaptive behaviours by the Okinawa woodpecker, which allowed the species to survive on the island with no carnivorous mammalian predators and only limited areas of forests (Kotaka et al. 2009, Kotaka 2011).

2) South Ryukyus—Ecosystem bounty that supports "world's smallest island with wildcats"

In general, the smaller the island's area, the smaller its food chain pyramid becomes and the lesser the number of high-level predators such as Carnivora (Holt, 2009). However, Iriomote Island in the South Ryukyus is home to Iriomote cats, the only Carnivora living in the nominated property. The island covers an area of only 28,961 ha, far smaller than overseas islands inhabited by related species belonging to the Felidae family (Imaizumi 1994) and too small for medium-sized carnivores to inhabit for a long period of time. In addition, while most of the similar-sized Felidae animals in the world prey on small rodents as their principal food supply (Watanabe and Izawa 2003; Nakanishi and Izawa 2015), the only rodent currently existing in Iriomote Island is an alien species of black rat.

Iriomote cat (*Prionailurus bengalensis iriomotensis*), the only Carnivora in the nominated propery (Photo: MOEJ)

Iriomote cats do feed on a limited number of mammals, such as the indigenous flying fox and black rat, as well as other animals in a variety of taxa, including birds, reptiles, amphibians, insects and crustaceans, according to the cycle of the seasons. So far, as many as approximately 80 species of prey animals have been identified (Nakanishi and Izawa 2015), indicating Iriomote cats' extremely wide variety of feeding habits compared to other species in the Felidae family (Sakaguchi and Ono 1994; Watanabe and Izawa 2003). Their frequently used feeding grounds include forest edges, lowlands, riverside, wetlands, and other water-rich areas that are abundant in small animals and rich in diversity among other locations on the island (Sakaguchi 1994; Watanabe et al. 2002). They also use mangrove forests, areas surrounding agricultural lands and coastal areas (Okinawa Prefecture 2006; Ministry of the Environment 2014). It is notable that, on Iriomote Island, there are eight species of frogs that have different breeding times and thereby can serve as a year-round source of prey for Iriomote cats. Another point is that the island's estimated annual average of biomass derived from frogs (11,460 g/ha) is much larger than those of Latin American tropical forests (781 g/ha to 1,150 g/ha) (Watanabe and Izawa 2005; Watanabe et al. 2005), providing an important source of food for Iriomote cats (Nakanishi and Izawa, 2016).

The factors that have allowed Iriomote cats to have an extremely extended range of habitat and source of preys and enabled them to adapt to the small-scale insular environment is considered that the existence of a wet and humid environment such as sub-tropical rainforests, highly-developed river systems, and back marsh at the mouth of those rivers provide habitats to the Island's abundant and diverse organisms.

2.a.5. Utilization of natural resources

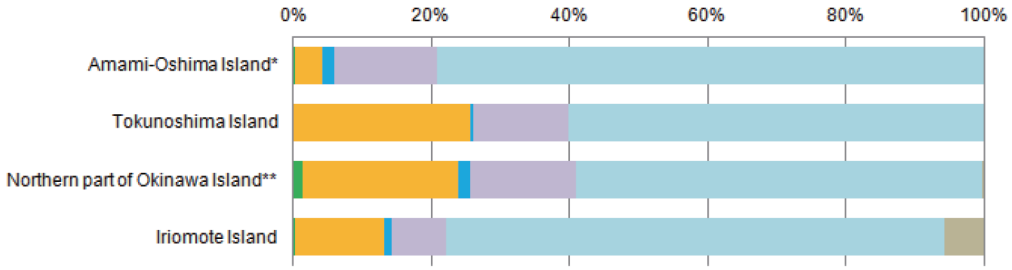
The four regions containing the nominated property are all inhabited. Table 2-33 below shows the numbers of residents.

Table 2-33: Populations and numbers of households in four regions containing the nominated property

Name of island (region)	Population	Number of households	Year of survey	Sources
Amami-Oshima Island*1	67,199	41,544	2016	1), 2)
Tokunoshima Island	24,741	12,738	2016	1)
Northern part of Okinawa Island*2	10,039	4,987	2016	1)
Iriomote Island	2,402	1,289	2016	3)

Sources: 1) Statistics Bureau, Ministry of Internal Affairs and Communications (2016); 2) Setouchi Town (2016); 3) Taketomi Town (2016)
*1: Excludes Kakeroma Island, Ukejima Island, and Yoro Island.
*2: Three villages: Kunigami Village, Ogimi Village, and Higashi Village

Figure 2-21 illustrates the number and percent distribution of the working population by industry in the four regions containing the nominated property. All of the four nominated islands (region) have a low percentage of workers in the primary industry relating to the use natural resources; i.e. 6.0% (1,661 people) for Amami-Oshima Island, 26.0% (2,865 people) for Tokunoshima Island, 25.5% (1,158 people) for northern part of Okinawa Island, and 14.3% (189 people) for Iriomote Island. In the primary industry, agriculture has the largest share of workers across all the islands. The overview of each of the agriculture, forestry, and fishery sectors is shown on the next item.



