資料２－１

Draft Nomination of the

OGASAWARA ISLANDS

for Inscription on the World Heritage List

GOVERNMENT OF JAPAN

November 2009

CONTENTS

Executive Summary

Country

Japan

State, Province or Region

Tokyo

Name of Property

Ogasawara Islands

Geographical coordinates to the nearest second

The center point for the geographic coordinates:

N : 25°58′36.37″ E : 141°33′39.46″

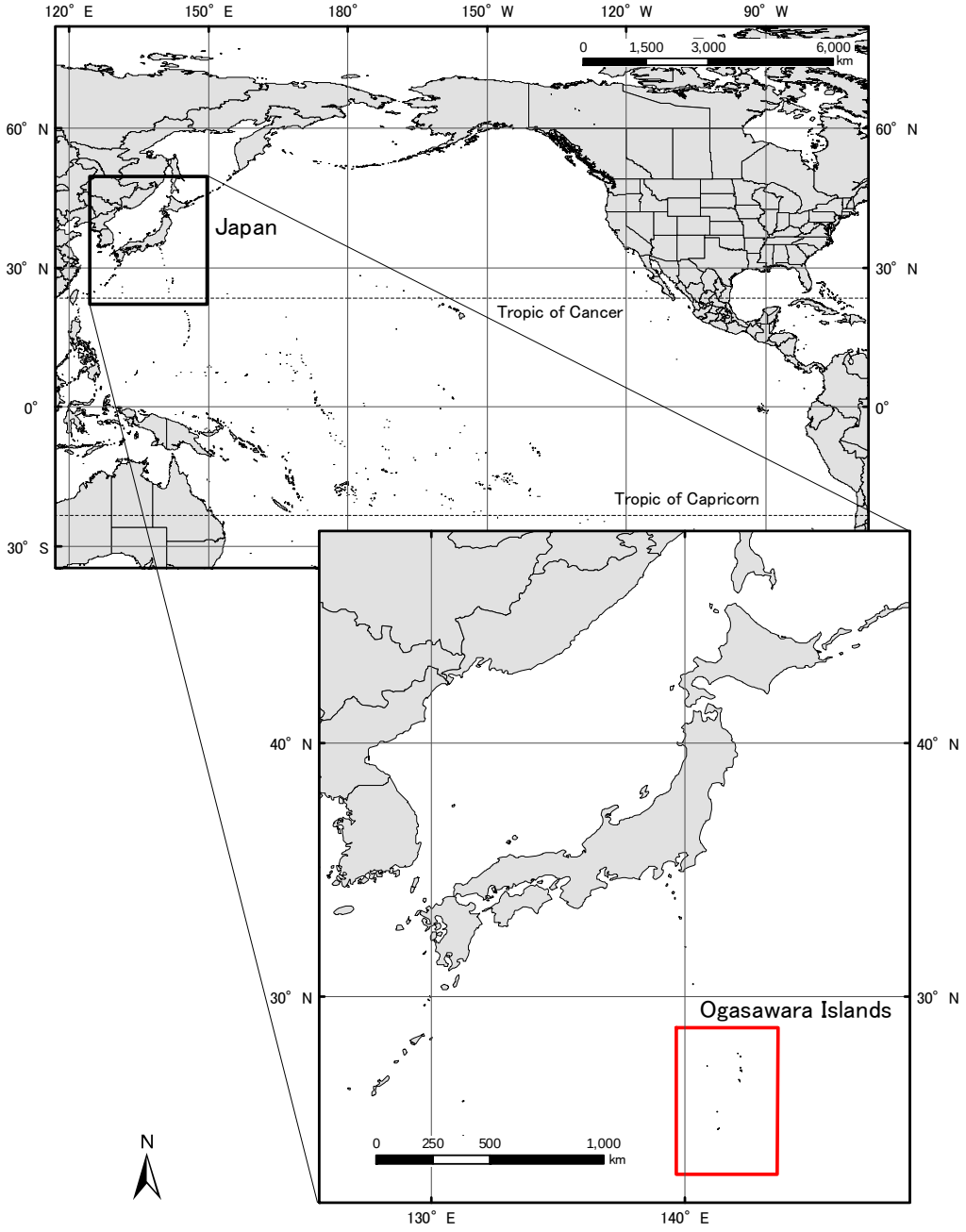
The outer boundaries:

N : 24°13′28.87″ - 27°43′43.87″

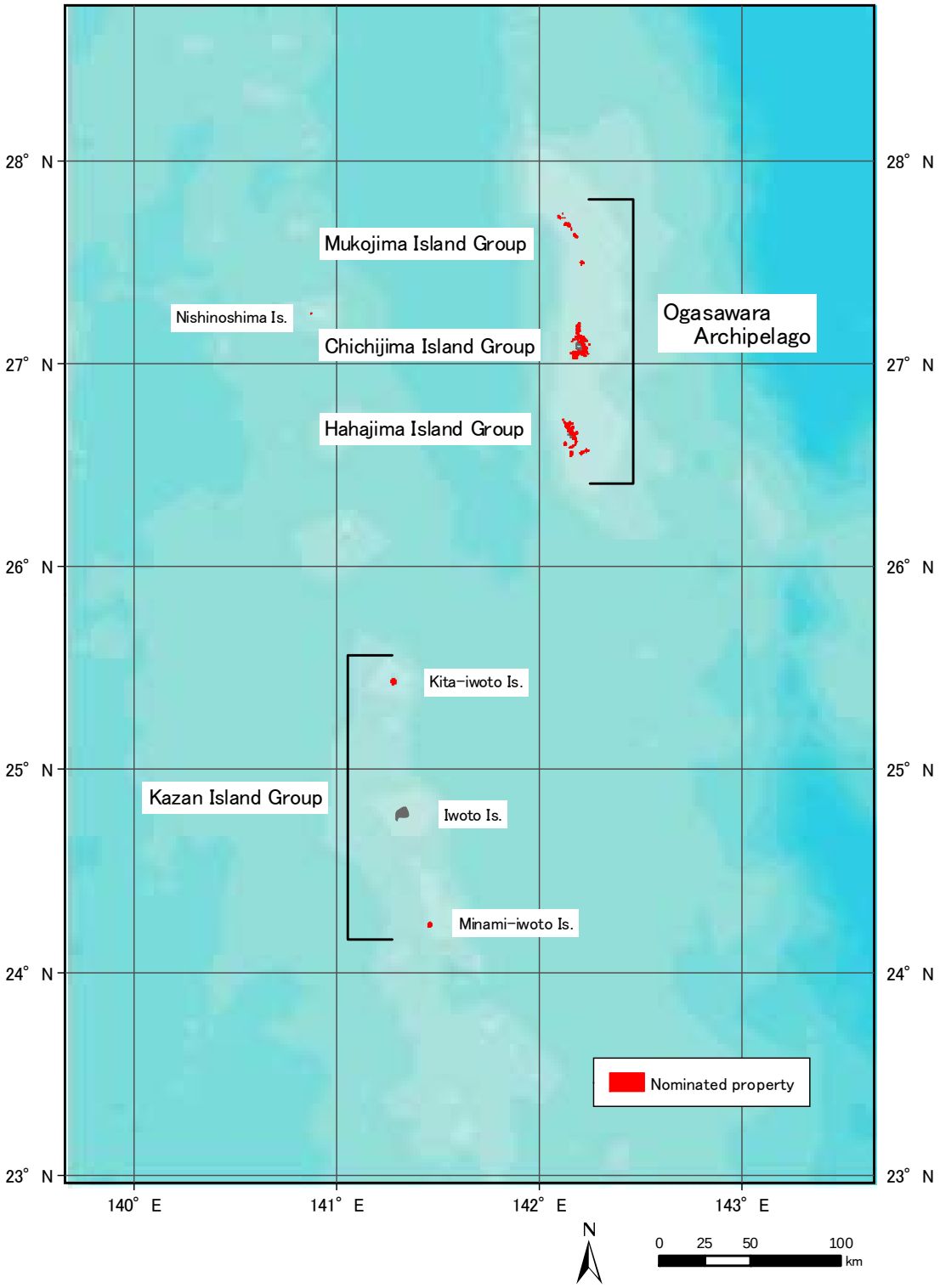
E : 140°52′20.87″ - 142°14′58.05″

Textual description of the boundary of the nominated property

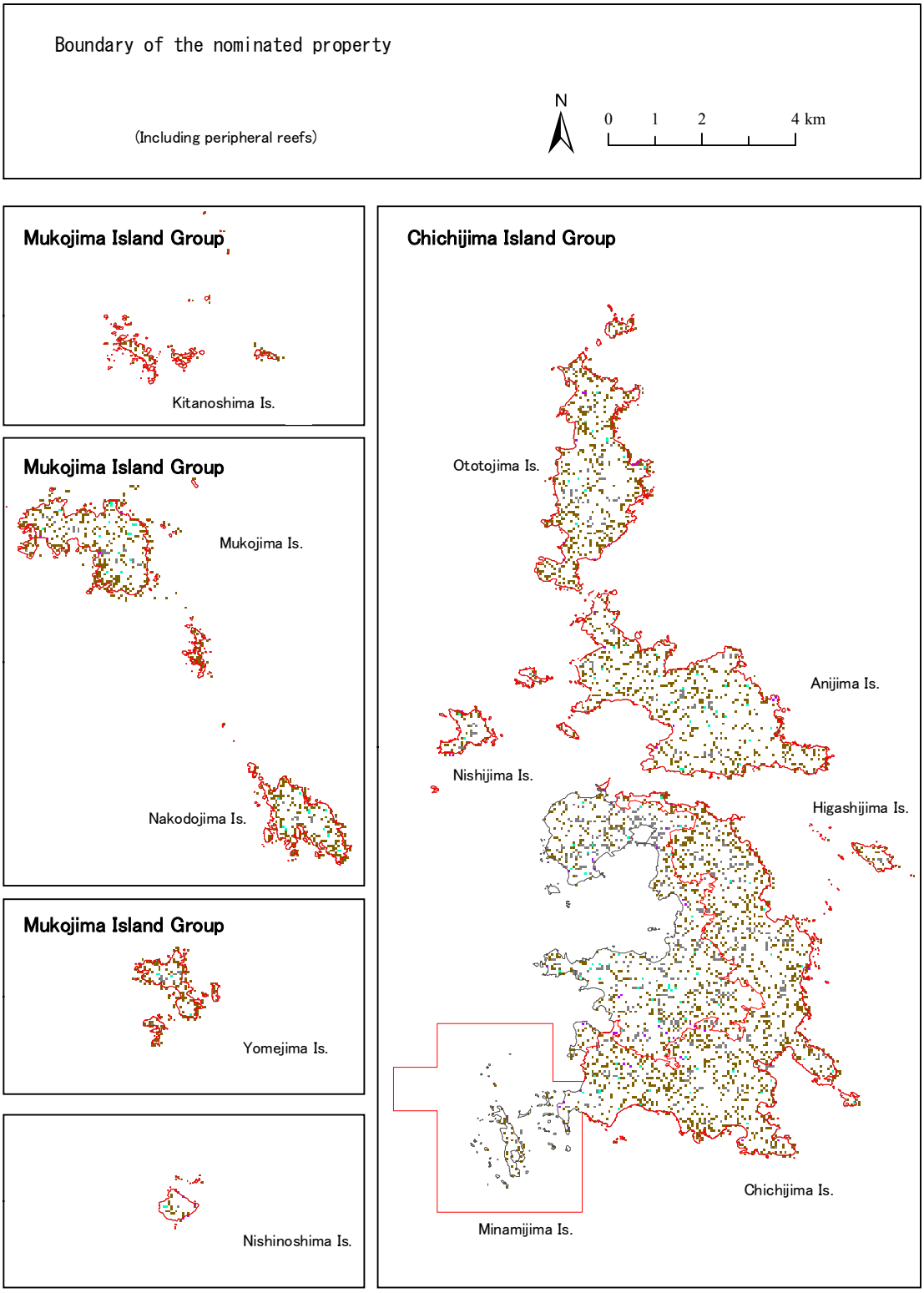
The nominated property located in the Western Pacific to the north of the Tropic of Cancer and 1,000 km south of the Japanese archipelago. It extends about 400 km from north to south and comprises more than 30 small islands. The nominated property covers, from north to south, the three island groups of Ogasawara archipelago, which are the Mukojima, Chichijima, and Hahajima Island Groups, Kita-iwoto and Minami-iwoto Islands, that are part of the Kazan Island Group, and the isolated Nishinoshima Island, which is situated to the west of Ogasawara archipelago. The whole terrestrial areas of the islands except for Chichijima and Hahajima Islands, of which some parts are excluded, and some marine areas surrounding a part of Chichijima are included in the nominated property (see the map showing the boundary). The terrestrial area is about 6,358ha, the marine area about 1,050ha, and the total area is about 7,408ha.



Location map of the nominated property in the Pacific Ocean



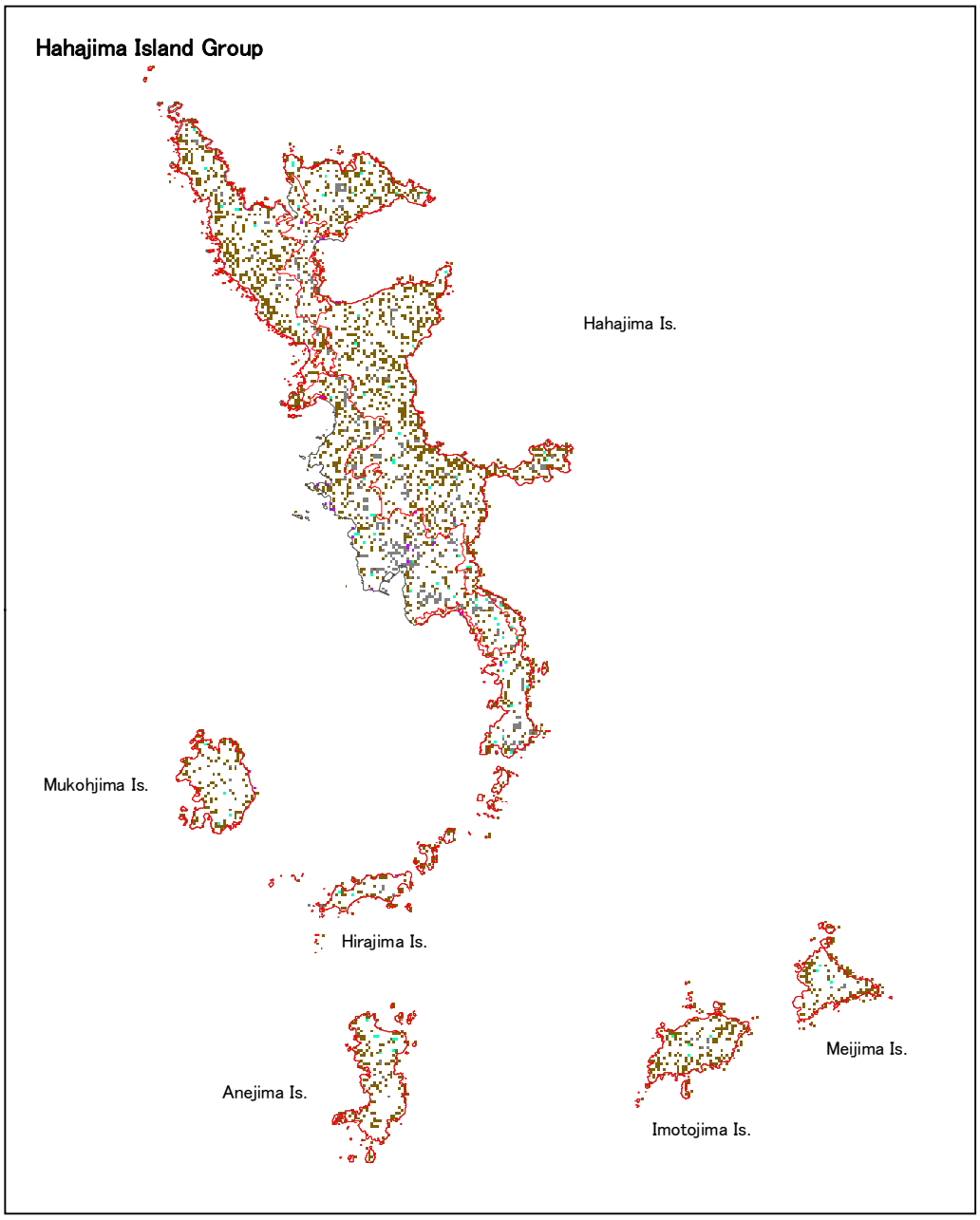
Location map of the nominated property

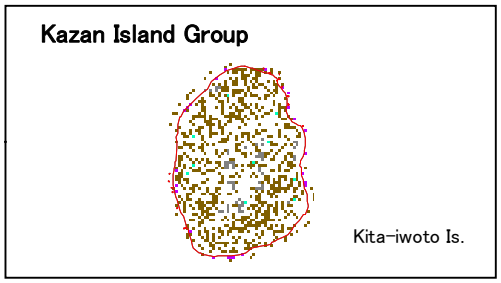


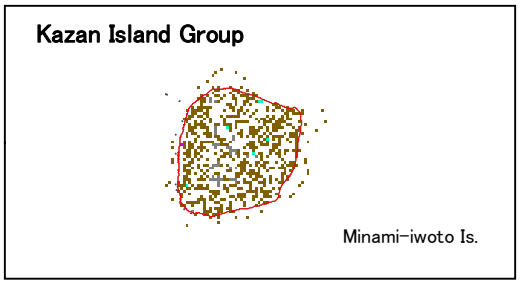
Boundary of the nominated property

(Mukojima, Chichijima Island Groups and Nishinoshima)

(Source: 'Yokosuka' Geographic Information (1/25,000) of Geographical Survey Institute)







Boundary of the nominated property

(Hahajima Island Group, Kita-iwoto and Minami-iwoto)

(Source: 'Yokosuka' Geographic Information (1/25,000) of Geographical Survey Institute)

Justification – Statement of Outstanding Universal Value

The Ogasawara Islands are oceanic islands located 1,000 km away from the main islands of Japan. Geologically, the islands are unique in the world in that they provide a rare opportunity to directly observe, on land, the normally hard-to-observe phases of the development of an oceanic island arc. Their large areas of exposed rock strata tell the tectonic story from the beginning of plate subduction 48 million years ago, through transitional periods, and into a stable phase 40 million years ago. The islands are the subject of the world's latest research into the development of oceanic island arcs, and are extremely valuable from a scientific perspective in that they provide insights into the evolutionary history of the earth, especially the mechanisms behind the formation of continents.

Biologically and ecologically, the Ogasawara Islands are peculiar island ecosystems with many endemic species as a result of unique processes of adaptive radiation and speciation on the oceanic islands. The Ogasawara Islands preserve the common characteristics of isolated oceanic islands, and offer the opportunity to witness the ongoing evolutionary process of speciation. They are also valuable as one of the few isolated land masses in the northwest Pacific region conserving globally significant species, making it very important to maintain this characteristic island ecosystem.

In short, the Ogasawara Islands preserve a valuable source of information on the evolution of the earth and the life on it.

Criteria under which property is nominated

The Ogasawara Islands are an oceanic island arc that formed on oceanic crust, far from any continent, and the property meets criteria (viii), (ix), and (x) as specified in paragraph 77 of the Operational Guidelines.

Criterion (viii)

The Ogasawara Islands provide a unique insight into the initial phases of the process of continent formation, a process which repeatedly took place in the Earth's geological history. More specifically, this is a process how oceanic island arcs began to form and took shape in response to the initiation of subduction beneath an oceanic plate. A series of varying volcanic activities and magma compositions records the evolutionary process from a juvenile oceanic arc to an establishment of a stable subduction zone with continental middle crust. The Ogasawara Islands are the only place on earth that preserve perfect exposures on land of the evolutionary processes of an island arc over millions of years, being an outstanding example

presenting significant on-going geological processes. This unique area continues to contribute to elucidating the mechanisms involved in continent formation throughout the earth's history.

Criterion (ix)

On the Ogasawara Islands, one can observe the process of unique speciation resulting from various mode of evolution including long-term isolated evolution and adaptive radiation, and the islands have high level of endemism. The Ogasawara Islands are an outstanding example of the ongoing evolutionary processes in oceanic island ecosystems. For example, the prominent examples of speciation through adaptive radiation are seen among the land snails. The various mode of speciation showing the characteristic evolution on oceanic islands are seen in the plant species. Further, the Ogasawara Islands have important examples indicating how some marine species evolved into terrestrial species.

It also shows distinctive characteristics of oceanic island ecosystems such as taxonomic disharmony, and Minami-iwoto Island is maintaining a precious pristine state. Because of all these interesting ecological characteristics on the Ogasawara Islands, researches into evolutionary processes in oceanic islands are on-going in various fields.

Criterion (x)

The Ogasawara Islands have a rich diversity of species of fauna and flora including endemic ones within a limited area of land, and provide habitats for many endangered species of global significance. The islands are invaluable for the conservation of biodiversity in the northwest Pacific region.

Even within the islands of the whole Ogasawara Archipelago, there are pronounced differences in ecological conditions. The diverse climatic conditions and topographical features have facilitated the formation of unique ecosystems for each island group. Also, the origins of biota reaching the Ogasawara Islands are quite diverse, including from Oceania, Southeast Asia, and the main island of Japan. Thus, a diverse biota has uniquely evolved in these isolated islands, and the Ogasawara Islands have a large number of species of fauna and flora per unit area of land, including many endemic and rare species.

The Ogasawara Islands also provide irreplaceable habitats for endangered species such as the Bonin flying fox, the black-footed albatross, an endemic dragonfly *Boninthemis insularis*, and an endemic land snail *Hirasea chichijimana*.

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  Web address：http://www.vill.ogasawara.tokyo.jp

1. Identification of the Property

1.a Country

1.b State, Province or Region

1.c Name of the Property

1.d Geographical coordinates to the nearest second

1.e Maps showing the boundaries of the nominated property

1.f Area of the nominated property

1.a Country

Japan

1.b State, Province or Region

Tokyo

1.c Name of the Property

Ogasawara Islands

1.d Geographical coordinates to the nearest second

The “Ogasawara Islands” is a term that collectively refers to groups of islands located at the north of the Tropic of Cancer in the Western Pacific, 1,000 km south of the Japanese archipelago. The islands comprise more than 30 islands extending about 400 km from north to south (Fig 1-1). They consist of the Ogasawara Archipelago, the Kazan Island Group and several isolated islands. The Ogasawara Archipelago is composed of the three island groups, i.e. Mukojima, Chichijima and Hahajima Island Groups, while the Kazan Island Group consists of Kita-iwoto Island, Iwoto Island, and Minami-iwoto Island

The nominated property covers, from north to south, the Ogasawara Archipelago, Kita-iwoto and Minami-iwoto, and the isolated Nishinoshima Island, which is situated to the west of Ogasawara Archipelago (Fig. 1-2).

The location (latitude & longitude) and area of each element of the nominated property are shown in Table 1-1.