	Amami-Oshima Island*	Tokunoshima Island	Northern part of Okinawa Island**	Iriomote Island
Forestry	103	14	59	3
Agriculture	1,039	2,814	1,024	171
Fishery	519	37	75	15
Secondary Industry	4,096	1,521	696	105
Tertiary Industry	21,757	6,645	2,670	953
Others	0	0	11	77
Total	27,630	11,039	4,535	1,324

Figure 2-21: Rate of population by industry (above) and actual number (below) in the four regions containing the nominated property

Source: 2010 Census by the Bureau of Statistics, Ministry of Internal Affairs and Communications (employed person by age group, 15 years-old and over)

* Includes Kakeroma Island, Ukejima Island, and Yoro Island.

** Three Yambaru villages.

Sugar cane field (Photo: MOEJ)

2.a.5.1. Agriculture

Among the four regions containing the nominated property, Tokunoshima Island has a certain area of arable land in the flat land at the foot of the mountains located at the centre of the island. However, the other three regions have vast mountain areas and only limited areas for cultivation (Table 2-34).

Table 2-34: Arable land area of four regions including nominated property

	Island Area (ha)	Paddy field (ha)	Farmland (ha)	Total (ha)	Arable land (%)	Year
Amami-Oshima Island*	82,107	58	2,112	2,172	2.6	2015
Tokunoshima Island	24,785	2	6,880	6,882	27.8	2015
Northern part of Okinawa Island	34,023	16	1,355	1,371	4.0	2015
Iriomote Island	28,961	89	565	654	2.3	2010

Land area data for the islands and regions was collected from the Land Area by Island and the Land Area by Municipality sections of the 2015 Statistical Reports on the Land Area by Prefectures and Municipalities in Japan by the Geospatial Information Authority of Japan. The figure for northern part of Okinawa Island shows a total area of the three Yambaru villages.
Arable land area was calculated, based on the results of the cultivated acreage survey by Ministry of Agriculture, Forestry and Fisheries of Japan (2015) for Amami-Oshima Island, Tokunoshima Island and the northern part of Okinawa Island; and on FY2015 Yaeyama Digest by Okinawa Prefectural Government Yaeyama Office for Iriomote Island.

*: Amami-Oshima includes Kakeroma Island, Ukejima Island, Yoro Island and other peripheral islands.

2.a.5.2. Forestry

1) Amami-Oshima Island and Tokunoshima Island

Forest area of Amami Island Group accounts for 66% (81,177 ha) of the Island Group's total area (123,144 ha) (Oshima Branch Office, Kagoshima Prefecture 2014), and about 87% (70,510 ha) of the forest area is distributed on the Amami-Oshima Island and Tokunoshima Island including the nominated property. The rate of forest area to land area of Amami-Oshima Island and the Tokunoshima Island are about 84% and 44%, respectively. One of the characteristics of these forests is that most of them are privately-owned forests (about 70% and 58%, respectively) (Table 2-35).

Logging for timber production is not implemented within the nominated property. Forest operations in the buffer zones are allowed only within the scope authorized under the Natural Parks Act.

2) Northern part of Okinawa Island and Iriomote Island

Okinawa Island's forest area accounts for 46% (56,897 ha) of the Island's total area (124,363 ha) (Forests Management Division, Department of Agriculture, Forestry, and Fisheries, Okinawa Prefecture 2014), and about 60% (33,975 ha) of the forest area is distributed in the northern part of Okinawa Island containing the nominated property (three Yambaru villages). The forest area of three Yambaru villages accounts for about 91% of the total area. One of the characteristics of these forests is that most of them are municipal forests (31%) (Table 2-35).

Partly for historic reasons, forests in the three Yambaru villages including the nominated property have been used as the basis of the Okinawa Prefecture's forestry industry (see 2.b.). The Okinawa Prefecture developed the "Policy for the Promotion of the Yambaru Model Forestry," a policy for treating the forests of the three Yambaru villages, with the aim of promoting the Yambaru-type forest and forestry industries, which combines an environment-friendly sustainable forest management (SFM) system, the recirculating forest products usage via the life cycle and environment-conscious nature experience activities. Logging for timber production is not implemented within the nominated property. Forest operations in the buffer zones are allowed only within the scope authorized under the Natural Parks Act.

The Yaeyama Islands' forest area accounts for 62% (36,716 ha) of the Islands' total area (59,198 ha) (Forest Management Section, Department of Agriculture, Forestry, and Fisheries, Okinawa Prefecture 2014), and about 73% (26,696 ha) of the forest area is distributed on Iriomote Island. Iriomote Island has a forest area to land area rate of approximately 92%, and is characterised by the largest proportion of national forests (94%) (Table 2-35). Logging for timber production is not implemented either in the nominated property or buffer zones on Iriomote Island.

Table 2-35: Forest area by owner of four regions containing the nominated property (ha: upper) and breakdown (in the parentheses: lower)

	Area	Forest Area	Rate of Forest (%)	National Forest	Prefectural Forest	Municipal Forest	Privately-Owned Forest
Amami-Oshima Island	71,235	59,718	83.8	4,386 (7.3)	249 (0.4)	13,498 (22.6)	41,585 (69.6)
Tokunoshima Island	24,785	10,792	43.5	3,825 (35.4)	9 (0.1)	667 (6.2)	6,291 (58.3)
Northern part of Okinawa Island	34,023	30,789	90.5	10,946 (35.6)	3,885 (12.6)	9,465 (30.7)	6,494 (21.1)
Iriomote Island	28,961	26,696	92.2	24,970 (93.5)	1 (0.0)	689 (2.6)	1,036 (3.9)

Areas of the islands and regions were obtained from the Land Area by Island and the Land Area by Municipality sections of the 2015 Statistical Reports on the Land Area by Prefectures and Municipalities in Japan by the Geospatial Information Authority of Japan. The area of the northern part of Okinawa Island was obtained by aggregating the areas of the three Yambaru villages.
The forest land area by owner was calculated using forestry records for state-owned forests held by the Forestry Agency and the GIS and forestry records for prefectural, municipal, and privately-owned forests held by the Kagoshima and the Okinawa Prefectures.

Column 5. Highly resilient forest dominated by Castanopsis

The four regions containing the nominated property are high in biodiversity and essential as habitats to endemic species and rare species. On the other hand, on Amami-Oshima Island and in the north of Okinawa Island, local forest resources have been used for timber, fuel wood, etc, since old times, and a certain level of forestry operations are conducted around the nominated property. The reasons for the two islands having been successful in both conserving endemic/rare species and engaging in the forestry industry include the high regeneration ability of the forests dominated by Castanopsis, a tree species with a strong sprouting power (Hirata et al. 1979). For example, a study was conducted to examine the sprouting ability of Okinawa's Castanopsis forests. The following is a report about the recovery process of a forest located in a former logging site in the north of Okinawa Island (Osawa et al. 2003).

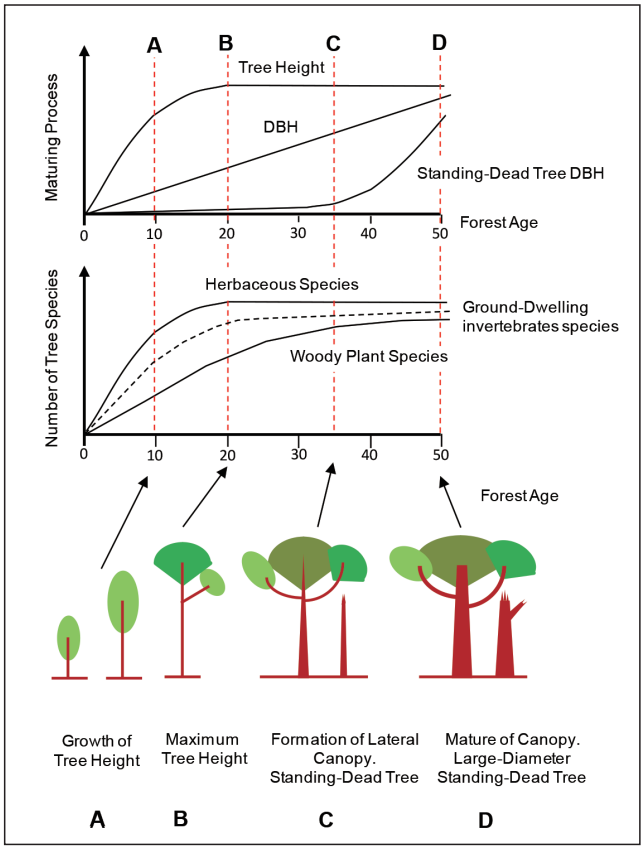


Figure 2-22: Regeneration Process and Structural Characteristics of Forests on Northern Okinawa Island (Osawa et al. 2003, partly modified)

Immediately after logging, pioneer broadleaved trees are dominant. Castanopsis appear from the 10th year and their height and stem diameter (diameter at breast height; DBH) increase year after year, up to around the 20th year since the deforestation (A and B in Figure 2-22).

Around the 20th to 30th year since the deforestation, the accumulated number of species constituting the forest canopy reaches the upper limit at 80 to 85. The broadleaved trees are replaced by new dominant species, such as Castanopsis, *Schima wallichii* ssp. *liukiuensis*, Japanese snowbell (*Styrax japonica*), and *Distylium racemosum*. While the tree height almost reaches the upper limit of 15 m, DBH (diameter at breast height: ca. 25 cm at this stage) continues to increase. This is the stage when the growth of DBH outperforms that of tree height (C in Figure 2-22).