Table 1-1 Latitude / longitude and area of islands in the nominated property

Name of Archipelago / Island Group	Name of island	Coordinates for the centre point of the main island		Area (ha)
		Latitude	Longitude	
Ogasawara Archipelago				
Mukojima Island Group	Kitanosima and peripheral reefs	N27°43′06″	E142°05′59″	33.58
	Mukojima and peripheral reefs	N27°40′52″	E142°08′20″	284.66
	Nakodojima and peripheral reefs	N27°37′40″	E142°10′42″	146.94
	Yomejima and peripheral reefs	N27°29′47″	E142°12′38″	77.36
Subtotal		N27°36′26″	E142°09′18″	542.55

Name of Archipelago / Island Group	Name of island	Coordinates for the centre point of the main island		Area (ha)
		Latitude	Longitude	
Chichijima Island Group	Ototojima and peripheral reefs	N27°09′59″	E142°11′27″	536.04
	Anijima and peripheral reefs	N27°07′21″	E142°12′35″	811.62
	Some parts of Chichijima and peripheral reefs	N27°04′12″	E142°12′33″	1,410.30
	Nishijima and peripheral reefs	N27°07′02″	E142°10′00″	51.07
	Higashijima and peripheral reefs	N27°05′36″	E142°14′42″	25.61
	Minamijima and peripheral reefs	N27°02′18″	E142°10′30″	33.24
	Sea area			1,050.31
Subtotal		N27°06′08″	E142°12′21″	3,918.19
Hahajima Island Group	Some parts of Hahajima and peripheral reefs	N26°40′01″	E142°09′20″	1,419.49
	Mukohjima and peripheral reefs	N26°36′11″	E142°07′47″	143.75
	Hirajima and peripheral reefs	N26°35′07″	E142°09′18″	63.93
	Meijima and peripheral reefs	N26°34′10″	E142°13′54″	93.63
	Anejima and peripheral reefs	N26°33′15″	E142°09′23″	153.45
	Imotojima and peripheral reefs	N26°33′33″	E142°12′35″	130.77
Subtotal		N26°36′38″	E142°10′50″	2,005.01
Total		N27°08′10″	E142°10′21″	6,465.76
Kazan Island Group	Kita-iwoto and peripheral reefs	N25°25′60″	E141°16′56″	557.21
	Minami-iwoto	N24°14′06″	E141°27′45″	354.59
Total		N24°50′03″	E141°22′21″	911.79
Nishinoshima and peripheral reefs		N27°14′48″	E140°52′33″	30.04
Whole the Ogasawara Islands				7,407.59

1.e Maps showing the boundaries of the nominated property

The nominated property covers areas with outstanding natural environments, such as outcrops of important rocks, ecosystems unique to the oceanic islands, and habitats of many endemic or rare species, that are protected by stringent legal protection regulations. The

scope of the nominated property is shown in topographical maps (Figs. 1-3, 1-4) and the boundaries of protected areas are shown in Fig. 1-5.

1.f Area of the nominated property

The terrestrial area of the nominated property totals about 6,358 ha. The breakdown is as follows:

- Mukojima Island Group: 543 ha;
- Chichijima Island Group: 2,868 ha;
- Hahajima Island Group: 2,005 ha;
- Kazan Island Group: 912 ha;
- Nishinoshima and peripheral reefs: 30 ha.

Part of the nominated property includes a marine area of about 1,050 ha. The total area of the nominated property is about 7,408 ha (Table 1-1).

Residential and some other areas on inhabited Chichijima and Hahajima are excluded from the nominated property. The nominated property represents approximately 60% and 70% of Chichijima and Hahajima in area respectively.

Areas surrounding the nominated property are under the regulations stipulated by the National Parks Law. Furthermore, the property, together with its outside areas, is being properly managed in accordance with the Ogasawara Islands Management Plan (hereinafter referred to as “Management Plan”, see 5.e). For example, measures to prevent invasion by alien species are implemented in areas both inside and outside the nominated property. For this reason, the areas inside and outside of the nominated property within the scope of the Management Plan have been designated as the main scope of the Management Plan or the “World Heritage Management Area” (Fig. 1-6), instead of designating areas outside of the nominated property as buffer zones. The area is centered at the Ogasawara Archipelago with surrounding waters of three to five kilometers off the coast. The area occupies approximately 129,360 ha, including the nominated property.

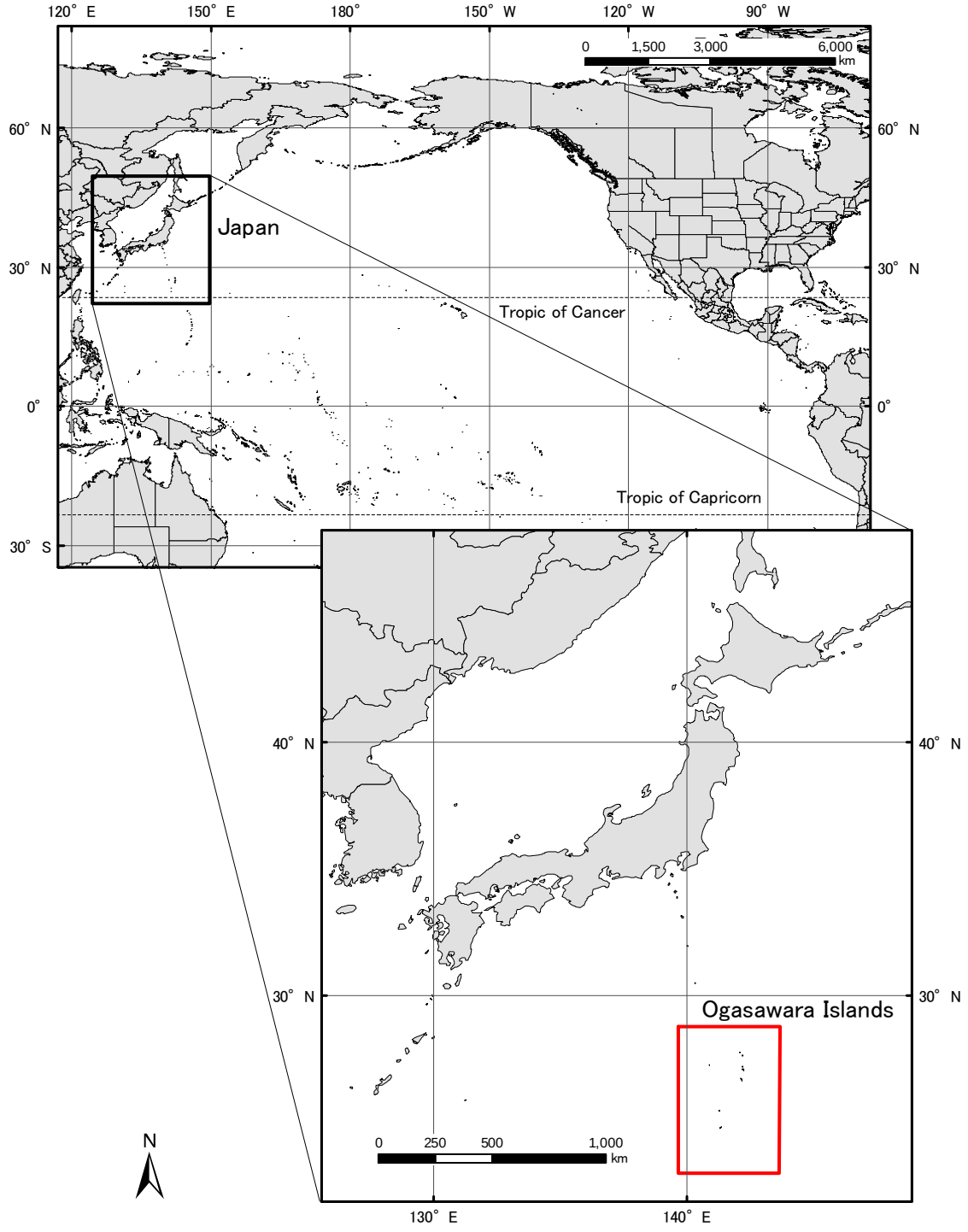


Fig. 1-1 Location map of the Ogasawara Islands

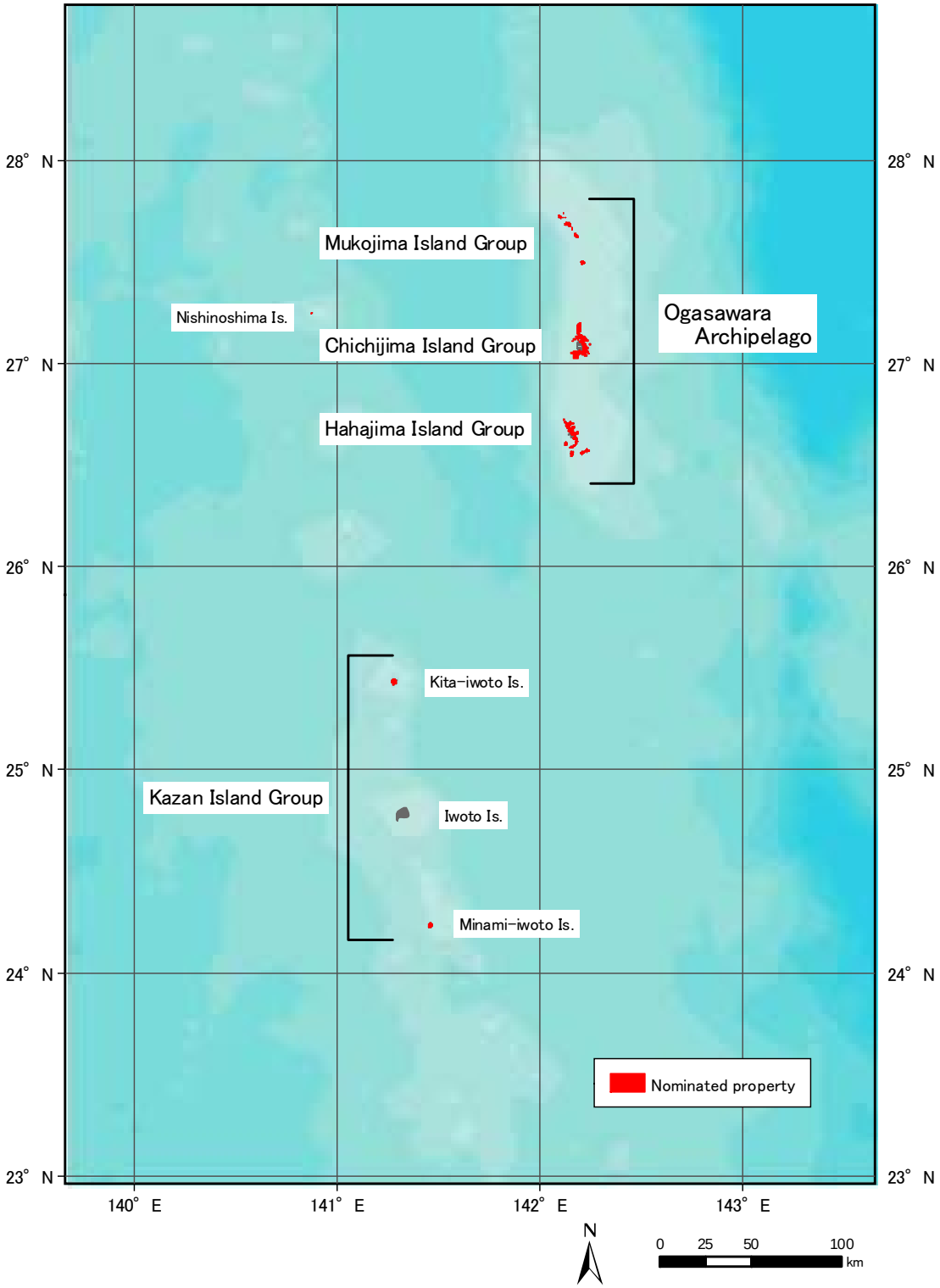


Fig. 1-2 Location of each Island Group in the Ogasawara Islands

(Source: USGS, ESRI, TANA, AND)

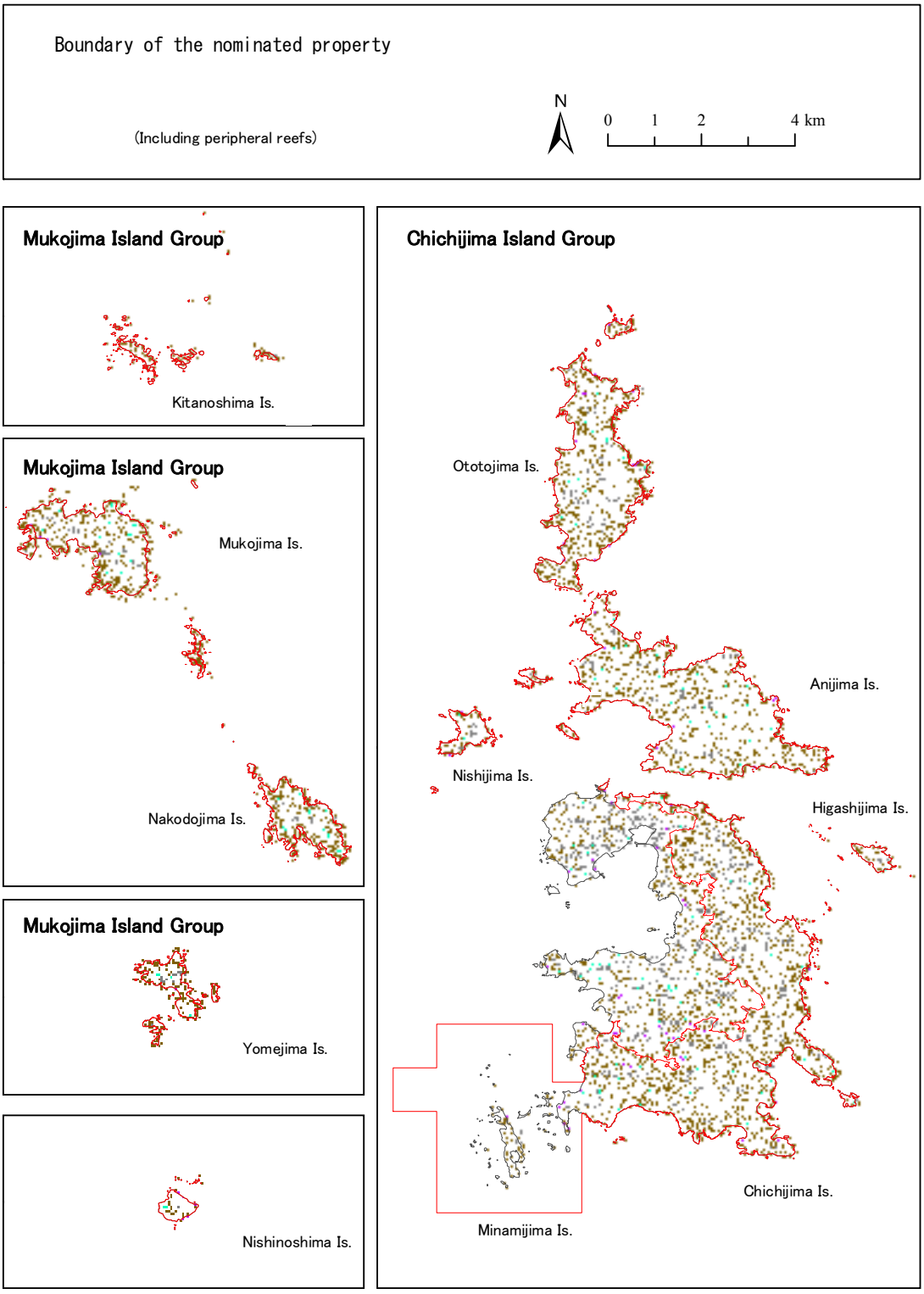


Fig. 1-3 Boundary of the nominated property
(Mukojima, Chichijima Island Groups and Nishinoshima)
(Source: 'Yokosuka' Geographic Information (1/25,000) of Geographical Survey Institute)

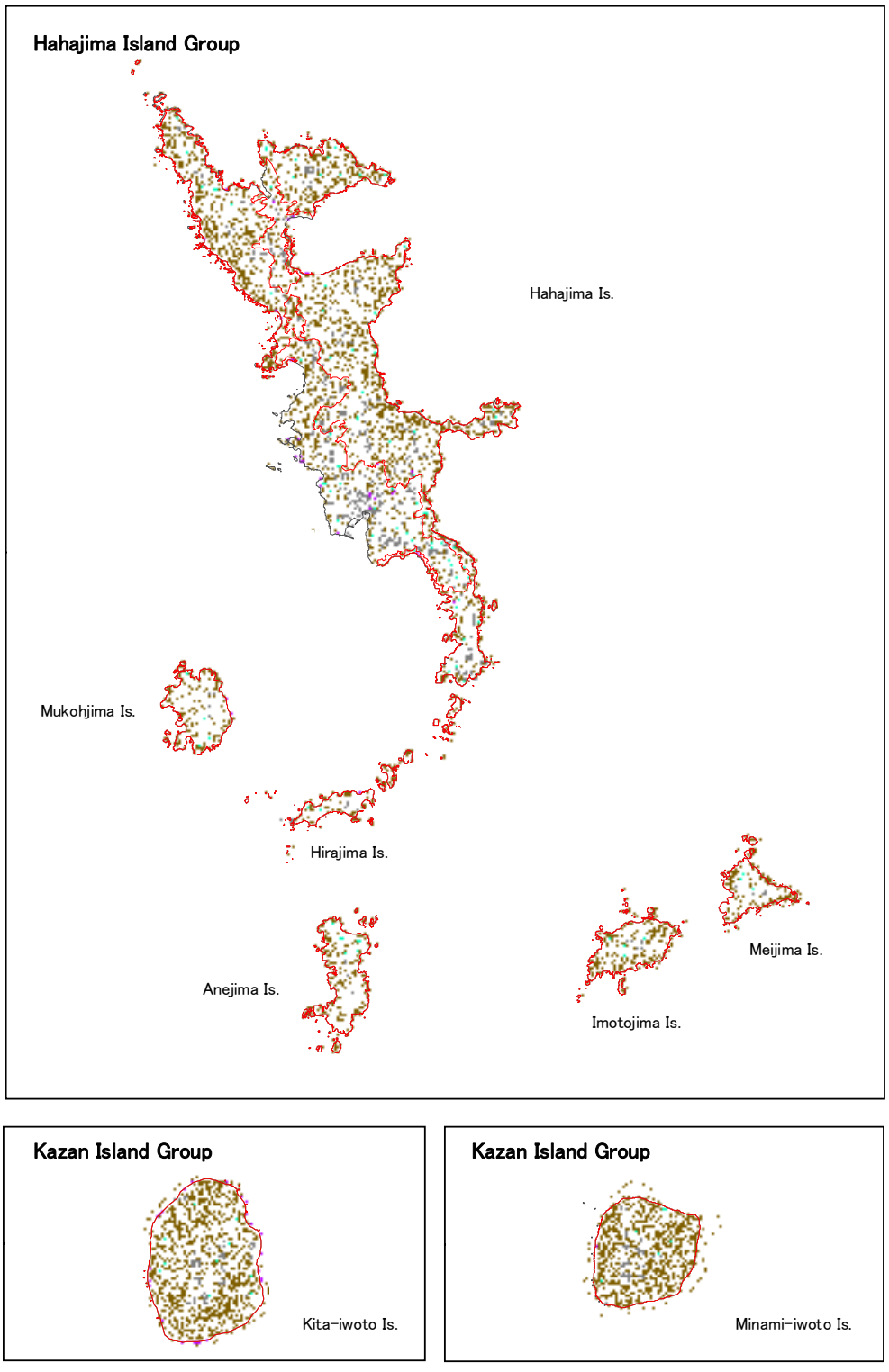


Fig. 1-4 Boundary of the nominated property

(Hahajima Island Group, Kita-iwoto and Minami-iwoto)

(Source: 'Yokosuka' Geographic Information (1/25,000) of Geographical Survey Institute)

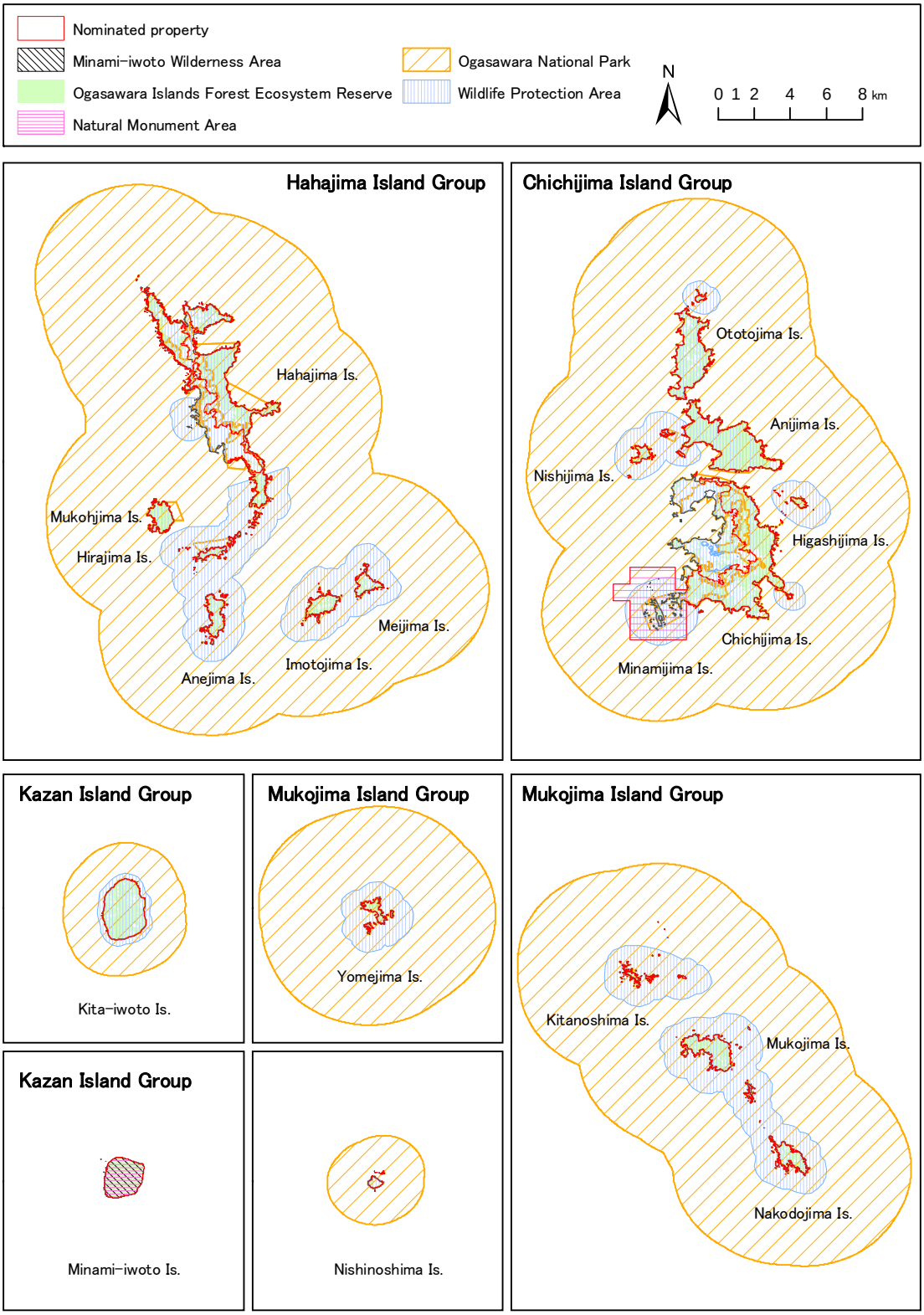


Fig 1-5 State of legal protection

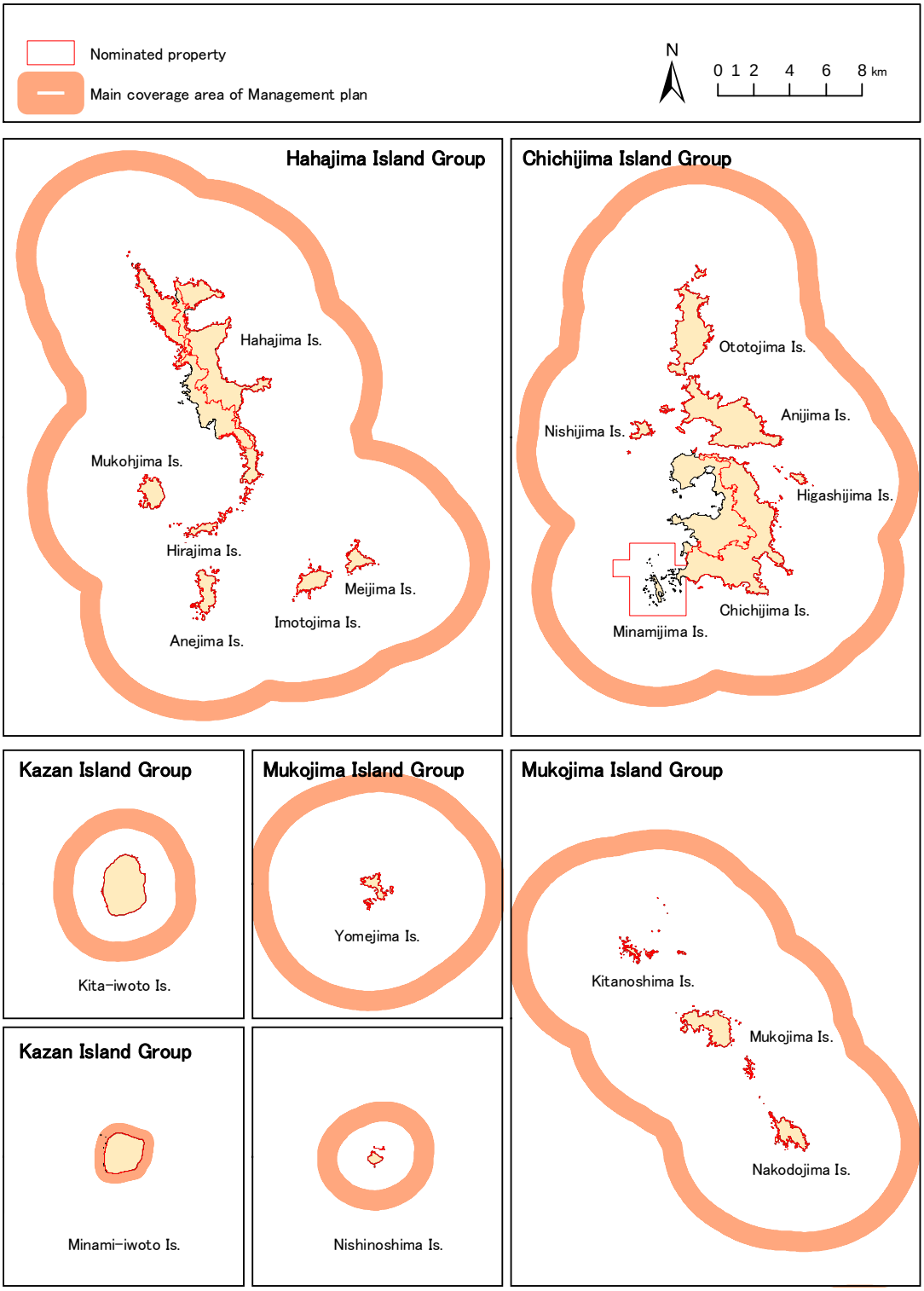


Fig 1-6 World Heritage Management Area

- Main scope of the Management Plan-

2. Description

2.a Description of Property

2.a.1 Geological features

2.a.2 Climate

2.a.3 Plants

2.a.4 Animals

2.a.4.1 Mammals

2.a.4.2 Birds

2.a.4.3 Reptiles

2.a.4.4 Aquatic animals (except mammals)

2.a.4.5 Insects

2.a.4.6 Land snails

2.a.4.7 Other invertebrates of note (soil animals)

2.b History and development

2.b.1 History

2.b.2 Interactions with humans (industry)

2.a Description of Property

2.a.1 Geological features

The Ogasawara Islands make up an oceanic island arc that was formed on an oceanic crust (Fig. 2-1). The Izu-Ogasawara (Bonin) Arc, on which the Ogasawara Archipelago and the Kazan Island Group rest, is an island arc-trench system extending 1,500 km in length that was formed along the eastern edge of the oceanic Philippine Sea Plate as a result of the subduction of the Pacific Plate 48 Ma (Ma: *megaannum*, or million years ago).