Around the 35th year after the deforestation, the structure of the forest layers consisting of canopy, subcanopy, and understory trees becomes clearer. Castanopsis and other canopy trees stretch their lateral branches further, while increasing the stem diameter (at this stage, DBH reaches around 30 cm at the maximum). As a forest tree community enters an adjustment phase, small-diameter trees are thinned out, and a rapidly increasing number of standing-dead trees begin to stand out (C and D in Figure 2-22). At this stage, a forest becomes able to meet habitat requirements of certain endemic/rare species such as Okinawa woodpeckers, which need, for nest building, large-diameter (DBH ≥ 20 cm) and rotten-centre trees.

After 50 or more years have passed since deforestation, a forest has become composed of large-diameter trees with DBH of around 65 cm at the maximum, and there may be some changes in their physical structure, such as hollows and shoots arising from thick lateral branches. A forest structure diversifies further, and some of large diameter

trees having DBH of around 60 cm become snags (D in Figure 2-22). At this stage, a forest becomes able to meet habitat requirements of certain endemic/rare species such as Yanbaru long-armed scarab beetles, which need tree hollows that have a sufficient level of humic substances to feed their larvae.

Amami-Oshima Island's chinquapin forests always recover from logging and restore itself in a relatively short period of time. However, large-diameter trees need a longer span of time to recover, and approximately 80 years after a selective cutting and approximately 110 years after a complete cutting are required to return to a state similar to that of the original primary forest (Shimizu et al. 1988).

It should be noted that the rapid sprout regeneration and growth of underbrush help prevent sediment runoff and contribute to the smooth restoration of forest.

2.a.5.3. Fishery industry

1) Amami-Oshima Island and Tokunoshima Island

The Amami Island Group, which includes Amami-Oshima Island and Tokunoshima Island, is surrounded by coral reefs and a number of natural patch reefs in adjacent waters, forming generous fishing grounds. Types of fishery operated there include vessel-based fishery (hook-and-line fishing such as single-hook fishing, trawl fishing, longline fishing, and drop-line fishing), net fishery (lift net fishing, gill net fishing, etc.) and diving apparatus fishery. Production volume of the vessel-based fishery in the Amami Island Group in 2010 was 2,025 tons (Oshima Branch Office, Kagoshima Prefecture 2014). In addition, the mild climate and warm seawater temperature allow the breeding of aquaculture species such as fish, pearl oyster and Japanese tiger prawn. (Oshima Branch Office, Kagoshima Prefecture 2014). However, the Amami Island Group's fishery industry is characterised by its small scale, with fishing boats weighing less than 10 tons accounting for 97% (1,924 boats) of all fishing fleet, and private operators accounting for 96% (786 operators) of all fishery businesses (Oshima Branch Office, Kagoshima Prefecture 2014).

The Amami Island Group —in particular, Amami-Oshima Island—has varied and irregular coastlines. Therefore, a number of fishing ports and harbours are situated in coves. As of 2013, Amami-Oshima Island and Tokunoshima Island have 23 and 4 fishing ports, respectively (Oshima Branch Office, Kagoshima Prefecture, 2014), but none of them are located within the nominated property or buffer zone.

2) Northern part of Okinawa Island and Iriomote Island

The coastal areas of Okinawa Prefecture, including the nominated northern part of Okinawa Island and Iriomote Island, have expansive reef flats formed by highly developed coral reefs. The ocean floor topography along the areas is characterised by the narrow sea shelves, with the Ryukyu Trench being located on the east side of the reef flats and the Okinawa Trough being laid on the western side. Such characteristics of the ocean area have encouraged people to operate offshore fishery, including pole and line fishery targeting diadromous fish (e.g. tuna and bonito), fishery using floating fish rafts (Payaos), and drop-line squid fishery, as well as continental shelf and coral reef fishery, such as bottom angling and spearfishing using diving apparatus (Department of Agriculture, Forestry and Fisheries 2014a, b; Okinawa Prefecture 2014; Okinawa General Bureau, Cabinet Office, Government of Japan 2014).

Okinawa Prefecture's fishery industry is characterised by its small scale, with fishing boats weighing less than 10 tons accounting for 95% (2,787 boats) of all fishing fleet, and private operators accounting for 99% (2,583 operators) of all fishery businesses. However, various measures have been implemented to promote the fishery industry and establish the basis for fishery production since FY1972, immediately after the return of Okinawa to Japan. At the same time, the "Resource-Controlling Fishery" and "Cultivation-Centric Fishery" projects have been launched to develop aquacultural basis for mozuku (*Nemacystus decipiens*), Japanese tiger prawn, sea grape, and *Monostroma nitidum* (Department of Agriculture, Forestry and Fisheries a, b, Okinawa Prefecture 2014; Okinawa General Bureau, Cabinet Office, Government of Japan 2014). The production volume of Okinawa Prefecture's fishery industry in 2012 was 15,295 tons and 17,458 tons for marine fishery and marine aquaculture, respectively.