The main bathymetric features around the Ogasawara Islands, from the Izu-Ogasawara trench to the Philippine Sea plate, are the Ogasawara Ridge, Ogasawara Trough, Shichito Ridge, Shikoku-Parece Vela Basin, and the Kyushu-Palau Ridge (Fig. 2-1). The islands of the Ogasawara Archipelago (from north to south, the island groups of Mukojima, Chichijima, and Hahajima) are dotted over the Ogasawara Ridge, which forms the fore-arc of Izu-Ogasawara Arc. They are submarine volcanoes of the Paleogene volcanic front that rose up above the sea surface due to the subduction of the Ogasawara Plateau. Quaternary volcanoes on the Shichito Ridge comprise the present volcanic front of the Izu-Ogasawara Arc, and include the active volcanoes of Nishinoshima Island and the Kazan Island Group of three islands (from north to south, Kita-iwoto Island, Iwoto Island, and Minami-iwoto Island). The Shikoku-Parece Vela Basin is a back-arc basin between the Izu-Ogasawara Arc and the Kyushu-Palau Ridge that developed and expanded from 30 to 15 Ma.

The Izu-Ogasawara Arc is one of the most studied in terms of geophysics, geology, and petrology because of its scientific importance as a typical example of an oceanic island arc. In particular, many of the Ogasawara Islands are surrounded by spectacular sea cliffs, which provide excellent outcrops for geological observation. Areas such as Chihiroiwa of Chichijima Island and Okuzure Bay of Hahajima Island offer not only breathtaking scenery, but also rich sources of historical information about the geological events that formed the Ogasawara Islands.

Within the geological features of the Izu-Ogasawara Arc, a continuous history of island arc growth, from its birth to the present date, is recorded in the form of changes in chemical magma composition and volcanic activity. However, because most of the Izu-Ogasawara Arc lies under the deep ocean, it is practically impossible to directly obtain and examine this extremely valuable geological record. Nevertheless, on the Ogasawara Islands large sections of geological strata that record the growth process of this oceanic islandarc are exposed on land, making the Ogasawara Islands the only site in the world where these geological records can be directly observed in detail. In addition, the middle crust, the origin of the continental crust, has been formed beneath the arc, which demonstrates the ongoing

evolution process from an oceanic island arc to a continent.

The geology of the Ogasawara Islands fully exhibits the typical growth process for an oceanic island arc, from the formation of the subduction zone through to its settling into a steady state. This is the why the islands provide an outstanding evolutionary record of how continental crust formed and grew on the earth.

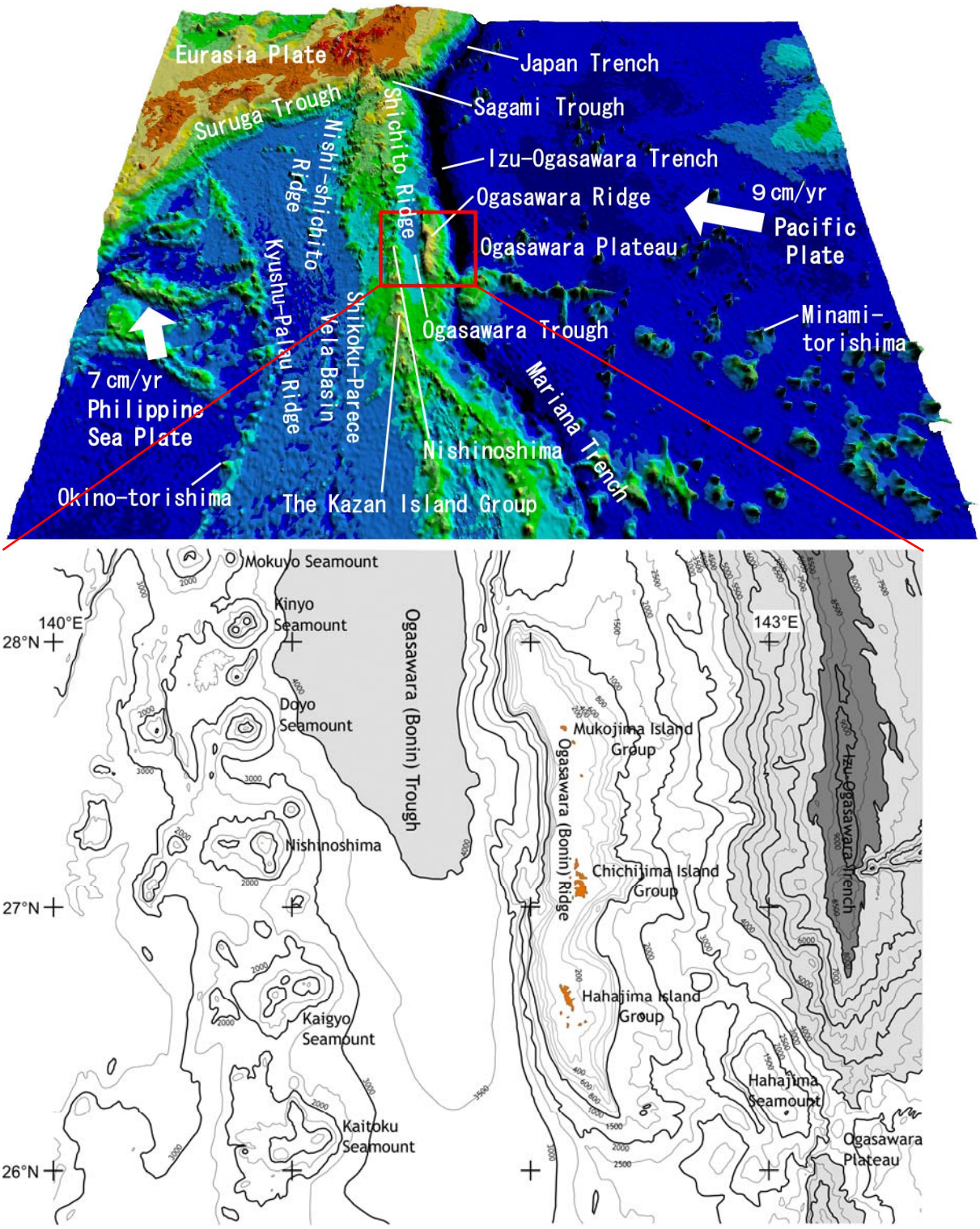


Fig. 2-1 Submarine topography around the Ogasawara Islands (above) and the Ogasawara Archipelago (below). (Revised from Umino, 2008)

(Column) The evolution of the earth from the formation of subduction zones to the creation of continents

Approximately four billion years ago, the "magma ocean" cooled down and water vapor in the atmosphere condensed and fell in the form of rain, which resulted in the primitive earth being covered entirely by ocean. The earth's surface subsequently cooled and the crust formed, marking the beginning of plate tectonics. There are three types of plate boundaries: *divergent boundaries* such as mid-ocean ridges, where plates spread apart; *convergent boundaries* such as subduction zones; and *transform or strike-slip boundaries*. Basaltic magmas erupt at mid-ocean ridges from deeper layers of the earth, resulting in the continuous formation of oceanic crust, and oceanic crust is then forced downwards into the earth at subduction zones. In the early history of the earth, the subduction of oceanic crust began with plate tectonics and oceanic island arcs developed above subduction zones, resulting in the creation of some of the first lands on the earth. The continual collision of island arcs through plate tectonics gradually contributed to the formation of larger landmasses and eventually to the birth of continents. This is the basic story of the role of plate tectonics in the creation of continents from the ocean-covered, primitive earth.

How did subduction zones, which are the cradle of continent formation, airese? And how did they develop to form continents? Once plates begin to be forced under one another, or start to "subduct", ocean trenches are formed, magma is ejected, submarine volcanoes are formed, and oceanic island arcs are created. As subduction proceeds further, the environments where magma is formed change; this, in turn, leads to various changes such as the chemical composition of rocks and the locations of submarine volcanoes. Then the subduction zones eventually reach a steady-state situation, where oceanic island arcs continue to develop. Many of the oceanic island arcs we see today are still developing and such island arcs evolve further as the subduction of plates continues. Island arc magmatism leads to the formation of andesitic middle crust under the earth's surface, and this crust has the average chemical composition of continental crust (Fig. 2-2; Kodaira et al., 2008; Suyehiro et al., 1996; Tatsumi et al., 2008). This phenomenon demonstrates that the process in which oceanic island arcs develop on oceanic crust, is also the very beginning of continent formation. Elucidating the mechanism of continent formation is one of the most important issues in unravelling the history of the earth, and better understanding of the process is being achieved through research into the formation and development of oceanic island arcs. The Ogasawara Islands offer an important research field for scientific studies because geological strata that record the whole development process of this oceanic island arc, from its formation to the present day, are exposed widely on land. Moreover, the presence of middle crust, which is the precursor to continents, has been confirmed beneath the Izu-Ogasawara Arc. As outlined above, the mechanisms of the evolution of the earth, from the appearance

of subduction zones to the formation of continents, is being elucidated at the Ogasawara Islands.

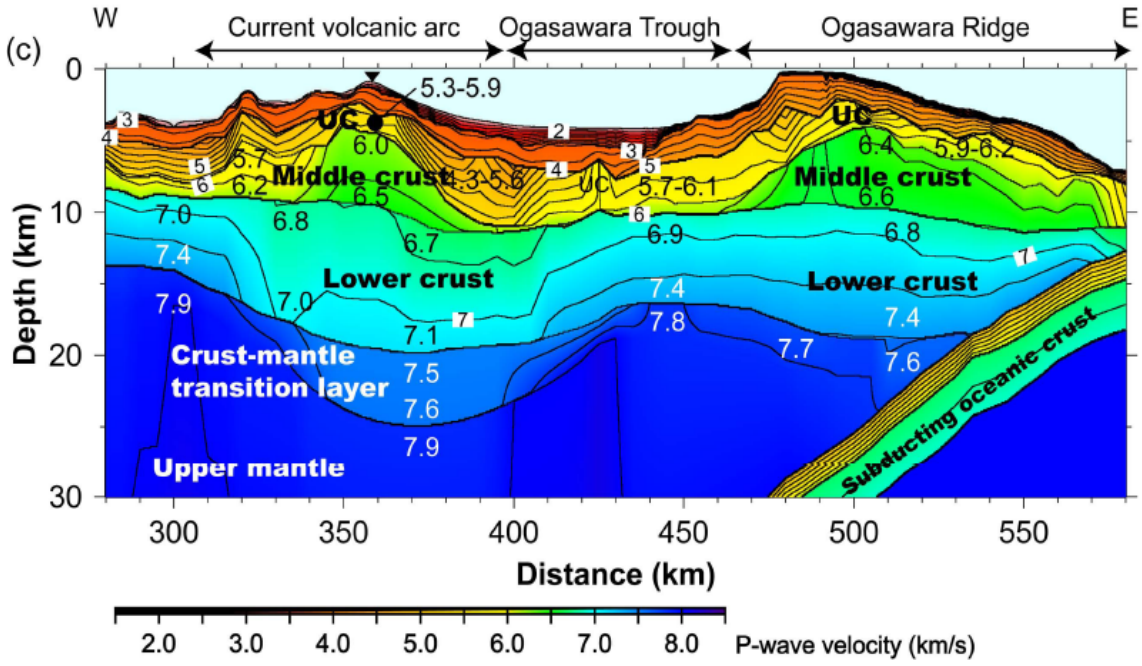


Fig. 2-2 Estimates for the crust structure of Izu-Ogasawara Arc (Takahashi et al., 2009)

The figure shows P wave velocity structure in the east-west cross section across the Izu-Ogasawara Arc. The zone that has velocities of 6.0–6.6 km/s is the middle crust, which occurs only under the island arc.

2.a.1.1 The development of the Ogasawara Islands

The progressive development of the Ogasawara Islands can be explained in terms of the formation of an oceanic island arc (Fig. 2-3). The formation of the Ogasawara Islands began as far back as 50 Ma, when the Pacific Plate initiated plate subduction (Fig. 2-3). Around this time the West Philippine Basin was spreading (Tatsumi and Maruyama, 1989), and the subduction of the Pacific Plate created a tension on the eastern edge of the upper Philippine Sea Plate, causing the fore-arc spread (Stern and Bloomer, 1992; Ishizuka et al., 2006). These conditions resulted in much shallower mantle material of high temperature (Fig. 2-3A). Around 48 Ma, the melting point of the wedge-shaped mantle dropped due to the fluid mainly consisting of water released from the subducted plate and magma was produced. This was the beginning of island arc volcanism, which characterizes the early stage of the volcanism in Ogasawara (Fig. 2-3B) (Umino and

Kushiro, 1989; Ishizuka et al., 2006). As subduction continued, the mantle wedge beneath Ogasawara cooled and the depth of magma production shifted deeper (Fig. 2-3C). By 40 Ma the volcanic front retreated to the present site of the Izu-Ogasawara Arc (where paleo-Izu-Bonin-Kyushu-Palau Ridge was located prior to its separation). This means that a stable subduction zone was established (Fig. 2-3D).

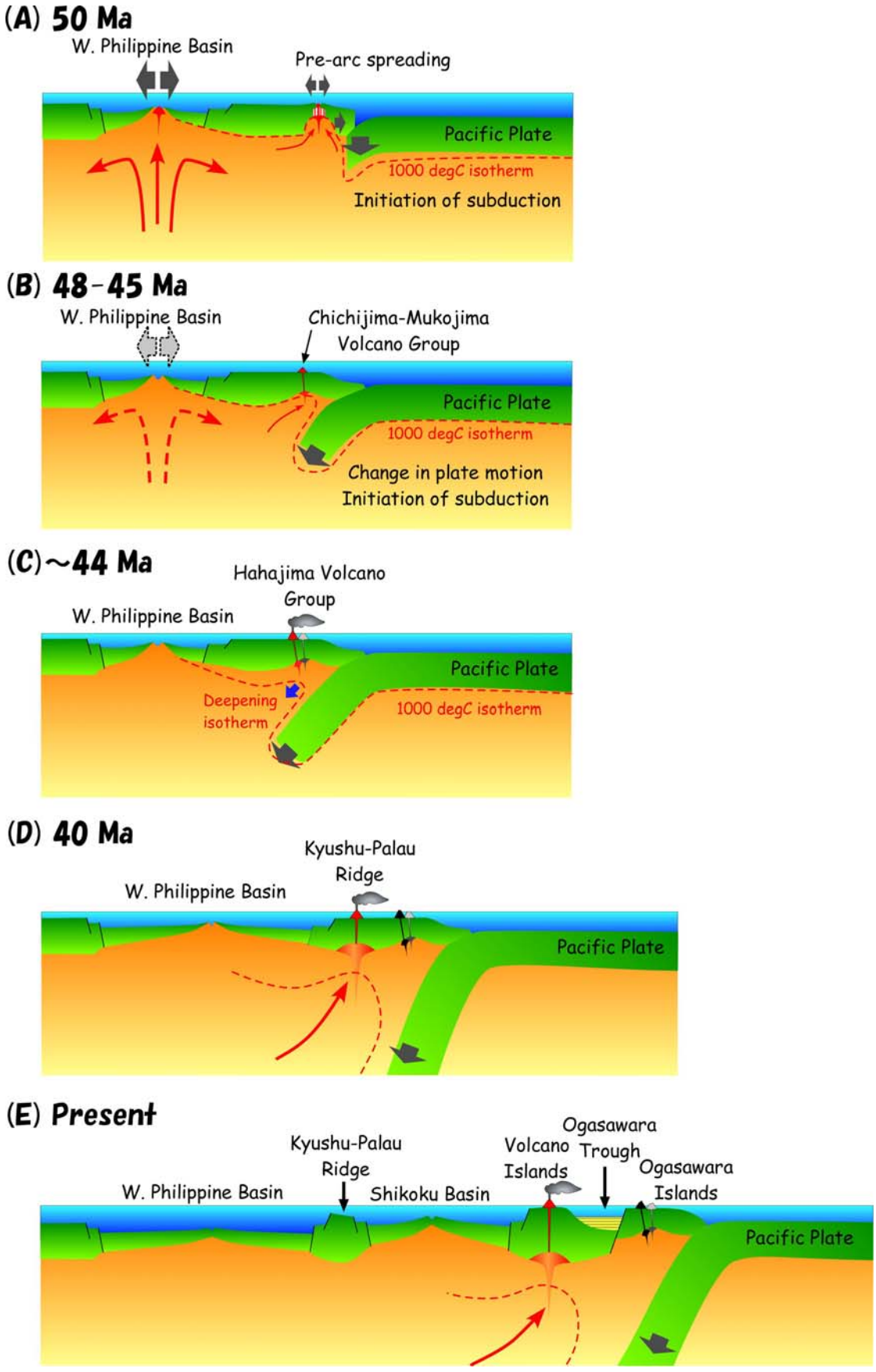


Fig. 2-3 Schematic model of tectonic development of the Ogasawara Islands

(A) Around 50 Ma

The Pacific Plate, which abuts on the Philippine Sea Plate, initiated subduction. At that time, the West Philippine Basin was spreading and the eastern edge of the Philippine Sea Plate was pulled by the subducting Pacific Plate and started to expand. These activities raised the temperature of the shallow mantle under Ogasawara.

(B) 48 Ma

Fluids, mainly composed of water supplied from the subducted slab of the Pacific Plate, caused production of boninite magma. Moderate lava stream eruptions, at areas from the Chichijima to Mukojima Island Groups, formed a group of submarine volcanoes. Growth of volcanic edifices caused Strombolian eruptions in shallower waters.

(C) 44 Ma

As subduction of the cold Pacific Plate continued, the shallow part of the wedge-shaped mantle cooled and thus the depth to produce magma increased. Accordingly, the chemical composition of the magma changed, generating arc tholeiitic magma underneath the Hahajima Island Group. Shallow marine to subaerial eruptions repeatedly extruded lava flows and ejected explosivepyroclastics.

(D) 40 Ma

The West Philippine Basin ceased spreading by 40 Ma. As the wedge-shaped mantle cooled down, the volcanic front retreated to the position of the paleo-Izu-Bonin-Kyushu-Palau Ridge before the opening of the Shikoku-Parece Vela Basin (about the same position as the present volcanic front).

(E) Present

The Izu-Bonin-Mariana Arc separated from the Kyushu-Palau Ridge by opening the Shikoku-Parece Vela Basin from 25 to 15 Ma. The collision with the Ogasawara Plateau and its predecessors led to a rise in the Ogasawara Ridge and the formation of the Ogasawara Trough. Nishinoshima Island and the Kazan Island Group are noted for their high concentrations of alkaline elements compared to their colleague volcanoes on the volcanic front.

Fig. 2-4 shows geological times for each stratum and its corresponding rock andchemical magma composition on each island. The chemical composition of the rocks changes genealogically and chronologically in accordance with the formation of each geological stratum. This indicates a series of changes in chemical magma composition along with the

development process of the plate subduction. This process has three stages, in summary:

- It began with boninitic magmas that formed submarine volcanoes in the Chichijima and Mukojima Island Groups (incipient subuduction stage);
- then changed through calc-alkaline and tholeiitic submarine to subaerial volcanism in the Hahajima Island Group (transitional stage);
- to reach the steady-state subduction zone volcanism that formed submarine volcanoes on the Kyushu-Palau Ridge such as Okino-torishima Island (steady-state stage).