Catch landing (Photo: MOE)

As of 2014, Okinawa Prefecture had 88 fishing ports, including 7 ports located in the northern part of Okinawa Island (the three villages of Kunigami Village, Ogimi Village, and Higashi Village) and one port located in Iriomote Island (Department of Agriculture, Forestry and Fisheries 2014c, Okinawa Prefecture 2014), but none of them are located within the nominated property or buffer zone.

2.b. History and Development

2.b.1. History

The geological history of the nominated property is described in the preceding section 2.a.7.1. This section provides an overview of the history after the emergence of mankind.

The Ryukyu Chain was first populated by mankind in the Paleolithic, or 30,000 years ago, at the latest. Some ancient human bones of the Yamashita Cave Man, discovered in the Yamashita Cave located close to the Naha city center on Okinawa Island, were subjected to a dating process using specimens collected from the site. As a result, they were estimated to date back 32,000 to 37,000 years. An early human settlement estimated to be 30,000–35,000 years old was found in Sakitari-do, another cave located in the southern part of the Okinawa Island. The cave also contained the world's oldest fishhooks and other artifacts, illustrating that people who lived in the cave led a life well adapted to the insular and oceanic environment (Fujita et al. 2016). The bones of the Minatogawa People, unearthed in the southern part of the Okinawa Island, too, were dated through the radioactive carbon dating method and estimated to be 16,000 to 18,000 years old. Geologists say that the Minatogawa People are close to the Jomon people (about 16,500 to 2,300 years ago) in mainland Japan and the Neolithic people from southern China to northern Indochina. There was no earthenware excavated from the ruins, but the People seem to have been able to use fire. (Hokama 1986; Takara 1993; Asato and Doi 1999; Hayaishi 2011).

After the Paleolithic Age, there is a long span of time for which no records exist. In the Ryukyu Chain, the Shell Midden Period apparently started some 6,000 years ago, under the influence of the Jomon culture. The Shell Midden people are considered to have had the ability of using earthenware and ground stones. They seem to have followed a lifestyle similar to that of the Paleolithic Age, sourcing their food from the nature, including seafood from coral reefs and plants and animals from the land (Hokama 1986; Takara 1993). At least by the middle of the Shell Midden Period (some 3,000 years ago), groups of settlements had been established at many locations of the Ryukyu Chain (Asato and Doi 1999; Hayaishi 2011).

Certain studies on animal fossils (Matsuoka 2000; Nakamura and Ota 2015) and analyses of the number of tree species constituting an evergreen broadleaved forest, island area, and forest area (Hattori 2014) suggest that, up to around this Period, evergreen broadleaved forests had been better developed than today in locations other than the nominated property, including the central and southern parts of Okinawa Island, Miyako Island, and other Central and Southern Ryukyu islands. They also suggest that, while these evergreen broadleaved forests provided habitats to species commonly shared with the nominated property (northern part of Okinawa Island and Amami-Oshima Island)—such as mountain-stream frogs, Okinawa woodpeckers, Okinawa rails, Amami jays, and Amami thrushes, increasingly dynamic human activities had caused a significant change in the vegetation and the fauna at such locations.

On Okinawa Island, influential families, who obtained ruling power through battles during the 12th to the 16th centuries and played a role as a local lord, built castles called *Gusuku* for residential and defense purposes, based on the self-defensive rural settlements established during the 10th to the 12th centuries. This period is referred to as the "Gusuku Period". Later, mega-sized Gusukus started to be built, and the Ryukyu Kingdom was established in 1429 (Government of Japan 1996). These Gusukus constitute the Cultural World Heritage, "Gusuku Sites and Related Properties of the Kingdom of Ryukyu." Incidentally, this cultural heritage does not have any overlap with the nominated property.

The Ryukyu Kingdom placed Amami-Oshima Island and Tokunoshima Island under its control by 1447 A.D., and Iriomote Island by 1500 A.D. However, in the 1600s, the Amami Island Group was separated from the Kingdom and belonged to the Satsuma Domain (current Kagoshima and Miyazaki Prefectures).

From 1944 to 1945, Okinawa Island became a World War II battlefield. After the war, the Amami Island Group and Okinawa Prefecture were placed under the administrative authority of the US military. It was in 1953 when the administrative rights were returned to the Amami Island Group and in 1972 to Okinawa Prefecture (Government of Japan 1996; Oshima Branch Office, Kagoshima Prefecture 2014). In 1953, when the US military had the administrative authority, the United States Civil Administration of the Ryukyu Islands promulgated the "Land Acquisition Procedure" and seized land in the main areas of the prefecture to construct military bases. As a result, as of 1972, the area of the US military installations located within the prefecture was as large as 28,660.8 ha, or approximately 12% of the prefecture's land area (Military Base Affairs Division, Executive Office of the Governor, Okinawa Prefecture, 2016).