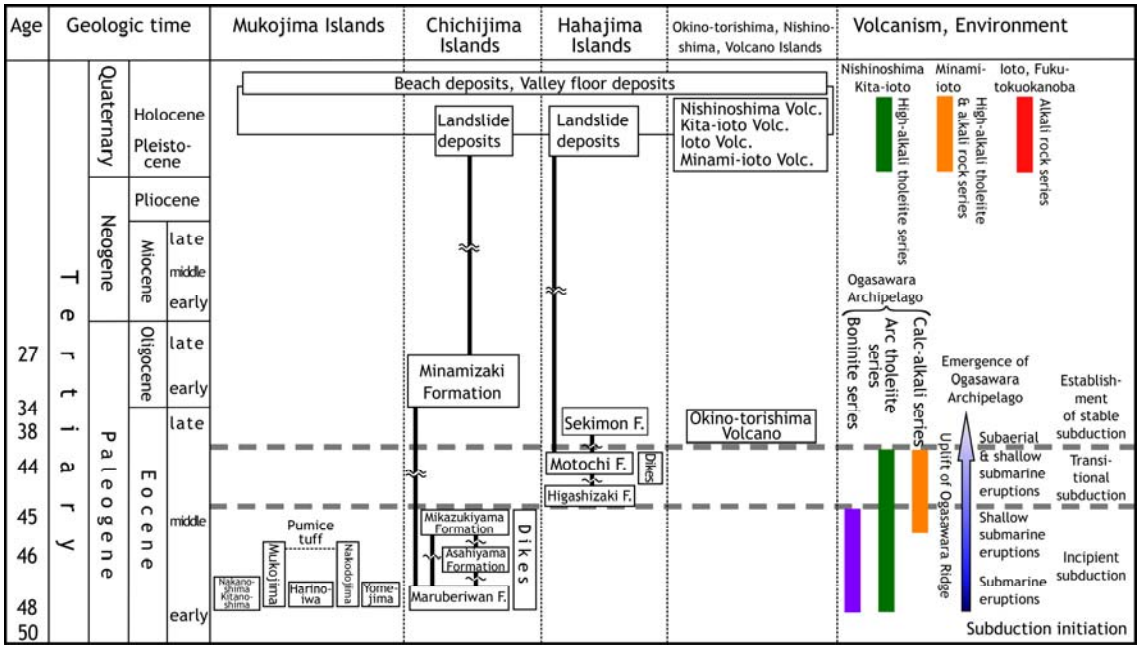


Fig. 2-4 Geological times of the Ogasawara Islands and thier corresponding rock and chemical magma composition (Modified: Umino et al., 2007)

Incipient subuduction stage

Island arc volcanic activity started from 48 to 45 Ma with the beginning of plate subduction (Figs. 2-3 A, B). During this period, the base of the Chichijima and Mukojima Island Groups were formed firstly through repeated non-explosive eruptions, producing gentle lava flows of boninite rock and arc tholeiitic rocks under deep water. The shallow submarine volcanism continued, and the chemical composition of erupted magma changed entirely to calc-alkaline andesite and dacite, bronzite andesite, and high-Ca boninite.

Boninite is a high-Mg andesite characterized by the absence of plagioclase and the presence

of abundant orthopyroxene (bronzite-enstatite) crystals embedded in the glassy matrix. Boninite is not found from currently active volcanoes anywhere in the world and is therefore considered to be not produced by steady island arc volcanism. This is because boninitic magma is produced under very specific temperature-pressure conditions; that is, melting of the hydrous upper mantle less than 30 km in depth (which is shallower than the generation depths of island arc basaltic magmas). Boninite magma is, therefore, a distinctive magma produced in the incipient stage of a subduction zone formation. In Ogawasawa, water was supplied in the shallow mantle of high temperature beneath the West Philippine Basin by subduction of the plate, and boninite magma was produced (Tatsumi and Maruyama, 1989; Ishizuka et al., 2006). Boninite was first discovered and described from Chichijima, and it was named after "Bunin", which is a corrupt form of an archaic term *Munin,* meaning "uninhabited" (Petersen, 1891). Not only Chichijima, the type locality of boninite, but also other islands of the Ogasawara Archipelago have the world's largest and best exposures of boninite.

Transitional stage

This period experienced a transition of the subduction from its incipient stage to the steady-sate stage 44 to 40 Ma (Fig. 2-3C). The regions where magma was produced shifted from a shallow trench side to a deeper back-arc side. The result of this was a change in chemical magma composition from boninitic to common arc tholeiitic.

At this stage, volcanic eruptions in the shallow waters and on the ground formed the foundations for the Hahajima Island Group. The Hahajima Island Group alternately experienced explosive and quiet eruptions that both extruded magmas of island arc tholeiitic and calc-alkaline compositions, characteristic of the transitional period.

Volcanism in the Ogasawara Archipelago came to an end before Steady-state stage. After the cessation of volcanic activity, foraminifers and others became deposited in the shallow seas around the Hahajima Island Group during the middle to late Eocene, and formed limesotne. In the southwest of Chichijima, coral reefs developed in the early to late Oligocene (34 to 27 Ma), eventually forming the limestone of Minamijima Island and other islands.

Steady-state stage

This is a period of island arc volcanism at the subduction zone from 40 Ma to the present day (Fig. 2-3D). By 40 Ma, the volcanic front retreated almost to the present position of the Izu-Ogasawara Arc and the thermal structure beneath the island arc reached a steady-state situation like normal subduction zone. Okino-torishima, located above the Kyushu-Palau Ridge about 1,000 km southwest of the Ogasawara Archepelago, is a 5,000 m-tall submarine volcano formed on the subdcution zone at its steady state during that time. At about 30 Ma,

the Izu-Ogasawara Arc began to split, and the expansion of the Shikoku-Parece-Vela Basin had separated the Kyushu- Palau Ridge from the Izu-Ogasawara-Mariana Arc by 15 Ma. Since then, the andesitic middle crust beneath the Izu-Ogasawara Arc was formed by steady subduction during the last 40 million years. The oceanic island arc volcanism transforming oceanic crust into continental crust is still underway beneath the Izu-Ogasawara Arc, as demonstrated by the recently active volcano chains of Nishinoshima and the Kazan Island Group (Fig. 2-3E).

2.a.1.2 Geological and topographical features

Chichijima Island Group

Chichijima covers 23.8 km^2 in area. Its highest elevation is 326 m above sea level, with a flat plain around 250 m to 300 m. There are satellite islands around Chichijima such as Anijima, Ototojima, Nishijima, Minamijima, and Higashijima Islands. The areas of Anijima and Ototojima are 7.87 km^2 and 5.2 km^2 respectively, while the rest of the islands are smaller than 1 km^2. These islands are all terrace-like in shape and bounded by sea cliffs.

The Chichijima Island Group was formed by submarine volcanic activity that began 48 Ma. This activity started with fairly calm eruptions forming pillow lava, which gradually gave way to more explosive phreatomagmatic eruptions as the volcanic edifice grew and became shallower. The strata of the Chichijima Island Group are classified into four formations from bottom to top: the Maruberi Bay, Mt. Asahi, Mt. Mikazuki, and Minamizaki Formations (Appendix 2). The Maruberi Bay Formation consists of volcanic boninite-series rocks such as pillow lava, and island-arc tholeiitic andesite extruded 48 to 46 Ma. The Mt. Asahi Formation consists of boninite-series rocks including dacite. The Mt. Mikazuki Formation consists of calc-alkaline andesite, dacite and so on extruded 45 Ma. All these three formations exhibit the characteristic chemical magma compositions produced in the incipient stage of the subduction. As for the Minamizaki Formation, it is a limestone stratum formed after the cessation of volcanic activity at Chichijima.

These rocks can be observed through out the Chichijima Island Group. For example, the oldest strata of boninite pillow lavas are distributed from the north to east and south shores of Chichijima as well as on Anijima and Higashijima. The strata are exposed and can be observed at the sea cliffs. In addition, the Mt. Mikazuki Formation can be observed at Mr. Mikazuki in Chichijima as well as in Ototojima.

The Mukojima Island Group

The Mukojima Island Group, located about 40 to 70 km north of Chichijima, is made up of

Mukojima Island, Nakodojima Island, Yomejima Island, and several other islands. The areas of Mukojima, Nakodojima, and Yomejima are 2.57 km^2, 1.37 km^2, and 0.85 km^2, respectively. All of the islands are flat and surrounded by sea cliffs.

The islands in the Mukojima Island Group are raised submarine volcanoes formed at about the same time (48 to 46 Ma) as the Chichijima Island Group. These islands are made up mainly of boninite, bronzite andesite pillow lava, pyroclastic rocks, and arc tholeiitic andesite that were erupted during the earlystage of plate subduction (Appendix 2).

The Hahajima Island Group

The Hahajima Island Group is located about 40 to 60 km south of Chichijima. Hahajima covers 20.2 km^2 in area. Its highest elevation, Mt. Chibusa, is 462 m, making it the tallest of the low-lying Ogasawara Archipelago. It is characterized by relatively precipitous ridges, and is surrounded on all sides by sea cliffs of 100 m to 350 m in height except for the west shore of the southern part of the island. The Sekimon area is marked by the development of a karst landform.

The Hahajima Island Group originated as volcanic islands which began with submarine eruptions under shallow water 44 Ma, and developed into shallow marine to subaerial eruptions. The volcanic rocks of the Hahajima Island Group are mainly island-arc tholeiite and calc-alkaline andesite. There is some undifferentiated basalt and dacite, but no boninite. Undifferentiated basaltic magma was produced at a depth of 35 kilometers, deeper than the boninitic magmas which formed the Chichijima and Mukojima Island Groups. Continued subduction for four million years cooled the shallow wedge-shaped mantle and disabled generation of further boninitic magmas. This change in chemical composition from boninitic to basaltic indicates the progress of the subduction zone to more advanced stages (Appendix 2). After volcanic activity subsided, foraminifers (*Nummlites* spp.), calcareous algae, and other reef-building organisms were deposited near the Sekimon area and ultimately became limestone.

Nishinoshima and the Kazan Island Group

Nishinoshima and the Kazan Island Group are volcanic islands stretching north to south, and located about 130 to 330 km to the west and south-southwest of the main Ogasawara Archipelago. They make up the Quaternary volcanic front of the Izu-Ogasawara Arc and were created by volcanic activity since the middle and late Pleistocene (Appendix 2). The Kazan Island Group, unlike other volcanoes to the north and south, is characterized by its high content of alkaline elements (Yuasa and Nohara, 1992; Ishizuka et al., 2007).

The Kazan Island Group is made up of Kita-iwoto, Iwoto, and Minami-iwoto Islands (from

north to south). Kita-iwoto covers 5.6 km^2 in area with its highest point of 792 m. Minami-iwoto covers only an area of 3.5 km^2, but with a peak elevation of 916 m, it is the tallest of the Ogasawara Islands. Kita-iwoto and Minami-iwoto are actually the summits of giant submarine stratovolcanos. The constituent rocks are highly alkaline tholeiitic or alkaline basalts. In addition, neither island is currently volcanically active, nor exhibiting historical records of eruptions. The ecosystems there have developed to roughly the same degree as the Ogasawara Archipelago. However, these young and discrete stratovolcano islands lack flat areas. Minami-iwoto is particularly void of flat terrain. Steep slopes, exceeding 40 degrees from the shore to the summit, make the island virtually inaccessible. This is why it has attracted no human activity and the original, natural state of the island has been well-preserved.

Nishinoshima lies on the peak of a large submarine volcano, rising 3,000 m above the seafloor and with a basal diameter of 20 to 30 km. The island is flat and triangular, covering an area of 0.29 km^2. It is composed of volcanic products and beach deposits dating from late Pleistocene to the present date (1973-1974 eruptions are the most recent ones) (Umino and Nakano, 2007). Volcanic eruptions and marine erosion are constantly changing the shape of this island.

2.a.2 Climate

The nominated property belongs to a relatively warm subtropical climatic zone. Because both the annual and diurnal temperature ranges are small and the level of humidity is high, the climate there is considered to have maritime nature. The nominated property is located at the center of the Ogasawara High that develops at the western edge of the North Pacific High. Because of this, the area is slightly affected by typhoon raifall, and the amount of precipitation is low. In the summer months, the amount of evaporation exceeds that of precipitation, and the soil and topographic conditions are characterized by shallow soils and precipitous coast areas, so the soil moisture condition becomes extremely dry in this season. In addition, because of the differences in elevation and wind direction whithin the nominated property, there is a wide range of climatic characteristics seen locally. As an example, cloud belts develop at the elevated area of relatively tall Minami-iwoto.

2.a.2.1 Climatic characteristics of the Ogasawara Islands

The nominated property extends about 400 km from north to south and comprises more than 30 islands spread over the Pacific (Ogasawara Islands Branch Office, Tokyo Metropolitan Government (TMG), 2008), and most of the area has a subtropical climate. Throughout the year, subtropical climatic zones are subject to the subtropical high-pressure belt and the

tropical air mass which occurs in the subtropical high-pressure belt.

The mean annual temperature of Chichijima in the nominated property is 23.0° C. The mean temperature of the coldest month (February) is 17.7° C, and the mean of the hottest month (August) is 27.6° C. The annual and diurnal temperature ranges are relatively small compared to other areas in Japan (Fig. 2-5). The mean annual precipitation is 1,276.7 mm. As for precipitation by month, February receives the least (61.4 mm) and May receives the most (174.4 mm). Mean monthly humidity is high, exceedind 80% from April through September. As described here, the nominated property belongs to a relatively warm subtropical climatic zone, characterized by small annual and diurnal temperature ranges and high levels of relative humidity, which qualifies it as a maritime climate.

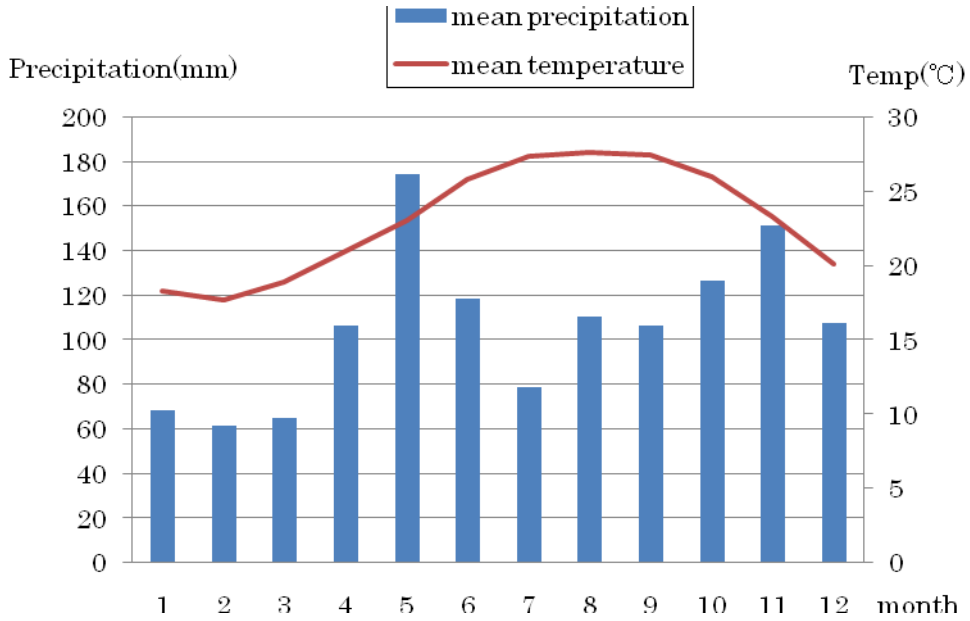


Fig. 2-5 Mean temperature and mean precipitation by the month on Chichijima

The nominated property belongs roughly to the same latitude belt as the Ryukyu Islands, and both are located in the Ogasawara High zone. The Ogasawara High that develops near Japan during the summer forms the western edge of the North Pacific High, which corresponds to a subtropical high. Compared with the eastern edge, there are fewer descending air currents which generally make the atmosphere less stable and conducive to wet weather (Nakamura and Komabayashi, 1996). The nominated property, however, is located more than 1,000 km away from the continent with its closeness to to the center of the Ogasawara High, the climatic environment is different from that of the Ryukyu Islands; as such there are

significant differences in the amount of precipitation in the two island groups.

When the mean monthly precipitation levels of Chichijima and Naha City (of Okinawa Prefecture, Ryukyu Islands) are compared, Chichijima receives less precipitation overall (the mean annual precipitation for Chichijima is 1,276 mm, compared with 2,036 mm for Naha City). The difference is particularly apparent in the summer months (June to September). This is mainly due to the higher rainfall attributable to typhoons, because the Ryukyu Islands are located peripherally to the Ogasawara High that develops in the summer and they lie in the path of typhoons. The nominated property, on the other hand, is located at the center of the Ogasawara High and belongs to a dry area with low winds and few clouds, making the influence of rainfall from typhoons fairly small. As a result, the amount of precipitation in the summer months (June to September) on Chichijima (414.9 mm) is only about half that of Naha City (835.2 mm) (Yamakawa, 1989).

One of the distinctive features of the climatic environment of the nominated property is that the amount of evaporation far exceeds that of precipitation in the summer months. The mean values for potential evaporation (the amount of evaporation that would occur when sufficient water is given) and annual changes in precipitation levels on Chichijima are shown for the beginning, middle, and end of each month for the period from 1970 to 2001 in Fig. 2-6(a). Potential evaporation (Kondo and Xu, 1997) is lowest in late December (an average of 2.3 mm per day), and highest in early July (5.4 mm per day). The average of total amount for the year is 1,380 mm. There is much precipitation in the rainy season from April to June, with its highest level in late May. The period from late June to late July is the summer dry period and precipitation is at its lowest level of the year (Iijima et al., 2004). Fig. 2-6(b) shows a wetness index (a figure derived by dividing the amount of precipitation in a given period by the potential evaporation. It is used as an index to show dryness and wetness of the soil moisture) for Chichijima.

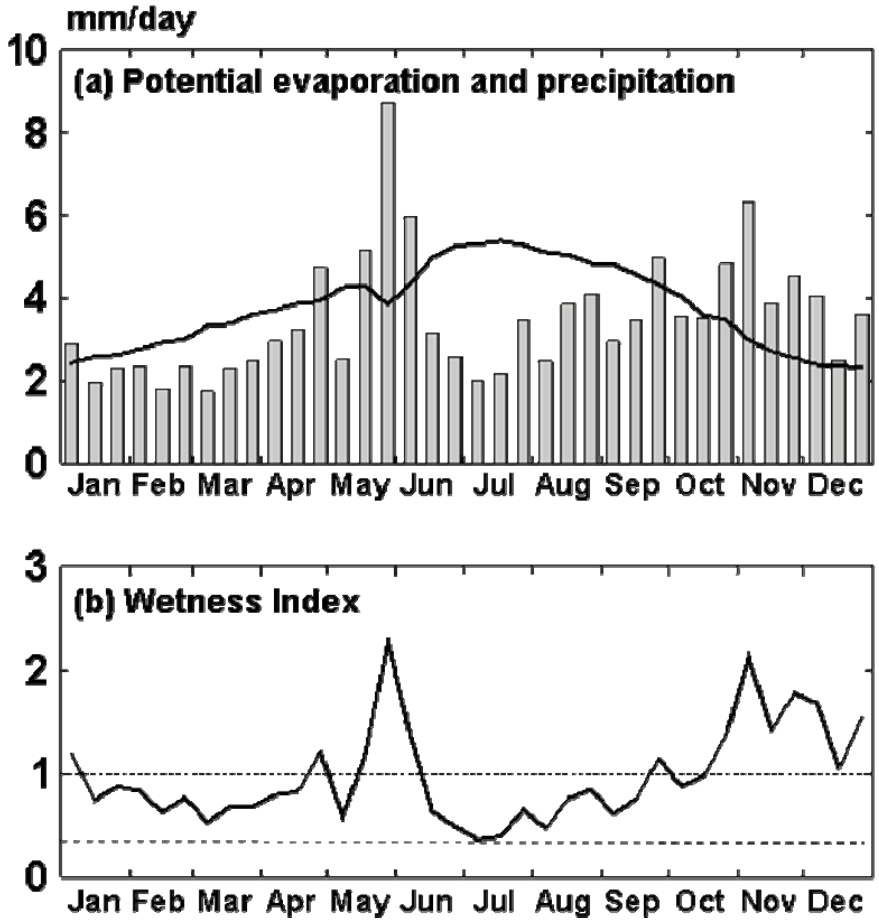


Fig. 2-6(a) Mean precipitation levels (vertical bars) for the beginning, middle, and end of each month from 1970 to 2001 and mean potential evaporation (solid line)
(b) Mean wetness index values for the beginning, middle, and end of each month from 1970 to 2001 (Graphs revised from Iijima et al. [2004])

From the ranges for wetness index, the climate conditions can be divided into three distinct periods:

- humid periods (when the wetness index is larger than 1),
- subhumid periods (in the 1 to 0.3 range), and
- dry periods (less than 0.3).

In effect, a wetness index of less than 1 means that the amount of precipitation is lower than that of potential evaporation and the soil moisture condition is consequently dry. From Fig. 2-12, it is clear that Chichijima only experiences humid periods during the rainy season

(which peaks in late May) and the cool period from late October to early January. Conversely, Chichijima experiences sustained dry and subhumid periods throughout the summertime from mid-June to mid-September (when precipitation is low). The wetness index is lowest in early July (0.37), and the soil during the months immediately after the end of the rainy season is extremely dry. Precipitation is also consistently lower than potential evaporation from mid-January to mid-April (a subhumid period), which is about the same dryness as the summer months.

The data demonstrate that for much of the year the amount of precipitation that Chichijima receives is less than the potential evaporation; and also show that periods of precipitation are concentrated (Iijima, 2004). Furthermore, these seasonal changes fluctuate greatly from year to year, and there are some extremely dry years (Oka et. al., 2000; Yoshida et. al., 2006). In addition, there are no major valley systemsin the nominated property, the soils in the mountain areas are shallow, and the slopes near the shores are steep and rocky. These soil and topographical conditions combine to make it difficult for soil to retain moisture when it rains; instead, such water runs off quickly (Iijima, 2004; Kato and Uzukawa, 1982).

The description above shows that owing to factors such as precipitation, evaporation, soil and topography, there are distinct seasonal wet and dry periods, and the contrast between them is an important feature that characterizes the natural environment of the nominated property (Iijima, 2004).

2.a.2.2 The unique climatic conditions forming cloud belts and their effects on the ecosystem

Because of the differences in elevation and wind direction in the islands within the nominated property, there is a wide range of local climatic characteristics. As an example, cloud belts develop on the top of the relatively tall islands such as Minami-iwoto. This is a result of slope upflow and the condensation of moisture in the upflow air above a certain altitude on slopes; such topographical conditions lead to the formation of fog. In arid regions the minimum altitude for cloud belts to form is relatively high, but on oceanic islands this altitude is lower (Oka, 2004). Kita-iwoto (792 m), Minami-iwoto (916 m), and Hahajima (463 m) meet the conditions for cloud belt formation. The frequent presence of fog, accompanied by high levels of humidity, allows many bryophytes, epiphytes and tree ferns to flourish, contributing to the distinctive scenery of the cloud belts. Such localized climatic conditions on individual islands are part of the unique environment of the Ogasawara Islands.

2.a.3 Plants

Many oceanic islands of the world are tropical, but the nominated property is located in a milder subtropical zone. For this reason, it has many plant species that have origins in the subtropical regions of Southeast Asia, such as *Schima mertensiana*, *Planchonella obovata*, *Elaeocarpus photiniaefolius*, *Rhaphiolepis indica* var. *umbellata*, *Distylium lepidotum*, *Syzygium buxifolium*, and *Ardisia sieboldii.* In addition, thre are many northern species that have originated in the mainland of Japan (means here Hosnhu, Shikoku, and Kyushu expect Hokkaido due to the fact that Hokkaido is located to the north of Blakiston's Line and thus has largerly different fauna and flora), such as *Stachyurus praecox* var. *macrocarpus* and *Rubus nakaii,* as well as southern species including *Meterosideros boninensis* and *Santalum boninense*. These species with diverse origins are a characteristic feature of the property and have achieved unique speciation, so despite the islands being oceanic and of small size, there are many plant species and the proportion of endemic species is high. A total of 138 families, 445 genera, and 745 species of vascular plants (including subspecies and varieties) have been recorded, of which, 441 are native, and 161 are endemic (Nature Conservation Bureau, MOE, 2004). The conservation measures to protect threatened species are discussed in 4.a.1.

2.a.3.1 Vegetation types

The nominated property has a relatively short history of human activities and this has helped to preserve diverse natural vegetation on each island (Fig. 2-7; Okutomi et al., 1983; Miyawaki, 1989). The Hahajima Island Group, Chichijima Island Group, and Kazan Island Group have particularly large natural vegetation areas. Different vegetation types dominate the different islands, forming a diverse natural environment. The characteristic vegetation types of the nominated property are described below.