The US military bases in Okinawa Prefecture have reduced approximately 34% since the prefecture's return to Japan. As of December 2016, the US military bases within Okinawa Prefecture cover an area of 18,822 ha, which accounts for 8% of the prefecture's total area. In particular, the US military installations in Kunigami Village and Higashi Village, located in the northern part of Okinawa Island containing the nominated property, occupy an area of 1,446 ha (7% of the village's land) and 2,267 ha (28% of the village's land), respectively. Much of the areas, or 3,658 ha, is used for the Camp Gonsalves (also known as Northern Training Area).

After the return of the Amami Island Group to Japan, a series of projects for reconstruction, growth, promotion, and development were launched for the area under special measures acts and plans based thereon, in light of its historical background and the gap with the mainland arising from its geographical and natural constraints (Table 2-36). Also in Okinawa Prefecture, promotion, development and growth projects were undertaken in accordance with special measures acts and plans based thereon in light of its historical background, the gap with the mainland arising from its geographical and natural constraints, as well as its societal circumstances, including the concentration of the US military installations.

As a result of recent legal revisions, the responsibility to develop promotion and development plans was transferred from the central government to the two prefectural governments, and relevant local municipalities developed plans on their own initiative with the participation of local residents (Okinawa Prefecture 2012; Kagoshima Prefecture 2014). These plans explicitly states their commitment to engaging in various measures designed to properly conserve and make the best use of the natural environment so that the value of the property as a natural World Heritage candidate will be preserved for the future. These plans have accomplished certain results in facilitating tourism promotion and exchange activities designed to achieve a shift to self-sustaining development while conserving the local natural environment and respecting traditional culture.

Nakama River, Iriomote Island (Photo: MOEJ)

Table 2-36: History of Special Measures Acts in Amami Island Group and Okinawa Prefecture

	Amami Island Group (Kagoshima Pref.)		Okinawa Pref.	
	Amami-Oshima Island	Tokunoshima Island	Northern part of Okinawa Island	Iriomote Island
1953	Amami Island Group returned to Japan		–	
1954	Act on Special Measures concerning the Reconstruction of the Amami Island Group (The Act has been amended and extended about every five years.)		–	
1964	Act on Special Measures concerning the Promotion of the Amami Island Group (renamed)		–	
1971	–		Act on Special Measures concerning the Promotion and Development of Okinawa (The Act has been amended and extended about every five years.)	
1972	–		Okinawa Prefecture returned to Japan	
1974	Act on Special Measures concerning the Promotion and Development of the Amami Island Group (renamed)		–	
2002	–		Act on Special Measures for the Promotion of Okinawa (renamed)	

"Sinugu" ceremony in Ada Village of northern part of Okinawa Island. One of the traditional events derived from local people's deep involvement in nature (see Column 6) (Photo: MOEJ)

Column 6. Local residents' traditional view of nature and landscape

The forests of the nominated property include only small areas of pure primeval sub-tropical rainforests, and most of them have been exposed to a certain level of human interference since old times. Still, they provide nurseries and habitats for a number of highly-endemic, rare species of plants and animals. The factors making this possible are local residents' recognition about nature and landscape, which they have fostered, over a long period of time, by making use of natural resources including endemic plants and animals in their daily life, their way of interacting with nature based on the recognition, and their lifestyle and culture they have developed therefrom and handed over from generation to generation (Environment Agency 1999; Kagoshima Prefecture 2003; Kagoshima University 2013).

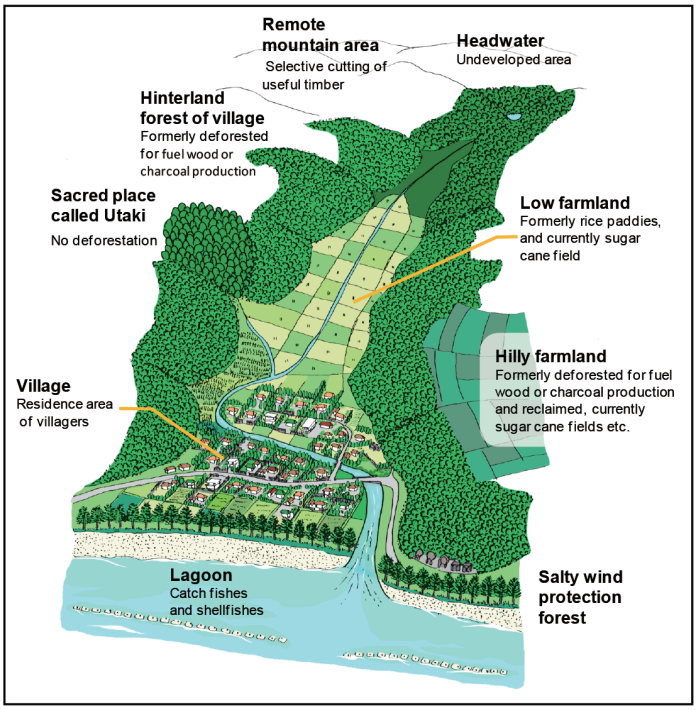


Figure 2-23: Schematic view of northern part of Okinawa Island's village and use of lands
Source: Nago City History Compilation Committee (1988)

Traditionally, people on the Central and South Ryukyus led their life in a close relationship with the surrounding nature. Their villages were unable to be separated from the sea and surrounding mountains in the sense that a village served as the basis of villagers' activities. They caught fish and shellfish in the sea in front of the village, washed things and caught Tanaga (a dialect of Tenaga-ebi, or freshwater prawn), cultivated land in the fields and mountains behind the village, and collected firewood and lumber therefrom as a way of living.

People believed that, beyond the sea, there was a paradise where gods lived (called by different names depending on the region, such as Neriya-Kanaya, Nirai Kanai, Ryugu, etc.), and the gods brought fertility and disaster to the people. During the age of the Ryukyu Kingdom, the "Noro" system was established. A Noro (which means a priestess) was in charge of performing rituals, farming rites and annual events to welcome gods and send them back. Various types of events and performing arts that are presumed to have been created in that era remain as the village's tradition, although they have been simplified and affected by the phenomenon of depopulation associated with the ageing of the local population and the declining number of young people. These traditional events and arts constitute the culture that is deeply rooted in the natural environment and is still prevalent.

In addition, religious beliefs have also influenced the structure of villages. For example, in the northern part of Okinawa Island, it was believed that gods, after welcomed by a Noro, would descend to a mountain, and then come down to the village along the mountain's ridge line. With such a belief, people imagined a sacred space composed of a Kami-yama (the mountain to which gods descend), Kami-michi (the road through which gods come to their village), and Myah (an open space located at the village centre to perform rituals) and formed a space (landscape) of their village as an integral part of the ocean in front of it and mountains behind it. A village faces the sea along the axis of a water system, and is separated from neighbouring villages by mountain ridges. Within the village, there are stone walls made of coral limestone and windbreak hedges made of Fukugi trees, which have been maintained

to protect houses from typhoons and tidewater damage (Figure 2-23). These traditional village landscapes are relatively well preserved in the north of Okinawa Island.

A village's lands have been used rationally for diffrent purposes, divided into the cultivation area, the fuel wood area, the building materials are, and the undeveloped remote headwaters area, which were placed in a concentric circle centred on the village. Such land use is based on a space concept focused on the protection of headwater areas. People who were engaged in forestry work designated the "day of the god of mountains" to express their gratitude to mountain gods, and observed the custom of staying away from mountains on the day. Such taboos and rules were designed to control access to a sacred domain, and created myths about encounters with holy spirits (called by different names depending on the region, such as Kenmun, Kijimunah, Bunagaya, etc.) and gods of mountains, as well as the existence of divine spaces. These myths have been handed down and protected among villagers in a variety of forms.

In this way, on the Central and South Ryukyus, people recognize that all the surrounding mountains, forests, and the sea are part of their sphere of life and this natural environment plays an integral role in their lives.

2.b.2. History of major industries

2.b.2.1. Agriculture

1) Amami-Oshima Island and Tokunoshima Island

The municipalities of the Amami Island Group, including Amami-Oshima Island and Tokunoshima Island of the nominated property, implemented land improvement projects during both the prewar and the postwar periods, mainly with the aim of improving paddy fields and promoting rice cultivation. As of 1953, when the Amami Island Group was returned to Japan, the arable land area of the Island Group as a whole was 16,376 ha, which was not enough to provide stable agricultural production. In order to improve the poor land conditions swiftly and ensure the stability of farm management, municipalities carried out the development of agricultural infrastructure through reconstruction and promotion projects from 1954 onward. The paddy field area was reduced from 4,252 ha in 1963 to 87 ha in 1998 for such factors as the special measure projects designed to convert paddies into dry fields, ageing of farmers, reversion of paddy fields to wild land due to lack of successors. On the contrary, dry fields cover 16,800 ha, accounting for 99.4% of the total cultivated land. Currently, the main crop of the Island Group is sugar cane. Cultivation of vegetables, flowers, and fruits is also carried out in addition to animal husbandry (Oshima Branch Office, Kagoshima Prefecture 2014).