Sclerophyllous scrub

One of the characteristics of the nominated property is the wide distributionof sclerophyllous scrub - dominated mainly by *Distylium lepidotum* and *Rhaphiolepis indica* var. *umbellate.* The shrubs and small trees range in height from around five to eight meters and are suited to dry climates, much like the sclerophyllous forests of the Mediterranean. The areas covered by sclerophyllous scrub include northeastern and southwestern parts of Anijima and Chichijima, the etire areas of Mukohjima, Meijima, Anejima, Imotjima, and the southernmost part of Hahajima. Most likely, the mild subtropical climate and the low levels of precipitation helped develop these globally rare types of vegetation (Ono, 1994). Three types of sclerophyllous scrub communities can be seen covering the relatively gentle slopes atop Chichijima and Anijima: Distylio-Pouterietum dubiae, *Distlium lepidotum* variant of

Machilio kobu-Schimetum mertensianae, and *Osteomeles lanata* association (sclerophyllous dwarf scrub), the latter being one of the plant communities in rocky desert on a continent. They cover 477 ha of Anijima (about 60% of the total area), and 481 ha (about 20% of the total area) of Chichijima, mainly on the Yoakedaira and Mt. Chuosan-Higashidaira areas.

The sclerophyllous scrub covering the gentle slopes atop Chichijima (Yoakedaira and Mt. Chuosan-Higashidaira area) and Anijima (overall) have so far not been disturbed by human activity. Based on data collected for Mt. Chuosan-Higashidaira area in 1976 and 1997 (Shimizu, 1999), as well as those of Distylio-Pouterietum dubiae, *Distlium lepidotum* variant of Machilio kobu-Schimetum mertensianae, and plant communities in rocky desert (TMG, 1997), 69 endemic species to Ogasawara Islands have been confirmed in the sclerophyllous scrub communities. This translates into a high endemic ratio of 67% (80.6% for woody plants) (Bureau of Environment, TMG, 2007).

On Hahajima Island Group, *Pittosporum parvifolium* var. *beecheyi*, endemic to this island group, grows in the dwarf scrub of Wikstroemio-Pouterietum-dubiae dominated by *Planchonella obovata* var. *dubia*, *Rhaphiolepis indica* var. *umbellata* and other such species. These characteristic sclerophyllous dwarf scrubs of the Hahajima Island Group have formed on steep slopes, ridges, and wind-beaten terrain with poorly developed soil (Okutomi et al, 1983). The sclerophyllous dwarf scrubs in Hahajima Island Group cover 37 ha of Anejima (about 26% of the total area), and 60 ha (about 20% of the total area) of Imotojima, 42ha (about 48% of the total area) of Meijima, and 61 ha (about 44% of the toal area) of Mukohjima.

Subtropical rainforest (Pisonio-Elaeocarpetum photiniaefoliae)

In the Sekimon locality of Hahajima, the Pisonio-Elaeocarpetum photiniaefoliae subtropical rainforest community grows to a height of 20 m or so. It contains many plants of Southeast Asian origin, such as *Elaeocarpus photiniaefolius*, *Pisonia umbellifera*, *Ardisia sieboldii*, *Planchonella obovata Morus boninensis*, *Celtis boninensis* and *Melia azedarach*. Pisonio-Elaeocarpetum photiniaefoliae is the most developed of the forest communities of the Ogasawara Islands (Okutomi et al, 1983). There are many endemic species in this community, notable ones being *Hibiscus glaber* and *Ochrosia nakaiana.* On the limestone rocks of the Sekimon locality, *Asplenium ikenoi* and *Procris boninensis* can be found but their distribution is extremely limited. Because the Ogasawara Islands lack shade-tolerant trees (such as oaks that become dominant in climax forests on the continent and the mainland of Japan), the composition of subtropical rainforests are characterized by shade-intolerant tree species typical of oceanic island vegetation. Unique regeneration patterns due to gaps attributable to typhoons and other disruptions have also been observed (Shimizu, 1998).

Ardisia sieboldii forests

The forests dominated by *Ardisia sieboldii* and *Schima mertensiana* are the Machilio boninensis-Ardisietum sieboldii community (Okutomi, et al., 1983). Machilio boninensis-Ardisietum sieboldii is spread over a large area in Hahajima. The *Fatsia oligocarpella* variant of Machilio boninensis-Ardisietum sieboldii occurs in cloud belts on Hahajima. Plant species such as *Fatsia oligocarpella*, *Colysis pothifolia*, *Cyathea spinulosa*, and *Goodyera boninensis* grow in this forest. This forest is also noted for its richness in epiphytes.

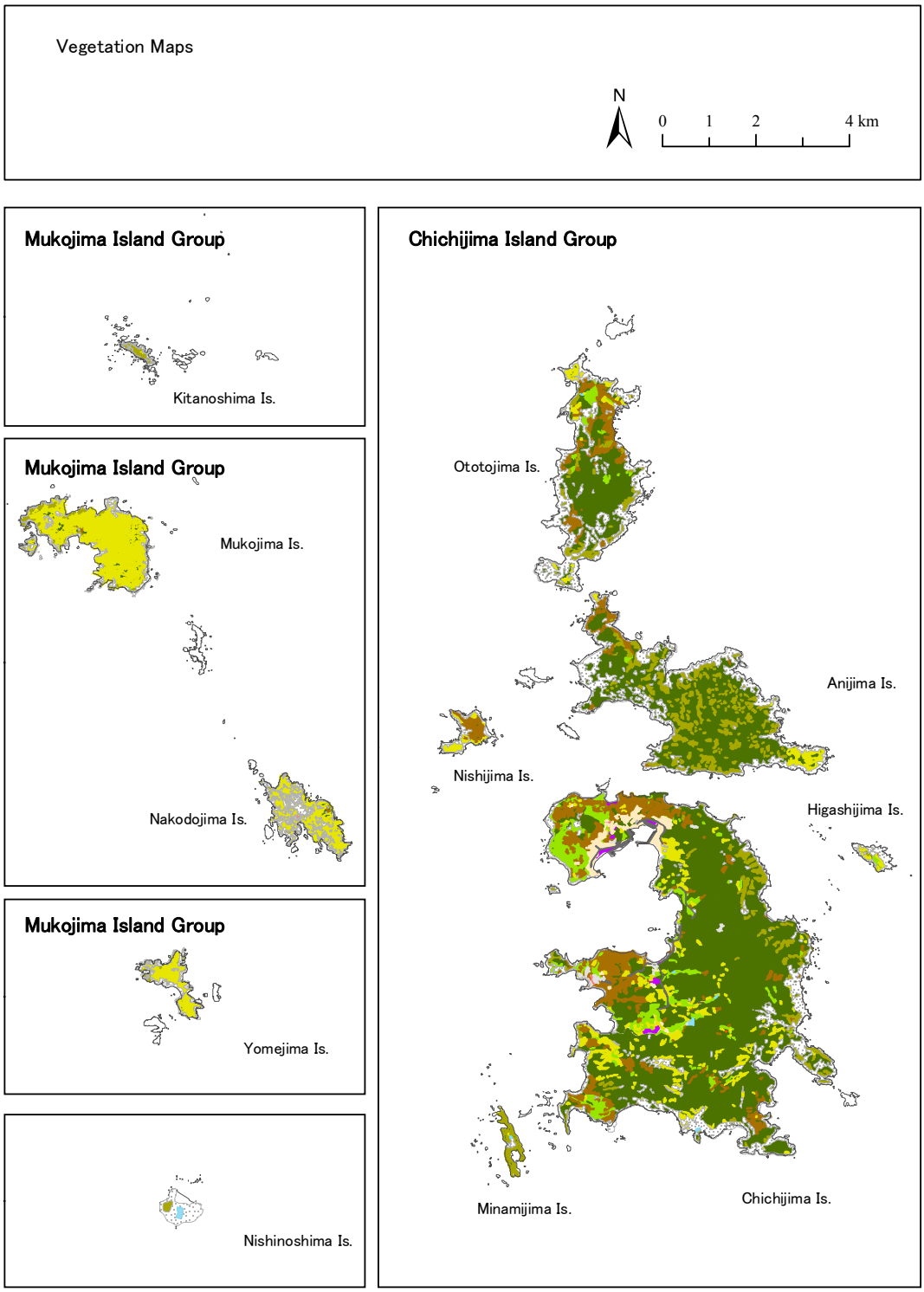


Fig.2-7-1 Vegetation map

(Mukojima, Chichijima Island Groups, and Nishinoshima Is)

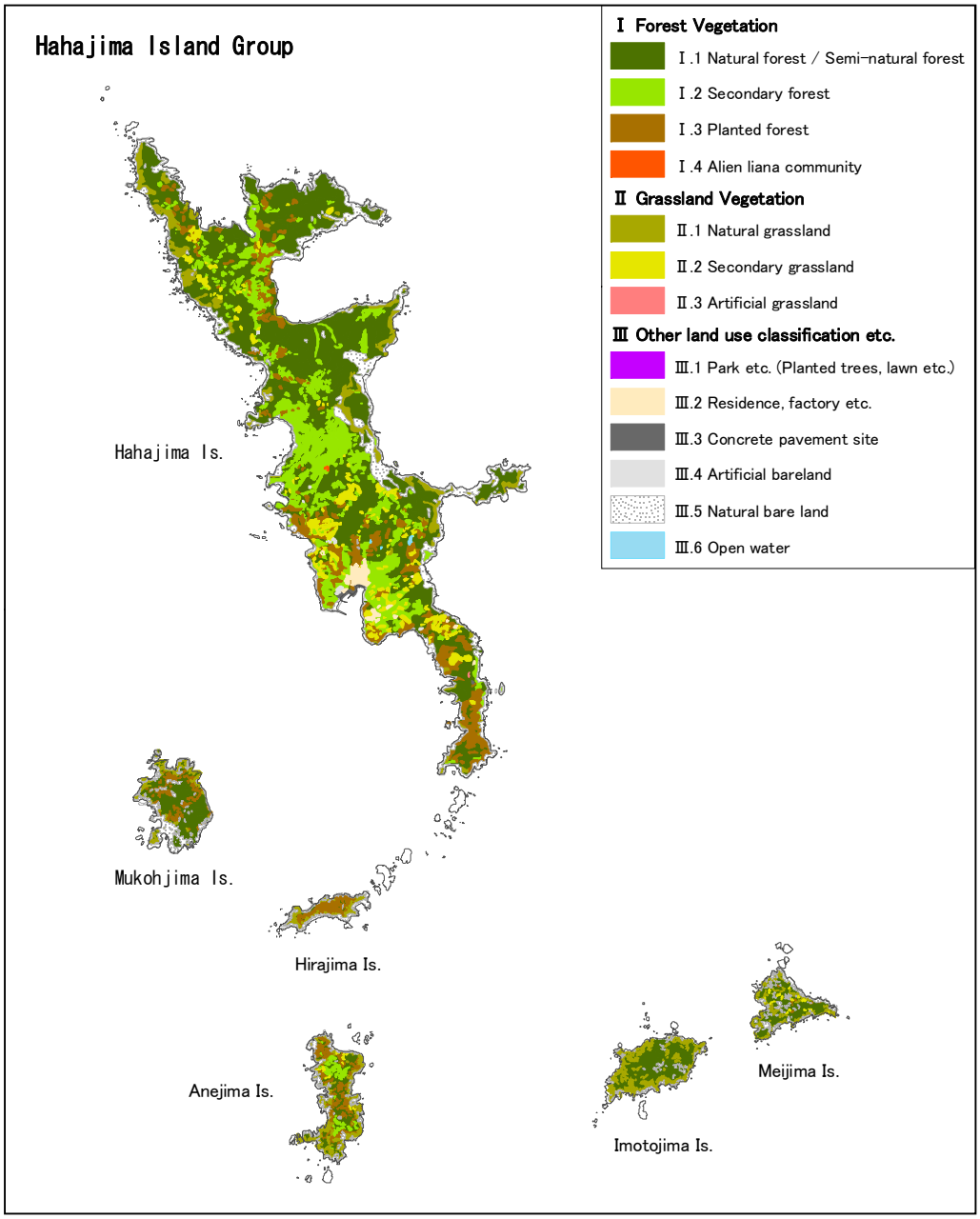


Fig. 2-7-2 Vegetation map

(Hahajima Island Groups, Kita-iwoto and Minami-iwoto Is.)

2.a.3.2 Flora

The diverse flora of the Ogasawara Islands includes plant species with origins in Southeast Asia, Oceania, the main island of Japan, as well as other endemic plants of unknown origin (Toyoda, 2003; Ono and Kobayashi, 1983). It is extremely difficult for dispersal unit (disseminule) such as seeds to transfer to oceanic islands. The plant species dispersed to the Ogasawara Islands are thought to have been carried by ocean currents, winds, and birds with a very low probability.

One of the characteristics of the area is that species with diverse origins achieved even further speciation, so despite the islands being oceanic and small in size, they have a high proportion of endemic species. The MOE Red List (2007) also includes 137 species that grow on the Ogasawara Islands, which is an extremely high number, making the area an important habitat for threatened plants.

Origins of the flora

About 70% of the component species of flora on the Ogasawara Islands are of Southeast Asian origin. In contrast, there are few species in common with Oceania (Micronesia, Polynesia, etc.), which is relatively close geographically, and even fewer related to those on the Izu Islands or the mainland of Japan (Fig. 2-8; Toyoda, 2003). It is thought that the tropical Oceania-derived and the other endemic plants are the oldest, while Southeast Asian-derived plants (which are greater in number of species) are newer (Toyoda, 2003; Shimizu 2007).

Some of the Southeast Asian-derived plants are *Schima mertensiana*, *Distylium lepidotum*, *Claoxylon centinarium*, *Elaeocarpus photiniaefolius*, and *Wikstroemia pseudoretusa* (Toyoda, 2003). *Meterosideros boninensis*, *Santalum boninense*, *Lobelia boninensis*, *Clinostigma savoryanum*, *Psychotria homalosperma*, *Boninia glabra*, *Hedyotis grayi*, *Osteomeles schwerinae* are some species that are closely related to plants on the islands of Oceania. For example, the species most closely related to *Meterosideros boninensis*, which is endemic to the Ogasawara Islands, is found on Fiji, and it is thought to be particularly old in origin (Wright et al., 2000). All of these species are highly endemic and speciation is thought to have occurred a long time ago. Since there are few species that have become dominant in the forest and many of the species grow on the forest edge on ridges, and on sea cliffs, it is often postulated that they came to the Ogasawara Islands far in the distant past and became endemic; subsequently, Southeast Asian plants came to the islands and displaced them (Shimizu 1998). It is thought that sutable conditions developed for Southeast Asian plants of a highly subtropical nature to replace much of the tropical vegetation that once covered the Ogasawara Islands. (Toyoda, 2003; Shimizu 2007).

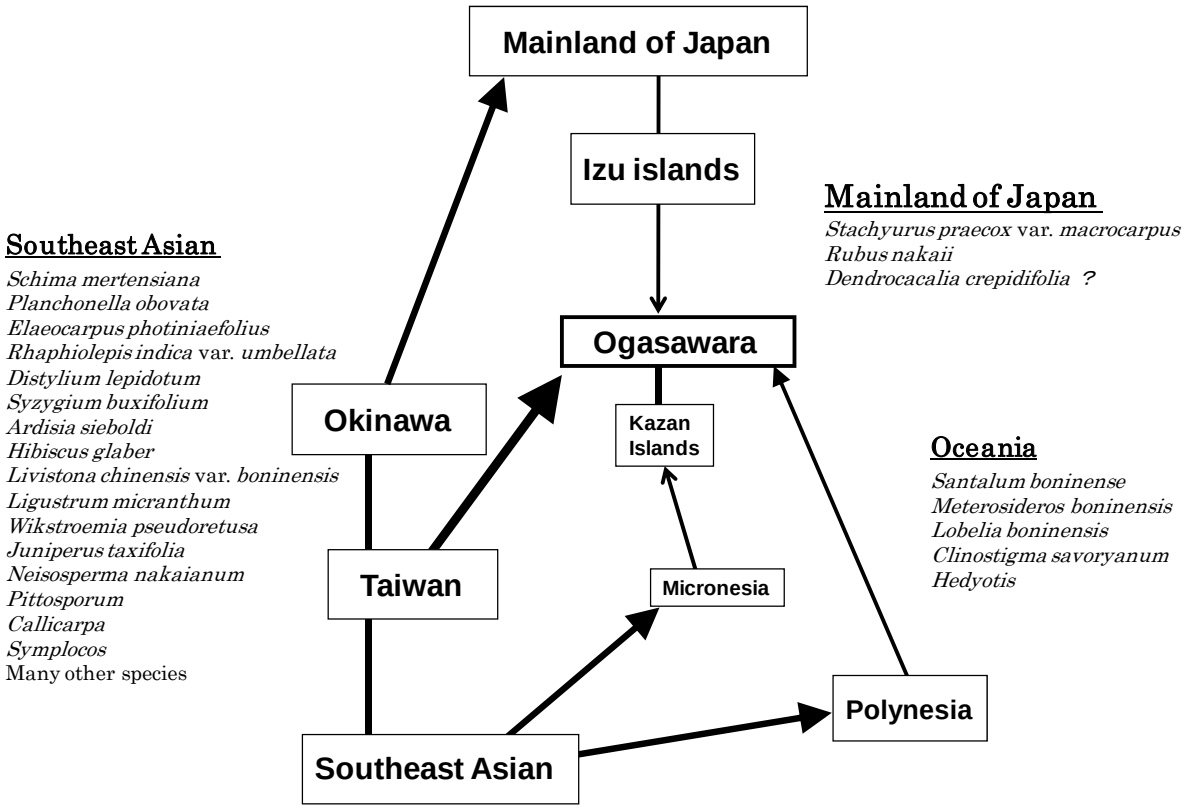


Fig. 2-8 Origins of flora of the Ogasawara Islands
(Revised from Shimizu, 2007)

Endemic species

The flora of the Ogasawara Islands is characterized by a higher number of species per area and higher percentage of endemic species than the mainland of Japan, the Ryukyu Islands, Taiwan, etc. There are 441 species of vascular plants (excluding alien species) on the Ogasawara Islands, which include two endemic genera and 161 endemic species, for an endemic ratio of 36% (Nature Conservation Bureau, MOE, 2004). Woody plants have an even higher endemic ratio of 64%, with two endemic genera and 88 endemic species out of 138 species in total.

Characteristic species of the Ogasawara Islands include the following three endemic genera: *Boninia* (Rutaceae), *Dendrocacalia* (Asteraceae), and *Marattia* (Marattiaceae, fern). There are also several genera with at least three endemic species each: *Pittosporum* (Pittosporaceae), *Boninia* (Rutaceae), and *Machilus* (Lauraceae) (Table 2-1).

The endemic species *Juniperus taxifolia* (Cupressaceae) is the only conifer native to the

Ogasawara Islands. It grows in broad areas from the shores to the summits of the Chichijima and Hahajima Island Groups. Very different growth types can be seen depending on conditions and environments of the area where it grows. Sometimes it creeps on the ground, and sometimes it grows straight up to heights of several meters (Kato, 2004).

Table 2-1 Genera on the Ogasawara Islands including at least three endemic species (Compiled with data from Soejima, 1995, and South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005)

Genus (Family)	No. of species	Species	Estimate No. of ancestral species	Distribution			
				Mukojima islands	Chichijima islands	Hahajima islands	Kazan islands
Pittosporum (PITTOSPORACEAE)	4	*boninense*	1		○	○	
		boninense var. *parvifolium*			○		
		parvifolium var. *beechevi*			○	○	
Callicarpa (VERBENACEAE)	3	*glabra*	1		○	○	
		parvifolia			○		
		subpubescens		○	○	○	○
Crepidiastrum (COMPOSITAE)	3	*ameristophyllum*	1		○	○	
		grandicollum			○		
		linguifolium			○	○	
Boninia (RUTACEAE)	3	*glabra*	1		○	○	
		grisea		○	○	○	○
		grisea var. *crassifolia*			○		
Ilex (AQUIFOLIACEAE)	4	*matanoana*	1-2		○	○	
		mertensii		○	○	○	
		mertensii var. *beecheyi*		○	○	○	
		percoriacea			○	○	
Ficus (MORACEAE)	3	*boninsimae*	1	○	○	○	○
		iidaiana				○	
		nishimurae		○	○	○	○
Machilus (LAURACEAE)	3	*kobu*	1	○	○	○	○
		pseudokobu			○	○	○
		boninensis		○	○	○	
Symplocos (SYMPLOCACEAE)	3	*kawakamii*	1		○		
		pergracilis			○		
		boninensis				○	

Sclerophyllous scrub species and cloud belt vegetation

Many of the same plant genera grow in the sclerophyllous scrub of Ogasawara as in the ohia forests (cloud forests) of Hawaii. One of the reasons proposed is that when the islands of Ogasawara were larger and taller, cloud forests similar to those in Hawaii developed in the cloud belts; as the islands lowered, flattened and split apart due to land erosion and glacial-interglacial sealevel fluctuations, species originating in the cloud forests survived in the form of sclerophyllous scrub (Shimizu, 1998).

One piece of evidence supporting this hypothesis is the distribution of the genus *Melastoma*. *M. tetramerum* (endemic) grows in the sclerophyllous scrub of Chichijima, while *M. tetramerum* var. *pentapetalum* (endemic) grows in the cloud forest-like environment on Hahajima, *M. candidum* (a widely distributed species) grows in a cloud forest on Minami-iwoto, and *M. candidum* var. *alessandrense* (an endemic variety) grows in a cloud forest on Kita-iwoto. This suggests that *M. tetramerum* was once a species that grew in cloud forest-type environments (Shimizu, 1998).

Another piece of evidence involves the distribution of the genus *Stachyurus*. *S. praecox* var. *macrocarpus* (endemic) grows in the sclerophyllous scrub of Chichijima, while *S. praecox* var. *macrocarpus* (an endemic variety) grows in the cloud belt covering the top of Mt. Chibusa on Hahajima (Shimizu, 1998). Furthermore, it is suggested that *Rhododendron boninense*, which remains in an area around the summit of Mt. Tsutsuji on Chichijima, also used to grow in an environment similar to the cloud belt (Shimizu, 1998).

The relationship between sclerophyllous scrub and related species of laurel forests on the mainland of Japan and the Ryukyu Islands

The small tree species that form the canopies of sclerophyllous scrub have many species and genera in common with the laurel forests that span from Southeast Asia to Okinawa. However, *Distylium lepidotum* on the Ogasawara Islands has leaves that are more suited to dry conditions than the related *D. racemosum* of laurel forest zones of other areas (Mishio, 1992; Ishida et al., 1998, 2008). This suggests that laurel forests transformed into sclerophyllous forests over a long period of increasingly dry environment as the Ogasawara Islands became lower and flatter and the cloud belts gradually disappeared (Shimizu, 1998).

2.a.3.3 Modes of evolution

Many endemic species are found in the natural sclerophyllous scrub and subtropical rainforest of the Ogasawara Islands. The species composition of sclerophyllous scrub is thought to reflect the geological history of the islands, especially the lowering and flattening of the islands (as described above). Different forms of speciation can be seen in endemic plant species on the islands, such as the evolution of dioecy, the development of woodiness in herbaceous plants, and so on, all modes of evolution are distinctive to oceanic islands.

Adaptive radiation and on going speciation

One of the notable characteristics of the speciation processes of adaptive radiation in plants on the Ogasawara Islands is “parallel speciation”, in which many different species have adapted to several types of environments, rather than the speciation resulted from the

adaptation of only one species to many different taypes of enviroments. Plant species thought to have evolved through adaptive radiation include those in the genera *Pittosporum*, *Callicarpa*, *Boninia* and *Symplocos* (Ito and Ono, 1998; Ito, 1998; Ito et al., 1997; Soejima, 1995). As described below, examples of parallel speciation can be seen in many species accompanying various morphological changes adapted to each of subtropical rainforest, sclerophyllous scrub, and sclerophyllous dwarf scrub environments (the latter occurs on very dry ridges with shallow soil beds and often reaches heights of only 0.5-2.0 m; however, there are no distinct boundaries between sclerophyllous scrub and sclerophyllous dwarf scrub in species composition or structure,: Shimizu, 2008).

Of three species in the genus *Symplocos*, *S. pergracilis* and *S. kawakamii* grow on the Chichijima Island Group, while the remaining *S. boninensis* occurs only on Mukohjima in the Hahajima Island Group. *S. pergracilis* grows in sclerophyllous scrub of 3-7 m in height, while *S. kawakamii* grows in much drier sclerophyllous dwarf scrubs of 0.5-1.5 m. It is thought that sclerophyllous dwarf scrubs diverged from sclerophyllous scrubs to adapt to drier conditions, and in parallel with this vegetation diversification, *Symplocos kawakamii* also diverged from *S. pergracilis* (Soejima el al., 1994; Shimizu, 1989).

In the genus *Boninia*, *B. grisea*, which has large leaves and reaches heights of over 10 m, is seen in subtropical rainforest, while the shorter *B. glabra* grows in sclerophyllous scrub, and the *B. grisea* var. *crassifolia*, which has thick and small leaves thought to have evolved to adapt to drier environments, grows in even shorter communities of sclerophyllous dwarf scrubs (Kato et al., 1998; Kato 2004; Shimizu, 1989; Mishio et al., 1997, 2007).

Furthermore, seeds of *Hibiscus glaber*, a species endemic to the Ogasawara Islands and probably derived from *H. tiliaceus* (originating from sea-drifted seeds), lost the ability to float on the seawater in its speciation process. It is known that genetic interaction of *H. glaber* is now limited even between the islands (Takayama et al., 2005). These two species are also different in the range. While the distribution of *H. tiliaceus* is restricted to the coastlines, the distribution of *H. glaber* expands from the coastlines to inland humps of 400m above sea level (Shimizu, 1984).

A recent study shows that *Syzygium cleyerifolium*, which has been considered a single species, exhibits morphological divergence corresponding to different vegetation types (Fujita et al., 2002). This is an example of ecological release and indicates that speciation in progress can be observed in the Ogasawara Islands.

The evolution of dioecy

The development of dioecy is a phenomenon often seen on oceanic islands. The mechanism of the evolution of dioecy on islands is not fully elucidated, but there is a theory that dioecy

developed as a defense mechanism to avoid the genetic risks caused by self-pollination because pollen-carrying insects lack the ability to fly long distances and tend to carry pollen between the flowers of the same plant (Kato and Nagamasu, 1995). In fact, there are many specimens on the Ogasawara Islands that exhibit dioecious trends. One of the characteristics of the area is that there are species in which dioecy is incomplete and in progress at the very moment (Kondo et al., 2007; Nishide et al., 2009).

For instance, *Wikstroemia pseudoretusa*, a species endemic to the Ogasawara Islands, is dioecious, but *Wikstroemia retusa*, a species in the Nansei (Okinawa, Ryukyu, etc.) Islands thought to be most closely related, produces hermaphroditic flowers. For this reason, it is thought that *W. pseudoretusa* evolved into a dioecious form after arriving in the Ogasawara Islands (Sugawara et al., 2004).

All the three species endemic to the Ogasawara Islands belonging to the genus *Callicarpa*, i.e. *C. subpubescens*, *C. glabra*, and *C. parvifolia*, have specimens that produce either hermaphrodite or male flowers. However, it has become clear that the pollen from specimens that produce hermaphrodite flowers lacks germ pores (i.e. small opening on pollen for germination) and thus lacks pollination ability, effectively making them female flowers. It is thought that this pollen lacking germ pores developed specifically as a reward (food) to attract insects (Kawakubo, 1990). There are no other dioecious plants in the family Verbenaceae known outsied the Ogasawara Islands, indicating that this feature is likely to have evolved on the Ogasawara Islands.In addition, *Dendrocacalia crepidifolia*, another species endemic to the Ogasawara Islands, has also evolved into a dioecious species (Kato and Nagamasu, 1995).

The development of woodiness in herbaceous plants

The development of woodiness in herbaceous plants is particularly evident in the Asteraceae, Cactaceae, and Campanulaceae families in oceanic islands such as the the Hawaiian Islands, the Galapagos Islands, and the Juan Fernández Islands (Ono, 1994). A similar phenomenon can be seen in the nominated property.

On the Ogasawara Islands, woodiness can be seen in three endemic species in the family Asteraceae: *Dendrocacalia crepidifolia*, *Crepidiastrum linguifolium*, and *C. ameristophyllum.* It is considered that the development of woodiness in these species occurred in the course of speciation after arrival of their herbaceous progenitor species at the islands (Ito, 1992; Ito and Pak, 1996; Kato, 2004). Of these, *Dendrocacalia crepidifolia* is a particularly large tree, growing four to five meters in height and having a trunk that can reach up to 10 centimeters in diameter.

As for *Lobelia boninensis* (Campanulaceae), all the species in the same genus seen in the

mainland of Japan are herbaceous, and it is speculated that this species also evolved from a herbaceous from into a woody plant. Flowering specimens of this species reach heights of up to three meters, but unlike other woody plants they have monocarpic characteristics (Kato, 1994; Toyoda, 2003; Uchiyama and Kachi, 1996; 1998; Uchiyama et al., 1996).

The coevolution of fauna and flora

Many examples of the coevolution of plants and insects can be seen on the Ogasawara Islands. This phenomenon can be seen in the three endemic species of the genus *Ficus*: *F. iidaiana*, *F. boninsimae*, and *F. nishimurae*. These *Ficus* genera developed a symbiotic pollination system relying on the fig wasps that parasitize *Ficus* flowers. Furthermore, in most cases there is one species of fig wasp acting as pollinator for each *Ficus* species, which is an example of species selectivity. Yokoyama (2003) has analyzed the distribution of *Ficus* species and fig wasps on the Ogasawara Islands and has proposed the following coevolutionary process: 1. populations of *Ficus* species establieshed in different environments on the Ogasawara Islands; 2. gene flow in *Ficus* and fig wasps became restricted, leading to changes in the characteristics of the fig wasps, and then; 3. further gene flow restriction caused genetic differentiation in the species of *Ficus*.

In addition, as stated below (see the section on insects), the absence of active ants in the past on the Ogasawara Islands is thought to have contributed to the loss of extrafloral nectarines that served to attract ants and keep away other predators (Sugiura et al. 2006; Pemberton, 1998; Sugiura, 2007). Among the psyllids of the Ogasawara Islands, of which there are many endemic species, speciation occurred through adaptive radiation, corresponding respectively to three species in the genus *Machilus*: *M. kobu*, *M. boninensis*, and *M. pseudokobu* (Matsumoto, 2009). As suggested, many of the dioecious flowers seen in a variety of taxa have most likely resulted from an evolutionary development through their relationship with pollen-carrying insects.

2.a.3.4 Biogeographic characteristics of plants in the Ogasawara Islands

< Chichijima Island Group >

Natural vegetation and semi-natural vegetation cover the eastern and southern parts of Chichijima. The main natural vegetation includes the Machilio kobu-Schimetum mertensianae, Distylio-Pouterietum dubiae, and Wikstroemio-Pouterietum dubiae communities (Okutomi, et al., 1983). Anijima has a large area of Distylio-Pouterietum dubiae sclerophyllous scrub and the proportion of natural vegetation is high. Minamijima is an island made up of limestone from raised coral reefs, and as such has natural vegetation characteristic of limestone beds, including Myoporetum boninensis, Limonium wrightii community, and Lycietum griseolae (Okutomi, et al., 1983).

< Hahajima Island Group >

Hahajima Island is noted for natural vegetation consisting mainly of Machilio boninensis-Ardisietum sieboldii and Pisonio-Elaeocarpetum photiniaefoliae communities (Okutomi, et al., 1983). Dwarf shrubs of Dendrocacalietum crepidifoliae dominated by *Dendrocacalia crepidifolia* (Asteraceae), the species endemic to the Ogasawara Islands, occur on the steep slopes and wind-beaten terrain in the cloud belts of Hahajima.

Mukohjima is an island with much natural vegetation, most notably *Livistonia chinensis* var. *boninensis-Pandanus boninensis* ass. and Wikstroemio-Pouterietum dubiae communities. Imotojima, on the other hand, is almost entirely dominated by a natural Wikstroemio-Pouterietum dubiae vegetation community. Natural vegetation of Wikstroemio-Pouterietum dubiae also covers about half of Meijima.

Even though Chichijima and Hahajima are only separated by about 40 km, they have their own endemic species growing on them. The presence of different florae distinctive to different islands is one characteristic of this area. A comparison of the endemic species of both island groups reveals that Chichijima Island Group has 19 species mainly adapting to dry conditions, while Hahajima Island Group has 15 species that grow in relatively damp forests, including fern species. These two island groups share 32 plant species in common, which is a fairly large number, but there are also many species endemic to each island (Toyoda, 2003; Nature Conservation Bureau, MOE, 2004), which suggests that evolution has progressed to the species level on each island.

It is thought that the islands' great distance from the continent, as well as separation between the islands in the archipelago, has led to different processes of evolution among the islands (the "archipelago effect"), resulting in a large number of endemic species (Shimizu, 1998).

< Mukojima Island Group >

In Mukojima, forests of Machilio boninensis-Ardisietum sieboldii remain along valleys. These forests have no dominant species, although relatively large areas covered with *Rhaphiolepis indica* var. *umbellate, Neisosperma nakaianum*, and *Livistona chinensis* var. *boninensis* is prominent there (Okutomi, et al., 1983).

< Kazan Island Group >

Almosot whole Minami-iwoto except coastal bluff areas is covered by pristine natural vegetation, mainly Boninio griseae-Elaeocarpetum pachycarpae, *Machilus kobu-Diplazium virescens* var. *virescense*, Cyathetum mertensianae, and Cyathetum tuyamae communities. While about 80% of Kita-iwoto is covered with a natural vegetation of Boninio griseae-Elaeocarpetum pachycarpae. These make this island group particularly rich in

natural vegetation (Okutomi, 1982; Okutomi, et al., 1983).

< Nishinoshima >

Nishinoshima is a geologically young island that has been heavily affected by submarine volcanic eruptions. Although there are few plant species on the island, the vegetation there is pristine, exhibiting no invasion by alien plant species. The island is an important site to study the processes by which plants disseminated by ocean currents after volcanic eruptions eventually settle on an island. Three plant species were recorded in 1969. Furthermore, several surveys were conducted after the 1973 eruptions, and four species were newly recorded in 1983, followed by six species in 2004. Of these six recorded in 2004, four species are thought to have been disseminated to the island via ocean currents, and the remaining two dispersed by seabirds or other animals (Abe, 2006).

2.a.4 Animals

On oceanic islands that are separated by large distances from the continent and have never been connected to it, all terrestrial animals present are species whose ancestors were somehow capable of crossing vast stretches of the ocean and ended up there through unlikely happenstance. For this reason, the structure of the fauna on such islands is quite distinctive: some taxa are completely absent, or conversely proportions of certain taxa are large. These phenomena account for the extremely disharmonic biological communities typical of oceanic islands (Ono, 1994). As for the terrestrial fauna on the Ogasawara Islands (except birds, which can migrate relatively easily), there is only one mammal species, two reptile species, and no amphibians. With regard to insects, although there is a variety of coleopterous species present on the continent, there is only one species of Cantharoidea and no native Chrysomelidae on the Ogasawara Islands (Takakuwa, 2004). On the other hand, 25% of the insects naturally distributed over the Ogasawara Islands are endemic. When considered together with the 95% ratio of endemic terrestrial snails, it is clear that the area is characterized by an abundance of endemic species and subspecies that evolved on the islands (Hasuo, 1970).

In short, because the nominated property consists of oceanic islands far from any continent, specific groups of animals have evolved independently, forming a unique fauna. The evolution of this fauna is still on-going, and as such it constitutes a site where the processes of animal diversification can be observed directly.

2.a.4.1 Mammals

Terrestrial mammals

There is only one native terrestrial mammal species: the Bonin flying fox (*Pteropus pselaphon*). The fact that the only mammal is a flying bat embodies the ecosystem characteristics of an oceanic island.

The Bonin flying fox is endemic to the Ogasawara Islands. It is listed as critically endangered (CR) on the IUCN Red List (2008), and CR (endangered IA) on the MOE Red List (2007).

Distribution of this species is confirmed on Chichijima, Hahajima, Kita-iwoto, Iwoto, and Minami-iwoto. Additionally, there is fragmental information on the species inhabiting Anijima (Abe et al., 1994) and Mukojima. The estimated population of the species on Chichijima is about 100 to 160 individuals (Incorporated Nonprofit Oraganization of Institute of Boninology (hereinafter reffered to as "Instituite of Boninology"), 2008) and over 100 on Minami-iwoto (Suzuki et. al., 2008), in addition to a few to tens of individuals in other distribution areas (for the current situation of the population and conservation of the flying fox, see the section "4.a.2 Present state of conservation"). The flying fox is reported to feed on 55 species in 18 plant families, including fruit, nectar, pollen, petals, and leaves (Inaba, 2004). Flying foxes are known to play an important role in the dispersal of diaspore. Research has shown that the dispersal distance is related to the flying foxes' habitat density (McConkey and Drake, 2006). The Bonin flying fox is likewise an important disperser. In fact, the species is considered crucial for maintaining the forests of the Ogasawara Islands.

Biogeographic characteristics of the Bonin flying fox populations

< Chichijima Island >

This species rests alone or in groups of a few individuals from spring to autumn, but it forms colonies at specific sites from late December to late April. The use of group gregarious resting sites is seen in other flying foxes, but colonization which depends on the season of the year is a peculiar feature of this flying fox on Chichijima, and is thought to be closely related to breeding behavior (Inaba, 2004).

< Minami-iwoto Island >

The daily behavior of this species in its known distributional areas of Chichijima and Kita-iwoto is nocturnal (Ibaba, 2001; Inaba el al, 2002). However, some individuals are oboserved active in search for food during the day on Minami-iwoto, showing that this species is not necessarily nocturnal. Daytime activities of this species on Minami-iwoto can be attributed to the absence of diurnal predators such as Raptores, and to extended searching time for food due to chronical food shortage (Suzuki et al, 2008). Given the absence of impact by alien species, Bonin flying foxes on Minami-iwoto are extremely important to

elucidate the prisitine biology of this species.

Marine mammals

Many species of cetaceans are seen in waters adjacent to the Ogasawara Islands. To date, 23 species in six families have been confirmed (Mori, 2004). There are 86 known species of cetaceans in the world (Jefferson et al., 2008). Excluding the four species that spend their entire life cycles in freshwater, there are 82 species in the world's oceans. This means that about 30% of all cetacean species inhabit adjacent waters of the Ogasawara Islands. These species represent nearly all cetacean species that are distributed or migrate in the subtropical waters of the North Pacific. The number of species is comparable to that of the Gulf of California, the Gulf of Mexico, and the coastal waters of the Hawaiian Islands and Ryukyu Islands, making waters off the nominated property an important habitat for cetaceans.

Of the 23 species that have been recorded from adjacent waters of the Ogasawara Islands, the IUCN Red List (2008) includes the sei whale (*Balaenoptera borealis*), blue whale (*B. musculus*), fin whale (*B. physalus*), and North Pacific right whale (*Eubalaena japonica*) as endangered (EN), while the sperm whale (*Physeter macrocephalus*) as vulnerable (VU).

Humpback whales (*Megaptera novaeangliae*) and sperm whales have been confirmed breeding in waters around the Ogasawara Islands (Darling and Mori, 1993; Mori et al., 1999). It is known that humpback whales breed in coastal shallow waters of the continents or islands at low latitudes, and there are breeding grounds in Hawaii and Mexico. However, the populations in Asian waters, including the Ogasawara Islands, have little or no interaction with those populations in the eastern and central North Pacific, and they are thought to have their own migratory routes as western North Pacific populations (Calambokidis et al., 2008).

Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and spinner dolphin (*Stenella longirostris*) occur all year around in the coastal waters off the Ogasawara Archipelago (Mukojima Island Group - Hahajima Island Group). Recent studies suggest that at least the Indo-Pacific bottlenose dolphin has a limited interaction with populations in other areas and it is resident within the areas of the Ogasawara Archipelago (Mori, 2009; Mori and Yoshioka, 2009).

2.a.4.2 Birds

The ability of birds to fly makes it relatively easy for them to cross seas but the Ogasawara Islands are separated by about 1,000 km from any other sizeable landmass, so it is not easy even for birds to reach the islands. As a result, the number of bird species that have settled

on the islands is limited compared to avifauna on the mainland of Japan. However, birds that did establish on the islands have evolved in isolation over a long period of time, resulting in a very distinctive avifauna that is not seen on the mainland of Japan. Studies of the Ogasawara Islands, the Hawaiian Islands, and the Galápagos Islands suggest that nearly all prominent examples of flora exhibiting adaptive radiation comprise species dispersed by foraging by birds (Ono, 1991); for this reason the role played by avifauna in oceanic island ecosystems is considered to be very important. Furthermore, the Ogasawara Islands serve as an important breeding ground for threatened seabirds.

Avifauna

Birds in the nominated property, documented as having occurred excluding those that were only recorded before World War II, comprise 15 orders, 46 families, and 195 species (Hasuo, 1970; Chiba, 1977; 1990; Higuchi, 1984; Hiraoka and Chiba, 1997; TMG, 2001; Suzuki and Chiba, 2004; Institute of Boninology, 2005; Nakano, 2006; Chiba et al., 2007; Clements, 2007).

Of these 195 species, 14 species are listed in IUCN Red List (2008), of which two species are designated as EN, six species as VU, and the remaining six species as near threatened (NT). While 38 species and subspecies are listed in the MOE Red List (2006), of which three subspecies are designated CR, 12 species/subspecies as EN (endangered IB), 14 species/subspecies as VU (endangered II), and five subspecies as NT (near threatened). Of those 195 species, 22 species of native birds have been breeding in the nominated property in recent years Of these native 22 species, terrestrial birds comprise eight species (nine species/subspecies), they are: one endemic species of Bonin honeyeater (*Apalopteron familiare*), seven endemic subspecies (*Buteo buteo toyoshimai, Columba janthina nitens, Ixos amaurotis squamiceps, I. a. magnirostris, Cettia diphone diphone, Zosterops japonicus alani,* and *Carduelis sinica kittlitzi*., and blue rock thrush (*Monticola solitarius*) (Committee for Check-List of Japanese Birds, 2000.

To date, 16 species of seabirds have been reported to breed in the Ogasawara Islands. However, since 1968, only 14 species have been documented breeding in the nominated property because of the local extinction of short-tailed albatross (*Phoebastria albatrus*) and red-footed booby (*Sula sula*) (Chiba et al., 2007; Kawakami et al., 2008). With regard to the Laysan albatross (*Phoebastria immutabilis*), the Mukojima Island Group is the only breeding site in the Western Pacific (Suzuki and Chiba, 2004). The black-footed albatross (*Phoebastria nigripes*) breeds also in Hawaii, but the population in Hawaii differs genetically from the one breeding in the Ogasawara Islands (Eda et al., 2008). In addition, Matsudaira's storm-petrel (*Oceanodroma matsudairae*) and a subspecies of Audubon's shearwater (*Puffinus lherminieri bannermani*) are endemic breeders which means they breed

exclusively in Ogasawara Islands, in spite of their wide range of inhabitation in the Pacific and/or Indian Oceans (Fig. 2-9).

Matsudaira's storm-petrel
(*Oceanodroma matsudairae*)

Audubon's shearwater (*Puffinus lherminieri*)
(The arrow shows the breeding site of *P. lherminieri bannrmani*)

Fig. 2-9 Distribution of Seabirds
(Blue: Distribution areas in non-breeding period / Red: Breeding sites)
(Maps taken from the Handbook of the Birds of the World, with modifications. Lynx Edicions, Barcelona)

Characteristics of the Bonin honeyeater, an endemic species

There have been records of four endemic species of terrestrial birds occurring on the Ogasawara Islands, however the Bonin honeyeater is the only existing endemic land bird at present.

The Bonin honeyeater, which occurs only on Hahajima and its satellite islands, exhibits the features of a bird that has followed a unique process of evolution in the Ogasawara Island, an oceanic island group in terms of lifestyle and distribution patterns.

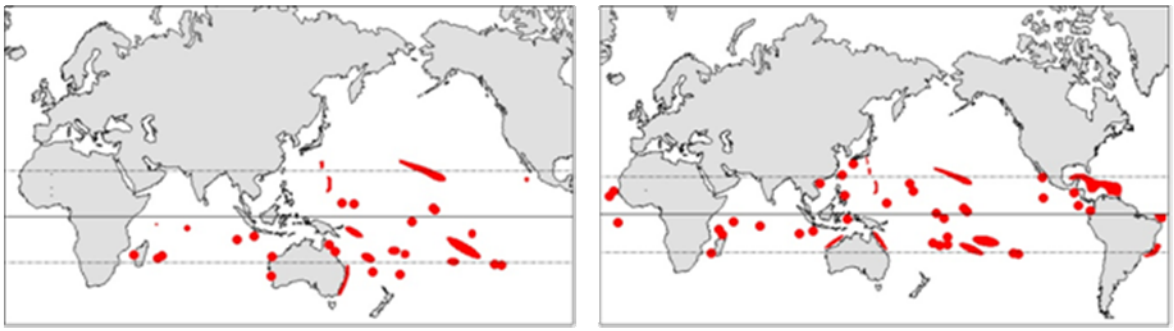
As the Ogasawara Islands are oceanic islands separated by a great distance from thecontinents the avifauna is quite different from that on the continents. For example, there are no birds living on the ground (such as pheasants), feeding at tree trunks (such as woodpeckers), or breeding in tree hollows (such as tits). It has been reported that the Bonin honeyeaters of Hahajima forage at the tree trunks like woodpeckers, and use tree cavities for nesting instead of nesting in the forks of tree branches, as normally observed for other honeyeaters (Kawakami and Higuchi, 2002). This is considered to be the result of the lack of other competitors using these habitats. Without competitors or terrestrial predators on the Ogasawara Islands, the honeyeaters have come to utilize a variety of places from the upper to understory layers of forests, including the ground, fallen trees, tree trunks, leaves and branches (Kawakami and Higuchi, 2003). In this respect, the bird communities on the oceanic Ogasawara Islands differ from those on the mainland of Japan, and component

species are fewer. For this reason, there are more niches available to the Bonin honeyeaters, and they effectively expand to range across these available niches.

The Bonin honeyeater is thought to be closely related to the golden white-eye (*Cleptornis marchei*) on Saipan (Springer et al., 1995), and there is a possibility that this southern species expanded its distribution. If that is the case, they must have flown across several hundred kilometers of ocean. However, at present the distance of the mere few kilometers of sea that separate the islands in the Hahajima Island Group is a sufficient barrier to the bird's movement. The Bonin honeyeater only occurs on Hahajima, Mukohjima and Imotojima, and does not occur on other nearby islands despite the presence of forest environments capable of supporting it. In addition to the sea, the open land environment has also proved to be a barrier, restricting its movement even within the island, which caused morphological or genetic differences among different populations (Kawakami et al., 2008). This loss of mobility is one of the most striking characteristics of birds that live on oceanic islands.

Characteristics of the Avifauna of the Ogasawara Islands

Most of the seabirds documented as breeding on the Ogasawara Islands, such as wedge-tailed shearwater (*Puffinus pacificus*), inhabit tropical and subtropical zones, with the Ogasawara Islands being the northern distributional limit for many of them. In addition, the area is also the southernmost breeding site for northern terrestrial birds such as the Eurasian buzzard (*Buteo buteo*), the Japanese bush-warbler (*Cettia diphone*), the brown-eared bulbul (*Ixos amaurotis*), the Japanese white-eye (*Zosterops japonicus*) (Fig. 2-10). As seen above, the nominated property occupies a location where the habitats of both southern and northern birds intersect.



Wedge-tailed shearwater (*Puffinus pacificus*)　　Brown booby (*Sula leucogaster*)

Eurasian buzzard (*Buteo buteo*)　　Japanese white-eye (*Zosterops japonicus*)

Fig 2-10　Breeding areas of the birds that also breed in the Ogasawara Islands
(Red: Breeding sites)
(Maps taken from the Handbook of the Birds of the World, with modifications. Lynx Edicions, Barcelona)

Characteristics of component parts of the serial property

The constituent parts of the Ogasawara Islands are each designated as Important Bird Areas (IBAs) by BirdLife International. In addition, the Ogasawara Archipelago is designated as an Endemic Bird Area (EBA) by BirdLife International, because it is the habitat of the endemic Bonin honeyeater and *Columba janthina nitens*, a restricted-range species (BirdLife International HP).