2) Okinawa Island and Iriomote Island

The arable land area across Okinawa Prefecture was 45,940 ha as of 1972, the year when the prefecture was returned to Japan. Arable land continued to decrease up until 1977 due to the influence of land conversion associated with the Okinawa Ocean Expo and the buying up of land by businesses. However, from 1978 onward, the arable land area began to increase owing to government-subsidised farmland/grassland development projects and the buying back of farmland lost through the buying up, before reaching a post-return high of 47,100 ha in 1992. However, after that, the arable land area continued to decrease, affected by the increasingly severe agricultural environment surrounding Okinawa Prefecture, such as import liberalization of canned pineapples and pineapple juice, and increased abandonment of cultivated land by aged farmers. As a result, the arable land area diminished to 38,900 ha in 2012. By land type, paddy fields decreased by 65% (1,590 ha) from 2,440 ha in

1972 to 851 ha in 2012. Similarly, dry fields decreased by 12% (5,400ha) from 43,500 ha to 38,100 ha. What is to be noted here is that pasture land increased by 1,260% (5,500 ha), while fruit tree orchards decreased by 65% (3,800 ha) (Okinawa General Bureau, Cabinet Office, Government of Japan 2012).

2.b.2.2. Forestry

In the Central and South Ryukyus, firewood has long been used in daily life, and for the production of salt, sugar, and dried bonito, etc. Also, timber, railroad ties, and charcoals for shipment have been produced from forests. In recent years, construction materials such as structural materials for buildings and laminated woods, as well as wood chips for muchroom production and livestock raisingare are the main forest products.

Castanopsis (*Castanopsis sieboldii*), which characterizes the region's subtropical rainforest, has a great capacity for sprouting and regeneration, and enables to balance forestry with conservation of landscapes and biodiversity (See Column 5: Resilient forest dominated by Castanopsis).

1) Amami-Oshima and Tokunoshima Islands

As the government took measures in line with its promotion plan to develop industry and social infrastructure in the Amami Island Group, following their reversion to Japan in 1953. Part of Amami-Oshima and Tokunoshima Islands was deforested to develop farmland and construct dams and roads. At the same time, forestry was developed primarily in prirvate forests in Amami-Oshima Island. Wood chips have been produced since the 1960s, leveraging natural regeneration of evergreen broadleaved trees, which takes place on a 35- to 45-year cycle. The timber production, however, has decreased by one half (about 0.1 million m^3) after peaking (about 0.2 million m^3) in the early 1970s, with no logging conducted on a large scale since the mid-1990s (Yoneda 2016).

Agriculture has long been an important industry in Tokunoshima Island, where forest resources are used in the daily life of local communities. With no industrial forestry, main forest products still constitute a major part of the island's forestry production. Timber production has dropped to almost one twentieth in recent years, from approximately 8,400 m^3 in the early 1970's (Shinohara 1975) to current 480 m^3. Moreover, forestry production today is mostly limited to main forest products. Therefore, most of the highland forests in the nominated region are maintained in good condition (Kyushu Regional Forest Office, Forestry Agency 2010).

2) Okinawa and Iriomote Island

The government took measures in line with its promotion plan to develop industry and social infrastructure in Okinawa Prefecture as well, following its reversion to Japan in 1972. As a result, part of Okinawa Island was also deforested to develop farmland and construct dams and roads. On the other hand, prefectural and municipal forests played a key role in developing forestry, with raising of seedling and afforestation done in parallel with logging and timber production. In fact, the forests in the northern part of Okinawa Island have recovered from the devastation in the postwar reconstruction period and are in better condition than ever before (Forest and Greenery Division, Agriculture, Forestry and Fisheries Department, Okinawa Prefecture 2013).

Iriomote Island, where malaria was once rampant, although it is now declared malaria-free, had long been unsuitable for settlement, which inhibited its development. For the most part, forest resources are used in the

daily life of local communities. With no industrial forestry, Iriomote Island remains largely intact with rich natural surroundings (Marusugi 1994, Kagoshima University 2013).

Column 7. *Somayama* system

In the 18th century, the Ryukyu Kingdom Government introduced the *Somayama* system through establishment of forest policy regulations regarding forest management and use. The government was also engaged in the protection, fostering, and recovery of forests in the northern part of Okinawa Island.

The *Somayama* system was intended to allow local residents to undertake the management of government-owned lands, and at the same time use the lands to a certain extent (Forest and Greenery Division, Department of Agriculture, Forestry and Fisheries, Okinawa Prefecture 2013). Furthermore, the government redrew boundaries between administrative districts to allocate forests and mountains to each district (Miwa 2011), established management rules and limitations as well as penalties for violations, developed hierarchical monitoring system, and implemented various systems including the "Mountain Game," in which villages competed with each other for forestry business performance (Nakama 1984). The government also provided a wide range of technical guidance concerning forest management. It has been confirmed that in the northern part of Okinawa Island, these systems had been maintained in a self-sustaining way almost up until the return of Okinawa Prefecture to Japan in 1972. It is believed that local communities had used and made necessary changes to these systems and practices to better manage their own resources (Miwa 2011).

Flowers of *Castanopsis sieboldii* (Photo: MOEJ)

Riparian forest, Tokunoshima Island (Photo: MOEJ)