< Chichijima Island Group >

Audubon's shearwater was found to breed on Higashijima of this island group in 2007. This is the only breeding record of this species after World War II (Kawakami et al., 2008). Minamijima and Higashijima of the Chichijima Island Group are the main breeding sites in the Ogasawara Islands for Bulwer's petrel (*Bulweria bulwerii*) (Chiba et al., 2007).

Higashidaira on Chichijima is an important breeding site for *Columba janthina nitens*, and this island group is designated as an IBA because it is the habitat of *Columba janthina nitens*, a restricted-range species.

< Hahajima Island Group >

As already stated, the endemic Bonin honeyeater has only been observed on Hahajima and two satellite islands in the Hahajima Island Group: Imotojima and Mukohjima. The island group is also an important habitat for Oriental greenfinch (*Carduelis sinica kittlitzi*), an endemic subspecies.

This island group is designated as an IBA, because of its importance as the habitat of the endemic Bonin honeyeater.

< Mukojima Island Group >

The Mukojima Island Group is the only confirmed breeding site of the Laysan albatross in the West Pacific, and the main breeding ground in the Ogasawara Islands for the black-footed albatross (Chiba et al., 2007).

This island group is designated as an IBA, because it contains habitats of the black-footed albatross, an internationally threatened species, and of *Columba janthina nitens*, a restricted-range species.

< Kazan Island Group >

Matsudaira's storm-petrel has been confirmed to breed only on the Kazan Island Group (Kawakami et al., 2008). Before World War II it was also breeding on Kita-iwoto, but at present its only known breeding place is Minami-iwoto. Because Minami-iwoto has suffered little human impact to this date, the island serves as important habitat for seabirds such as the Bonin petrel (*Pterodroma hypoleuca*) and Matsudaira's storm-petrel. Furthermore, in recent years, the possibility of Audubon's shearwater breeding there has been suggested (Kawakami et al., 2008).

This island group is designated as an IBA, because it is a habitat of *Columba janthina nitens*, a restricted-range species, and a regular habitat of more than 1% of the biogeographical population of Matsudaira's storm-petrel and red-tailed tropicbird (*Phaethon rubricauda*), gregarious seabirds.

< Nishinoshima >

This island developed its current figuration after submarine eruptions in 1973 and 1974. The terrain of the area is still changing by erosion and volcanic deposits, yet eight species have been recorded breeding there: that is over half of the birds for which there are breeding records in the nominated property This reaffirms the importance of the area as a breeding site for seabirds (Kawakami et al., 2005).

This island is designated as an IBA, because it is a regular habitat area of more than 1% of the world's population of great crested tern (*Thalasseus bergii*), a gregarious seabird.

2.a.4.3 Reptiles

There are only a few reptile species that have crossed the vast distance of ocean to reach and settle on the oceanic Ogasawara Islands, but this fact has contributed to the formation of a unique community structure on the islands.

There are two species in two families of terrestrial reptiles distributed on the islands: the Ogasawara snake-eyed skink (*Cryptoblepharus nigropunctatus*) and the Micronesian gecko (*Perochirus ateles*). The Ogasawara snake-eyed skink has been included in the MOE Red List as a Near Threatened (NT) species. With regard to marine reptiles, , there are four species in two families of sea turtle in the waters off the Ogasawara Islands. All are on the IUCN Red List (2008): the green turtle (*Chelonia mydas*, EN), the loggerhead turtle (*Caretta caretta*, EN), the hawksbill turtle (*Eretmochelys imbricate,* CR), and the leatherback turtle (*Dermochelys coriacea*, CR). It has been confirmed that the green turtle comes ashore every year at beaches on the Ogasawara Islands to lay eggs, making the nominated property important for the conservation of this threatened species.

Among the terrestrial reptiles, the Ogasawara snake-eyed skink endemic to the Ogasawara Islands utilizes a relatively wide variety of habitats, from the ground to trees, while other lizards of the same genus of *Cryptoblepharus* tend to be ground-dwelling (Suzuki and Nagoshi, 1999). This can be considered a result of this skink expanding its niche through ecological release in an environment where there are few competing species. The green turtle, a marine reptile, inhabits the tropical and subtropical seas of the world, but the species can be divided into several groups according to migration routes and breeding sites. In the Western North Pacific, there is a group that migrates from the northern part of the Mariana Islands to the waters off Japan (Bowen et al., 1992). For this group, the Ogasawara Islands is both the largest and most northern breeding site (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 2007). Egg-laying season on the Ogasawara Islands is from late April to early September. About 1,200 and 700 occurrences of egg-laying per year have been confirmed on Chichijima and Hahajima Island Groups, respectively. The green turtles lay eggs three or four times in one season, which means that over 500 adult females are thought to utilize the Ogasawara Islands as a breeding site. In addition, because the group of green turtles in the waters off the Ogasawara Islands has genetic characteristics different from groups in other areas (Bowen et al., 1992, Karl et al., 1992, Roberts et al., 2004), these turtles are also valuable as subjects for scientific studies on the ecology and evolution of this little-known species. (For the situation regarding their

conservation, see “History and development” in Section 2.b).

Biogeographic variation in lizards

Lizards of the genus *Cryptoblepharus* are widely-distributed in the Pacific and the Indian Ocean regions. In recent years, the taxonomic consensus has recognized that the the Ogasawara snake-eyed skink (*C. nigropunctatus*) of the genus’s northernmost distribution, is not only a distinct but an endemic species (Horner, 2007; Hikita, 2007). Furthermore, recent genetic analyses have confirmed that this species is genetically diversified even within the Ogasawara Islands (Hayashi et al., 2009). That is, there are major genetic variations between the population of Chichijima Island Group and that of Hahajima Island Group. At the same time, it has been shown that among the populations distributed throughout the Kazan Island Group, populations living on Minami-iwoto are genetically different from populations on Kita-iwoto, but are closely related to the populations in the Hahajima Island Group, while populations on Kita-iwoto have a number of genes similar to those of populations in the Chichijima Island Group (Hayashi et al., 2009).

As for the Micronesian gecko, an arboreal lizard seen throughout island regions including the Western Pacific (such as the Marianas and the Chuuk Islands), occurs only on Minami-torishima and Minami-iwoto in the Ogasawara Islands; none are present on the other islands to the north (Sengoku et al., 1996).

These two lizard species are important examples of terrestrial fauna development in the Ogasawara Islands, resulting from the interaction of multiple conditions such as unstable and complex seasonal ocean currents (Asami, 1970a), and the sequence of islands’ formation (Asami, 1970b; Yamashita 2004).

2.a.4.4 Aquatic animals (except mammals and reptiles)

Aquatic animals such as fish are commonly thought to swim freely in the ocean and easily disperse via ocean currents, but large sections of ocean without any landmass and strong ocean currents in fact form barriers that prevent their movements. For this reason, there are only certain species of aquatic animals capable of traveling to the Ogasawara Islands, which are separated from the nearest landmass by approximately 1,000 km. Aquatic animals that have settled in the waters around Ogasawara, are those species which overcame these prohibitive waters. In addition, freshwater species on the islands are limited to diadromous species thanks to their capability of disperse via sea waters.

1) Freshwater animals

Factors which have affected the characteristics of freshwater animals on the Ogasawara Islands include the fact that there are no large rivers and that they are separated by large distances of ocean from other bodies of inland water. As a result, there are only a few species of freshwater animals. This separation, however, is also thought to have caused some species to evolve into endemic diadromous species, and some of these species to evolve into endemic species that are diadromous in origin but that have strong land-locked tendencies. The Ogasawara Islands are home to peculiar species that has advanced their life history places from coastal waters to brackish water, and then from brackish water to freshwater, making it a valuable area to study the evolutionary progress from saltwater to freshwater.

Fish

Forty species in 19 families of fish have been recorded from the inland water areas of the Ogasawara Islands to date (Yoshigou, 2002). Generally it is well-known that due to the limited, small areas that oceanic islands occupy, in addition to unstable climatic conditions, there are fewer species on such islands than on continental islands. There is only one species of freshwater fish endemic to the Ogasawara Islands: *Rhinogobius* sp. BI (a type of goby). It is listed on the MOE Red List as CR species. Most fish in the genus *Rhinogobius* are freshwater species of the family Gobiidae that have originated on continents and are therefore distributed on continents and continental islands. For this reason, the presence of this particular species on the remote Ogasawara Islands is considered to be an exceptionally rare example. *Rhinogobius* sp. BI has a longer pelagic period than other amphidromous *Rhinogobius* species that live in Honshu. This is thought to be an adaptation that increases the possibility of finding rivers to run, as changes in water levels are extreme in Ogasawara and river mouths often become closed (Yokoi, 2006).

Crustaceans

Eight species of freshwater shrimps in five genera in two families have been reported from the rivers of the Ogasawara Islands (Stimpson, 1858: Kato and Takeda, 1981: Suzuki, 1972: Yoshigou, 2002: Satake ans Cai, 2005: Cai et al., 2006). In addition, one shrimp species is reported from anchialine pool (Mitsuya, 1998). These nine shrimp speceis comprise one species in the family Alpheidae, three species of two genera in the family Palaemonidae, and five species of three genera in the family Atyidae. Of these, there are two species endemic to the Ogasawara Islands: *Palaemon ogasawaraensis* and *Paratya boninensis*. Four species are on the MOE Red List (2006): *Paratya boninensis* (CR＋EN), *Metabetaeus minutes* (NT), *Palaemon ogasawaraensis* (NT), and *Atyoida pilipes* (NT).

Seven of these nine species have been amphidromous in their life histories, migrating between rivers and the ocean, while endemic *Palaemon ogasawaraensis* lives only in

brackish water. In addtion, endemic *Paratya boninensis* lives only in upstream parts of the rivers (i.e. riverheads) and lays small numbers of large eggs, suggesting that they spend their entire life landlocked in rivers. There are no other landlocked freshwater shrimp on other oceanic islands in the world (Satake and Ueno, 2001; Satake and Cai, 2005). Despite *Paratya boninensis* being considered as a landlocked shrimp, it is found in several river systems on Chichijima and Hahajima.

As for crabs, seven species in seven genera in three families have been reported on the Ogasawara Islands (Yoshigou, 2002). *Eriocheir ogasawaraensis* moves to the sea to mate, but normally lives in a freshwater environment (Kobayashi, 2005). *Uca crassipes* inhabits the tidal flats at the mouths of rivers (Imajima, 1970). Little is known, however, about the distribution of the other species. At present, *E. ogasawaraensis* is the only recognized endemic species to the Ogasawara Islands and is include in theMOE Red List (2006) as VU.

The Ogasawara Islands have six species of terrestrial hermit crabs reported. Five of them belong to the genus *Coenobita* while one is a coconut crab of the genus *Birgus* (TMG Board of Education, 1987; Sasaki and Horikoshi, 2008; Asakura, 2004). *Birgus latro* and *Coenobita perlatus* are categorized as VU on the MOE Red List (2006). Of these crub species, only *Coenobita purpureus*, is endemic to Japan. It is distributed in Kagoshima, the Amami Islands, Okinawa Island, Miyakojima Island, and the Yaeyama Islands (Sasaki and Horikoshi, 2008). All the *Coenobita* species were designated as Japan's Natural Monuments in 1970 because they are in danger of a sharp population decline due to the capture as pets (Kuwabara, 1995).

As for other crustaceans, two species of isopods have been reported from inlandwater environments in the Ogasawara Islands. They are thought to be endemic to Ogasawara (Nunomura and Satake, 2006; Nunomura et al., 2008). Of these, *Gnorimosphaeroma boninense*, is listed as critically endangered (CR+EN) on the MOE Red List (2006).

Gastropods

To date, 17 species in 11 generain six families of freshwater gastropods have been recorded on the Ogasawara Islands (Habe, 1969; Kanno, 1973, Komatsu, 1993; Fukuda, 1993, 1995; Satake et al., 2006; Institute of Boninology, 2007, 2008). Of these, three species are on the MOE Red List: *Stenomelania boninensis* (VU), *Neritodryas subsulcata* (VU), and *Septaria lineata* (NT) (MOE, 2007).

Stenomelania boninensis is a freshwater gastropod endemic to Ogasawara that belongs to the genus *Stenomelania* of the family Thiaridae. It is thought to have diverged five to three million years ago from an ancestor in common with *S. juncea*, which lives on and south of Yonaguni (Miura et al., 2008). Most of the component species that make up the genus

Stenomelania are widely distributed in the tropics of the western Pacific Ocean. *S. boninensis*, which diverged into a species endemic to only certain island groups, is unusual species in this genus. The genus is also amphidromous, developing into a young shellafter pelagic larval period. This is considered to be the reason why its distribution is limited to river mouths near brackish areas and lowland rivers (Bandel et al., 1997; Köhler and Glaubrecht, 2001). However, while *S. boninensis* has a pelagic larval stage (veliger), it lives only in freshwater with no brackish areas (Sasaki et al., 2009), and its distribution extends up to headwaters of 250 m or moreabove sea level. It is also capable of reproducing and growing in pure freshwater environments (personal communications with Sasaki, Satake, and Chiba). In Thiaridae, the only other species whose distributions extend up to such high elevations and that can spend their entire lives in freshwater are those groups of species in which the female directly produces living young shell (viviparity). *S. boninensis* is the only known species of this kind in the world that has a pelagic larval period. From the standpoint of evolutionary ecology, *S. boninensis* is an extremely valuable species in that it could contribute to the elucidation of the processes by which gastropods adapt to pure freshwater environments.

2) Marine animals

As stated above, the barriers such as ocean currents and distance from continental coasts have limited the number of species in the marine fauna. Most of the component species arrived at the islands coincidentally. As a general rule, there are fewer endemic species of marine animals seen in small areas compared with terrestrial animals; however, in areas separated from large landmasses by large distances, such as the Ogasawara Islands, there are some endemic species, most notably those that inhabit coastal waters and brackish water environments.

Fish

There are 801 species of fish reported around the coastal waters of the Ogasawara Islands (Randall et al., 1997). The fish fauna of the Ogasawara Islands is more similar to that of southern islands such as the Marianas than the Izu Islands to the north. Furthermore, east-west regional comparisons of Pacific piscifauna shows a similarity with fish fauna in the western Pacific, demonstrating that these species have been strongly influenced by the highly diverse Western Pacific and southern seas (Senou, 2004).

As for the distribution of these fish in marine areas, there are many areas that have not been sufficiently studied, and since there is a high probability of the same species being found in other waters, it is difficult to confirm that any of them is a species endemic to the

Ogasawara Islands. Nevertheless, as of now, *Scarus obishime, Genicanthus takeuchii, Ammodytoides kimurai,* and *Pseudamia rubra* are considered endemic species, as they have not been recorded outside of the Ogasawara Islands, aside from random, incidental spottings (Senou, 2004).

Gastropods

Two subclasses, 15 orders, 112 families, and 1,031 species of marine gastropods have been reported around the Ogasawara Islands (Fukuda, 1993, 1994, 1995). Of these, there are 884 species (85.7%) of *Prosobrancha* and 147 species (14.3%) of Heterobranchia. Within Prosobranchia, there are 148 species (16.7%) in Archaeogastropoda, 327 (37%) in Neotaenioglossa, and 409 (46.3%) in Neogastropoda. The low ratio of Archaeogastropoda species is a common characteristic of oceanic islands and is also seen in the Hawaiian, the Mariana, and the Seychelles Islands.

There are few species that are endemic to the Ogasawara Islands in the strictest sense, i.e. species not present on the southern tip of the Izu Islands or the northern tip of the Mariana Islands. The number is thought to be less than five. These include *Cellana mazatlandica*, which is designated as aNatural Monument, as well as *C. enneagona*, and *Lunella ogasawarana* (Tachikawa, 2009).

Hermatypic corals

To date, 226 species of hermatypic corals have been reported from the Ogasawara Islands (MOE and the Japanese Coral Reef Society, 2004). The reason why the number of species is relatively small, is thought that the inflow and outflow of species at the Ogasawara Islands have been limited due to the lack of the effects of the main Kuroshio current and the equatorial countercurrent. The major component species include *Acropora florida*, which forms large colonies, and massive or encrusting species of Faviida family. However, one of the characteristics of the Ogasawara Islands is that coral community structure mainly composed of diverse species of *Acropora* rarely occurs in this area (Inaba, 2003).

There are few shores suitable for hermatypic corals to develop because of the narrow wave-cut benches around the islands there, formed by wave erosions in Holocene epoch.

Aside from data on a part of Chichijima, there is very little information available on the structure and distribution of coral communities. The size of coral reefs varies widely depending on the particular island, but there are discontinuous apron-type reefs around each island (Inaba, 2004). The main distribution areas where relatively developed hermatypic corals can be seen are: the shores off Futami Bay and Tatsumi Bay on Chichijima, the Anjijima straight, Takinoura Bay on Anijima, and Higashi Port and Kita Port on Hahajima

(Inaba, 2004). Except these areas, there are continuous sheer cliffs on the Chichijima and Hahajima Island Groups, which makes poor conditions for the coral communities to develop, leaving patchy formations of small and encrusting species of Mussidae and Faviidae families on the surface of rock reefs (Inaba, 2004). In this way, the Ogasawara Islands have characteristic coral communities as oceanic islands, and thanks to the fact that the islands are adjacent to the open ocean, they are less affected by high sea temperatures (Inaba, 2003). Therefore, as coral communities in other areas are disturbed by bleaching, those of Ogasawara have a potential role as a gene pool; this makes the Ogasawara Islands an important site for coral conservation.

3.a.4.5 Insects

One of the characteristics of the insect fauna on the Ogasawara Islands is the large proportion of endemic species and the imbalance in taxonomic composition. At present, there have been 1,406 species of insects recorded in total. Of these, 12 genera, as well as362 species are endemic (proportion of endemic species: 25.7%). Some insect taxa are not represented because most of Ogasawara's component species reached the islands by flying, were carried by seasonal winds or typhoons, or floated on ocean currents, resulting in this imbalanced taxonomic composition. Insect communities formed by the imbalanced taxa have created unique interactions among organisms, which in turn has resulted in evolution and ecosystems unique to the islands.

The insect fauna on the Ogasawara Islands is characterized by Indomalaya (which includes Southeast Asia), Micronesian, and Palearctic elements. Most of the endemic species are either Indomalayan or Micronesian species. Species with origins in these zones became established in Ogasawara quite early. The ancestral populations of these species spread to different islands in the area, and after being separated from each other, they evolved into endemic species or subspecies (Takakuwa, 2004).

The insect fauna of the Ogasawara Islands

The insect fauna of Ogasawara is characterized by larger proportion of endemic species than seen on the Japanese Archipelago and, as already stated, an imbalanced taxonomic composition.

As of 2002, there were 1,406 species of insects recorded from the Ogasawara Islands (such as Ohbayashi et al., 2004). These species are included in 24 orders in total:

- 457 species of beetles (Coleoptera),
- 275 species of moths and butterflies (Lepidoptera),

- 210 species of stink bugs, cicadas, leafhoppers, etc. (Hemiptera),
- 185 species of flies (Diptera),
- 132 species of wasps, ants, and bees (Hymenoptera),
- 42 species of grasshoppers, locusts, and crickets (Orthoptera),
- 20 species of thrips (Thysanoptera),
- 18 species of dragonflies and damselflies (Odonata),
- 14 species of lacewings (Neuroptera), and
- 15 other orders each of that has less than 10 species..

Endemic species account for up to around a quarter of these insects, a typical feature of oceanic islands. Some major orders with high proportion of endemic species are Coleoptera at 31.7%, Diptera at 31.9%, Hemiptera at 29.0%, and Hymenoptera at 25.0% (Table 2-2)

The imbalanced taxonomic proportions suggest that only certain taxa were able to reach the islands, as the Ogasawara Islands are so remote from any large landmass. In the beetles, which have been relatively well-researched, there are many species with larvae that bore into wood, while there are only few that depend on living plants. For example, there are many species of jewel beetles (Buprestidae) and tumbling flower beetles (Mordellidae), which are not prevalent on the Japanese Archipelago, yet there are thought to be no native species of phytophagous scarabaeids or leaf beetles (Chrysomelidae). In addition, there are no records of mayflies (Ephemeroptera) or stoneflies (Plecoptera), which not only spend their larval stages in freshwater but have short life spans as adults and have fragile bodies. There are also no records of stick insects (Phasmida), which lack the ability to travel long distances on their own and rely on living plants for food. This imbalanced composition ratio is called “taxonomic disharmony,” and is one of the characteristic features of oceanic islands.

Table 2-2 Comparison of numbers of insect species between Ogasawara and Japan as a whole

(Kyusyu University et al. (Eds.), 1989; Ohbayashi et al., 2004)

	Japan mainland (1989)		Ogasawara Islands (2002, reviesed)						
Order	No. of species	Proportion in the whole	No. of families	No. of genera	No. of species	endemic species	Percentage of endemic species	Proportion in the whole	Ogasawara/ Japanese Mainland
Collembola	360	1.28	4	4	5	0	0.0	0.39	1.39%
Protura	50	0.18	2	2	2	0	0.0	0.16	4.00%
Diplura	13	0.05	2	2	2	0	0.0	0.16	15.38%
Microcoryphia	14	0.05	1	1	1	0	0.0	0.08	7.14%
Zygentoma	11	0.04	1	3	3	0	0.0	0.23	27.27%
Ephemeroptera	105	0.37	0	0	0	0	-	0.00	0%
Odonata	190	0.68	6	13	18	5	27.8	1.41	9.47%
Plecoptera	160	0.57	0	0	0	0	-	0.00	0%
Embioptera	2	0.01	1	1	1	0	0.0	0.08	50.00%
Blattaria	54	0.19	2	6	9	1	11.1	0.70	16.67%
Mantodea	9	0.03	1	3	3	0	0.0	0.23	33.33%
Isoptera	20	0.07	2	5	6	0	0.0	0.47	30.00%
Orthoptera	225	0.80	10	29	42	8	19.0	3.28	18.67%
Phasmida	20	0.07	0	0	0	0	0.0	0.00	0%
Dermaptera	20	0.07	2	3	5	0	0.0	0.39	25.00%
Grylloblattodea	6	0.02	0	0	0	0	-	0.00	0%
Psocoptera	83	0.30	6	6	10	2	20.0	0.78	12.05%
Mallophaga	150	0.54	1	1	1	0	0.0	0.08	0.67%
Anoplura	40	0.14	0	0	0	0	-	0.00	0%
Thysanoptera	200	0.71	2	13	20	3	15.0	1.56	10.00%
Hemiptera	2800	9.99	42	135	210	61	29.0	16.39	7.50%
Neuroptera	166	0.59	3	6	14	0	0.0	1.09	8.43%
Coleoptera	9000	32.10	53	234	457	145	31.7	35.68	5.08%
Strepsiptera	31	0.11	1	2	2	0	0.0	0.16	6.45%
Hymenoptera	4130	14.73	21	74	132	33	25.0	10.30	3.20%
Mecoptera	38	0.14	0	0	0	0	-	0.00	0%
Siphonaptera	69	0.25	1	1	1	0	0.0	0.08	1.45%
Diptera	4600	16.41	35	107	185	59	31.9	14.44	4.02%
Trichoptera	300	1.07	2	2	2	1	50.0	0.16	0.67%
Lepidoptera	5170	18.44	30	94	275	44	16.0	21.47	5.32%
	28036		231	747	1406	362	25.7		5.01%

The IUCN Red List (2008) includes five species of dragonflies and damselflies (Odonata) which inhabit the Ogasawara Islands: *Boninagrion ezoin*, *Indolestes boninensis*, *Rhinocypha ogasawarensis*, and *Boninthemis insularis* are classified as CR, while *Hemicordulia ogasawarensis* is classified as EN (IUCN, 2008). In fact, all dragonfly and damselfly species endemic to Ogasawara are on the IUCN Red List (2008). Of these, *Boninagrion ezoin* and *Boninthemis insularis* are the only species in their respective genera, making the genera also endemic to Ogasawara. The MOE Red List (2007) lists 73 species (CR+EN: 29 species; VU: 30 species; NT: 14 species), including the lycaenid butterfly (*Celastrina ogasawaraensis*), which is considered to be one of the most critically endangered of Japanese butterflies, and

the tiger beetle (*Cicindela bonina*), which has the rare distinction among ground-dwelling insects there by sharing common origins with species on the Japanese Archipelago. Of these 73 species, 71 species are endemic to Ogasawara, making Ogasawara important as a habitat for threatened insects. (For their conservation measures, see "Current state of conservation" in Section 4.a.6).

Origins of the Insect fauna

As already stated, the three constituent elements of the insect fauna on the Ogasawara Islands are Indomalayan (which includes Southeast Asia), Micronesian, and Palearctic. Because most of the endemic species are either Indomalayan or Micronesian in origin (Kurosawa, 1976b), they most likely settled on the Ogasawara Islands very early and evolved into endemic species.

On the other hand, most species with Palearctic features are thought to have been introduced by humans very recently. However, the endemic *Cicindela bonina* (a species of tiger beetle) is thought to be Palearctic (Kurosawa, 1976a) and it is a close relative of *C. elisae* found throughout the Japanese Archipelago and China. This gives *C. bonina* an unusual origin among the insects endemic to Ogasawara. Moreover, the recently discovered and not yet described species of licinine carabid beetles (Badister) is thought to be endemic, and with no closely related species in the Indomalayan region or Micronesia (Ball, 1992), thus it is highly probable that this species is of Palearctic origin. This is a very interesting example because species of this genus feed exclusively on land snails, and it is highly possible that the newly discbverd beetle has similar origin to some taxa of land snails.

The ancestors of these insect species came to Ogasawara by flying, were carried by seasonal winds or typhoons, or floated to the islands on ocean currents (Habu, 1968; Kato, 1991). Only certain taxa, such as some dragonflies, damselflies, moths and butterflies, flew to the islands under their own abilities, while the majority most likely arrived by happenstance. There are many endemic species of Diptera and Hemiptera. Most of these are small, floating insects that are thought to have arrived via air currents. Many Coleoptera species, such as those in the jewel beetles (Buprestidae), longhorn beetles (Cerambycidae), and tumbling flower beetles (Mordellidae), bore into hard, decaying or dead trees. It has been surmised that many of them arrived adrift at the islands carried by such decaying trees (Kato et al., 1991).

The evolution of endemic species of insects

The endemic insects seen in Ogasawara today are valuable products of unique evolutionary processes that involved the conflation of unlikely coincidences. Most species in Homoptera Auchenorrhyncha of Hemiptera including Tropiduchidae, Ricaniidae, and Ciadelloidea

families, which are plant-sucking insects, are small and are thought to have ancestors that evolved into endemic species after arriving in Ogasawara on wind currents. Of the 65 Auchenorrhyncha species on Ogasawara, 34 of them are endemic; the percentage of endemic species is 52.3%.

Wood-boring insects most likely arrived at the Ogasawara Islands on ocean currents, after which many of them evolved into endemic species. Of the 20 species of tumbling flower beetles, 19 of them, or 95%, are endemic. Out of the 47 longhorn beetles, 33 species (70.2%) are endemic. Furthermore, of the 93 weevils (Curculionoidae), 42 species (45.2%) are endemic, except bark and ambrosia beetles (Scolitynae) (Morimoto, 2005). There are only three species of lucanid beetles (Lucanidae), all of which are endemic (Table 2-3). In addition, nine species out of 11 Apoidea are endemic (Kyushu University and Japan Wildlife Research Cenrer (Eds.), 1989; Goubara, 2002), of which four species belong to the geuns *Hylaeus* that utilizes wood hollows to nest.

Table 2-3 Taxa with high percentages of endemic species

order	suborder etc. higher group	superfamily	family	No. of species in the family	No. of endemic species in the	No. of species in the group	No. of endemic species	percentage of endemic species in the group
Hemiptera	Homoptera Auchenorrhyncha	Fulgoroidea	Cixiidae	2	1	65	34	52.3
			Delphacidae	12	1			
			Derbidae	1	1			
			Tropiduchidae	8	8			
			Flatidae	2	0			
			Ricaniidae	8	6			
		Cicadoidea	Cicadidae	1	1			
		Cercopoidea	Aphrophoridae	3	3			
		Membracoidea	Membracidae	1	0			
		Cicadelloidea	Iassidae	1	1			
			Drabescidae	1	1			
			Tartessidae	1	1			
			Coelidiidae	6	5			
			Paraboloponidae	1	1			
			Typhlocybidae	3	1			
			Deltocephalidae	15	3			
Coleoptera	Polyphaga	Scarabaeioidea	Lucanidae	3	3	–	–	100
		Buprestoidea	Buprestidae	9	6	–	–	66.7
		Tenebrionoidea	Mordellidae	20	19	–	–	95.0
		Chrysomeloidea	Cerambycidae	47	33	–	–	70.2
		Culculionoidee	Anthribidae	18	14	93	42	45.2
			Brentidae	2	1			
			Nanophyidae	1	1			
			Curculionidae	64	24			
			Rhynchophoridae	8	2			
Hymenoptera	Apocrita	Sphecoidea	Sphecidae	20	11	–	–	55.0
		Apoidea	Colletidae	4	4	11	9	81.8
			Megachilidae	3	3			
			Anthophoridae	3	2			
			Apidae	1	0			

At the genus level, there are genera endemic to the Ogasawara Islands, including *Boninella* of the family Cerambycidae, and *Ogasawarazo* of the family Curculionidae (Morimoto, 2005; Hasegawa 2009). These genera radiated and speciated within the islands, and as such provide excellent sources of primary studies in evolutionary processes. Psyllids (Psylloidea) evolved to adapt to the flora endemic to the Ogasawara Islands. In a population of the genus *Trioza,* which feeds on plant species of genus Machilus, speciation occurred for each plant species of this genus, including *M. kobu*, *M. boninensis* and *M. pseudokobu*, and galls of each species show significant diversity in their locations and shapes (Fig. 2-11). Psyllids on the Japanese Archipelago produce similar type of galls on the same family or genus of plants, however on the Ogasawara Islands they have diversified to adapt to genetic divergence witin the plant species (Matsumoto, 2009).

Throughout the Ogasawara Islands, there are species that do not appear to have speciated significantly within the islands, although they are thought to have originated on the Ryukyu Islands and elsewhere and evolved into species different from those of their places of origin. On the Japanese Archipelago and continents, where diverse species coexist, ecological niches dominated by a specific species are usually limited, but on the Ogasawara Islands few species dominate a variety of niches that are widely available to them. For example, on the mainland of Japan there is a one-to-one correlation between longhorn beetles and their host plants, meaning the selection range of host plant species by these beetles is limited, but on the Ogasawara Islands, in contrast, single longhorn beetle species use multiple tree species. Furthermore, dominant species such as *Phloeopsis bioculata* use a wide range of tree species, and in this sense they can be called super-generalists (Sugiura et al., 2008; Olesen et al., 2002). It has been suggested that a broad range of feeding habits works as an adaptive advantage in the event that such a species arrives on a new island that is not rich in flora (Sugiura et al., 2008), and can be considered one stage of adaptive radiation leading up to speciation.

Surveys on the entomofauna of the Ogasawara Islands are not yet complete. Even in the relatively well-studied longhorn beetles, as an example, prominent new endemic species such as *Boninoleips kitajimai* and *Olenecamptus fukutomii* have been discovered in recent years (Hasegawa 2004, and others), and there are some species that are currently being prepared for description. Additional surveys are very likely to reveal the existence of unknown endemic species. Taxonomic groups yet to be studied are expected to lead to the discovery of many new endemic species.

Adult of *Trioza* sp.（Type2）
（Photo by Dr. Kouichi MATSUMOTO）

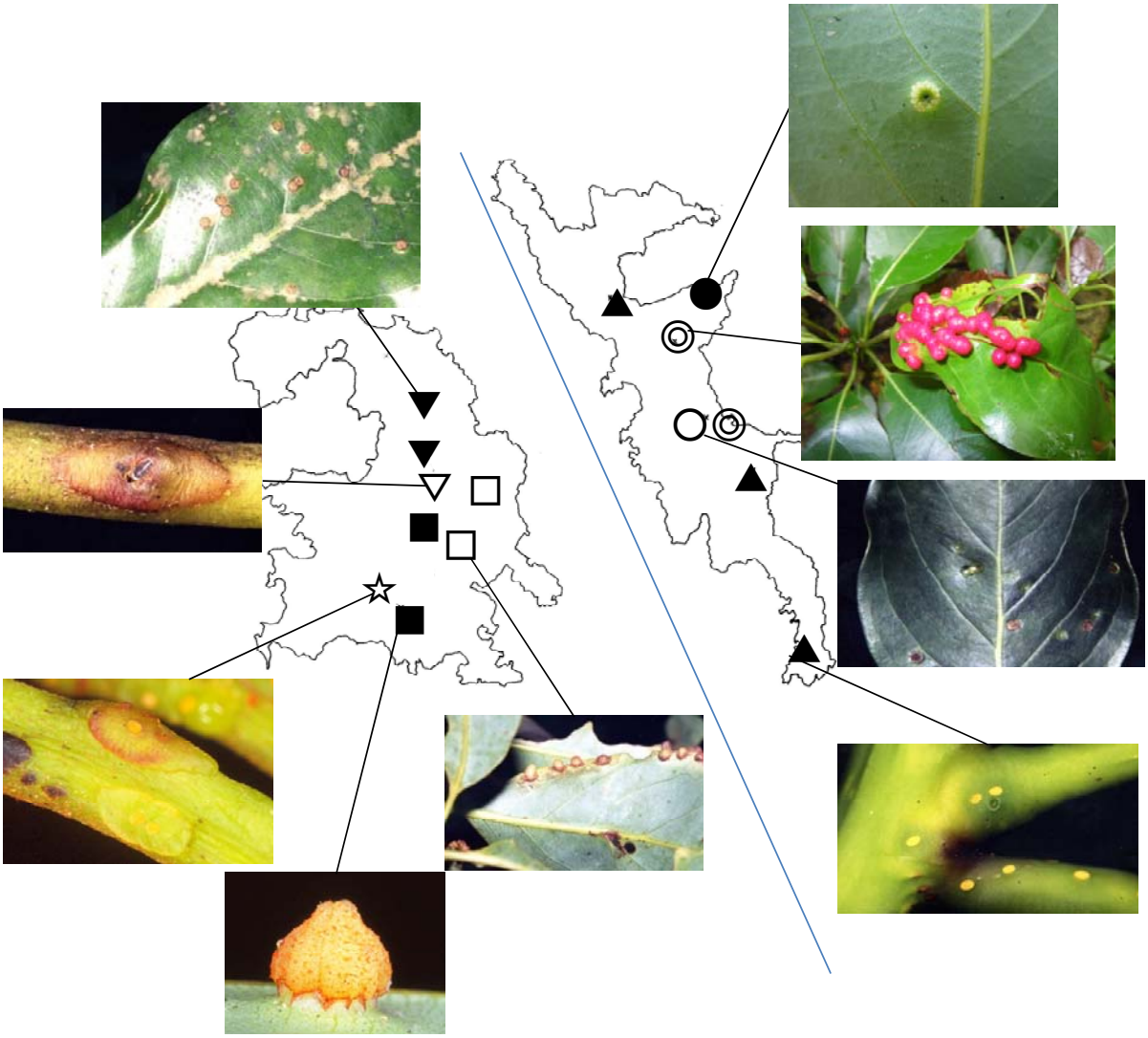


Fig. 2-11 Distribution of the genus *Trioza* on the Ogasawara Islands and the types of their galls on their host plants of the genus *Machilus*

○;Type 1, ▼;Type 2, ◎;Type 3, □;Type 4, ▽;Type 5, ▲;Type 6, ■;Type 7, ●;Type 8, ☆;Type 9. ○◎●; "*M. boninenis*" of Hahajima Is, ▲; "*M. kobu*" of Hahajima Is , ■□; "*M. boninenis*" of Chichijima, ▼▽; "*M. kobu*" of Chichijima, ☆; "*M. puseudokobu*" (Matsumoto, 2009 revised)

Unique interactions among insect species

As stated above, compared to continents or the Japanese Archipelago, the Ogasawara Islands exhibit an imbalanced fauna, with some taxonomic groups entirely absent. However, because of this imbalance, unique and pronounced ecological relationships have been formed, creating ecosystems not seen anywhere else.

In tropical and subtropical regions, ants (*Formicidae*) usually occupy the greatest proportion of biomass and perform various functions in ecosystems. Recent studies indicate that there were no native active ant species on the Ogasawara Islands in the past (Sugiura et al., 2007). Consequently, the extrafloral nectaries that act as a defense mechanism for plants have regressed. Extrafloral nectaries serve to attract ants to protect the plants from predators. It is known that from tropical to subtropical regions, 14.8% to 53.3% of plants have extrafloral nectaries (Blüthgen and Reinfenrath, 2003; Oliveira and Freitas, 2004). However, many plants on the Ogasawara Islands, for example the endemic species *Hibiscus glaber*, have lost these extrafloral nectaries (Sugiura et al., 2006). Only 7.5% of all plant species on the islands have extrafloral nectaries (Pemberton, 1998). This is considered to illustrate a unique evolution which has occurred in Ogasawara ecosystems characterized by few ants (Sugiura, 2007). There are still almost no active ants on Minami-iwoto, making the island significant for its preservation in a primitive oceanic island ecosystem.

Worms often play an important role as decomposers in soil ecosystems, but all 10 known worm species in Haplotaxida on the Ogasawara Islands are alien, and it is thought that the large Haplotaxida species was not present originally on the islands (Nakamura, 1994). Minami-iwoto is valuable as a soil ecosystem because it has not been invaded by alien species of Haplotaxida. The breakdown of humus that worms are normally responsible for has most likely been the role of Oniscidea on the Ogasawara Islands. There is a high ratio of endemic species in Oniscidea: of the 25 species confirmed, 14 of them are endemic. Some species among these 25 do not have scientific names yet, and hold the possibility of being new endemic species (Yamaki et al., 2008).

The Ogasawara Islands have no native social bees. All of the bees (about 10 species have been confirmed, all of which are considered to be endemic) are solitary. At present, the distribution of European honeybees (*Apis mellifera*), which are alien and social, is confirmed. However, some satellite islands as well as all of the Mukojima Island Group have yet to be invaded by European honeybees, and still maintain ecosystems without social bees. These ecosystems are valuable in that their main pollinators are solitary bees.

Biogeographic characteristics of isect distribution

< Chichijima Island Group >

According to the Species List in Appendix, there are at least 62 species and 11 subspecies of insects endemic to the Chichijima Island Group. This is the largest number of endemic taxa in the Ogasawara Islands, which is partly due to the fact that it is the largest island in area. The existence of endemic aquatic insects such as *Indolestes boninensis*, *Limnogonus boninensis*, and *Goera ogasawaraensis* suggests that a stable water system has existed for a long period of time. One characteristic of insects in the Chichijima Island Group is the presence of endemic species with close associations to sclerophyllous scrub, such as the tiger beetle, which lives in open spaces around sclerophyllous scrub, and endemic cerambycidae species *Olenecamptus fukutomii*, whose host plant is *Distylium lepidotum,* the typical constituent sclerophyllous scrub species.

< Hahajima Island Group >

There are at least 45 species and 11 subspecies of insects endemic to the Hahajima Island Group, giving it the second highest number of endemic taxa behind the Chichijima Island Group. Many endemic species are found in the subtropical rainforests. One characteristic feature is the many species which live in decaying logs and hollows of large trees in the developed forests, including *Duolandrevus major*, *Morion boninense*, and *Glipa kurosawai*. Hahajima itself is also important as the only extant habitat for an endemic species of lycaenid butterfly, which is thought to be extinct on the Chichijima Island Group.

< Mukojima Island Group >

Four species, including *Chlorophorus kusamai*, and two subspecies, including *Tamamushia virida fujitai*, are known to be endemic insects to the Mukojima Island Group. The ecosystem of the Mukojima Island Group is generally considered to be in poor condition owing to the destruction of vegetation by goat grazing, but at the same time the islands are still home to large populations of such endemic insects as bees and longhorn beetles. It is also an important refuge for insects on Chichijima and Hahajima that have suffered the impacts of invasive alien species (such as the green anole).

< Kazan Island Group >

There are at least five species and two subspecies of insects endemic to the Kazan Island Group, including *Figulus yujii* and *Chlorophorus minamiiwo*. *Satozo minamiiwoensis*, which lacks hind wings, is classified under the endemic genus *Satozo*. *Satozo* is a rich subject of interest as the only endemic genus on the Kazan Island Group.

< Evolution and speciation in each island group >

The phenomenon of speciation from a single original species within the Ogasawara Islands into subspecies that differ among island groups can be observed in beetles and several other taxa. Such speciation at the subspecies level occurs between the Chichijima and Hahajima Island Groups, and also between the Mukojima Island Group and the Chichijima/Hahajima Island Groups. In addition, there are also examples such as *Rhinocypha ogasawarensis* in which differences are not morphologically perceptible, but nevertheless the species shows signs of isolation from island group to island group at the genetic level.

An example of prominent speciation among different island groups can be seen in the genus *Chlorophorus*. There are five species native to the Ogasawara Islands in this genus, each with different areas of distribution. The Mukojima Island Group are home to *C. kusamai* and *C. masatakai*, while the Chichijima/Hahajima Island Groups are inhabited by *C. boninensis* and C. *kobayashii*. *C. kusamai* of the Mukojima Island Group is closely related to *C. boninensis* of Chichijima/Hahajima Island Groups. The same is the case with *C. masatakai* and C. *kobayashii*. The color patterns of their bodies on each, however, show similarities with the other, less closely related species within the same island group(s). The Kazan Island Group is inhabited by *C. minamiiwo*, which is thought to have origins distinct from the species above. It is classified into subspecies comprising populations that are present separately on Minami-iwoto and Kita-iwoto, respectively.

The genus *Ogasawarazo*, which has lost the ability to fly due to vestigial hind wings, demonstrates speciation by island group as well as by individual islands, with both arboreal and ground-dwelling species found on each island (Fig. 2-12). It is interesting to note that the closely related but distinct genus *Satozo*, which is also unable to fly, is present on Minami-iwoto. Molecular phylogenetic research is being conducted to analyze the relations of these taxa.

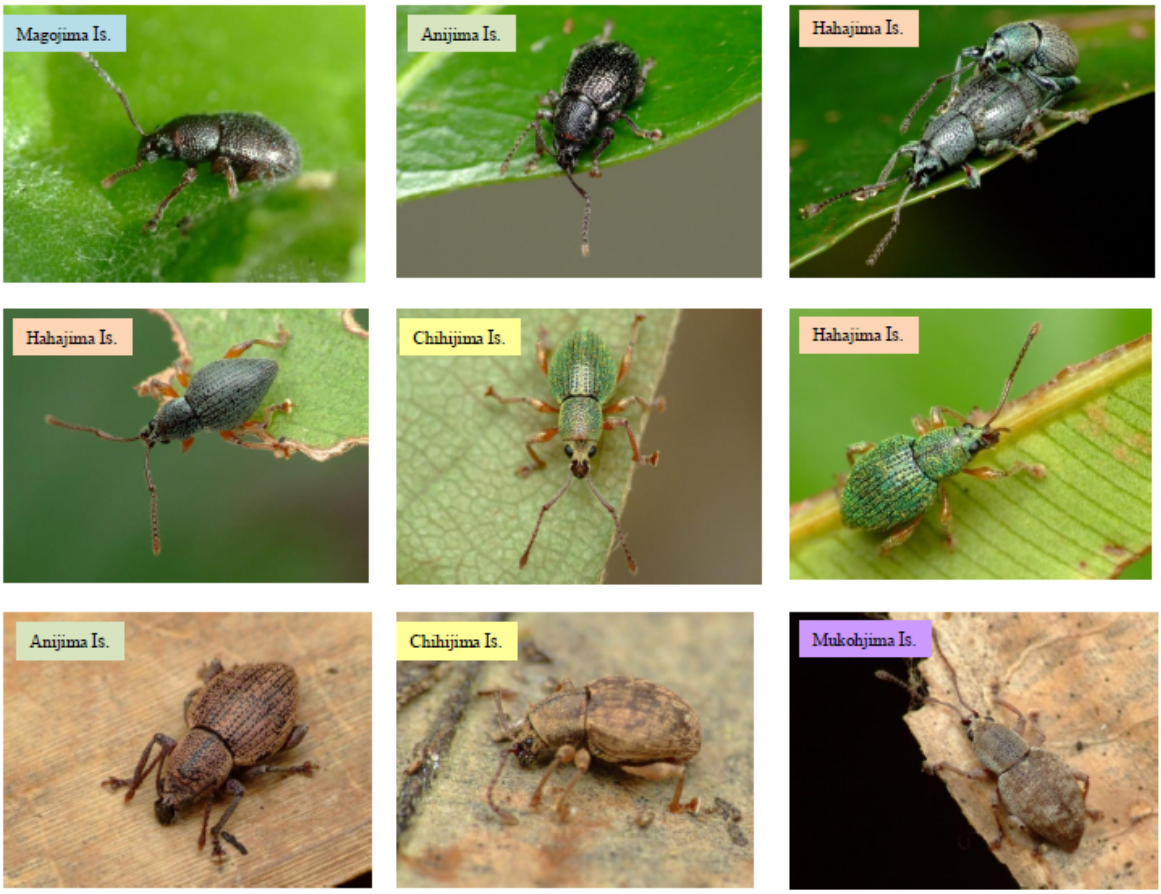


Fig. 2-12 Diversity of the endemic weevil genus *Ogasawarazo*

The figure shows nine taxa including *Ogasawarazo lineatus*, *O. mater*, *O. rugosicephalus rugosicephalus, O. rugosicephalus hahajimaensis* and five undescribed new species. Taxonomic and phylogenetical studies are in progress.

2.a.4.6 Land snails

One of the most distinctive and apparent examples of adaptive radiation in the unique fauna of the Ogasawara Islands is that of land snails. The land snails in the nominated property are an outstanding example of a fauna clearly exhibiting biological evolution characteristic of oceanic islands.

To date, 130 species of land snails (in 44 genera of 23 families) have been recorded from the Ogasawara Islands, 104 species of which are native to the islands. Of the latter, 98 species, or 94%, are endemic to the Ogasawara Islands (Chiba, 2009). Furthermore, 80 of the native species are extant species, 74 of which are endemic (Chiba, 2009). The extinction rate is low compared to other oceanic islands, and this is one notable feature of the land snails on the Ogasawara Islands. Land snails on the Ogasawara Islands originated from a range of areas,

including the Asian mainland, Micronesia, Polynesia. As the progenitor species of these land snails that reached the Ogasawara Islands have followed distinctive evolutionary processes, and the species composition seen today is exceptionally unique. The adaptive radiation within the islands has led to 94% of more than 100 land snails documented from the Ogasawara Islands being endemic to the area.

The history of this distinctive adaptive radiation is gradually becoming clearer with the progress of studies using DNA analyses. In the genus *Mandarina*, as an example, species with the same life habits are very similar morphologically even if they differ in their differentiaton lineages on different islands and island groups. This suggests repeated occurrence of speciation and rapid adaptation to each life habit on each island and island group.

In addition, the land snails on the Ogasawara Islands provide evidence of evolution along a variety of time scales. Comparisons between fossil and extant species reveal the temporal change of the evolutionary sequences and species diversification that have occurred in the past. There are also specimens exhibiting ongoing evolutionary processes to respond to environmental change in recent years.

(For their conservation measures, see “Current state of conservation” in Section 4.a.7).

Origins and speciation in land snails

Among the land snails endemic to the Ogasawara Islands, there are those that originated from the Asian mainland, the Japanese Archipelago, and the southern islands of the Pacific such as Micronesia and Polynesia. Their progenitor species represent only the few specimens that managed to cross the vast distances of ocean from their places of origin and by happenstance reached Ogasawara, after which they diversified (or radiated) into the species and groups that are found today. For this reason, the family levels of the land snails on the Ogasawara Islands have a significant and unique difference (apparent in genus structure) from the land snails of the mainland of Japan, Ryukyu Inlands, and the Marianas to the south of Ogasawara.

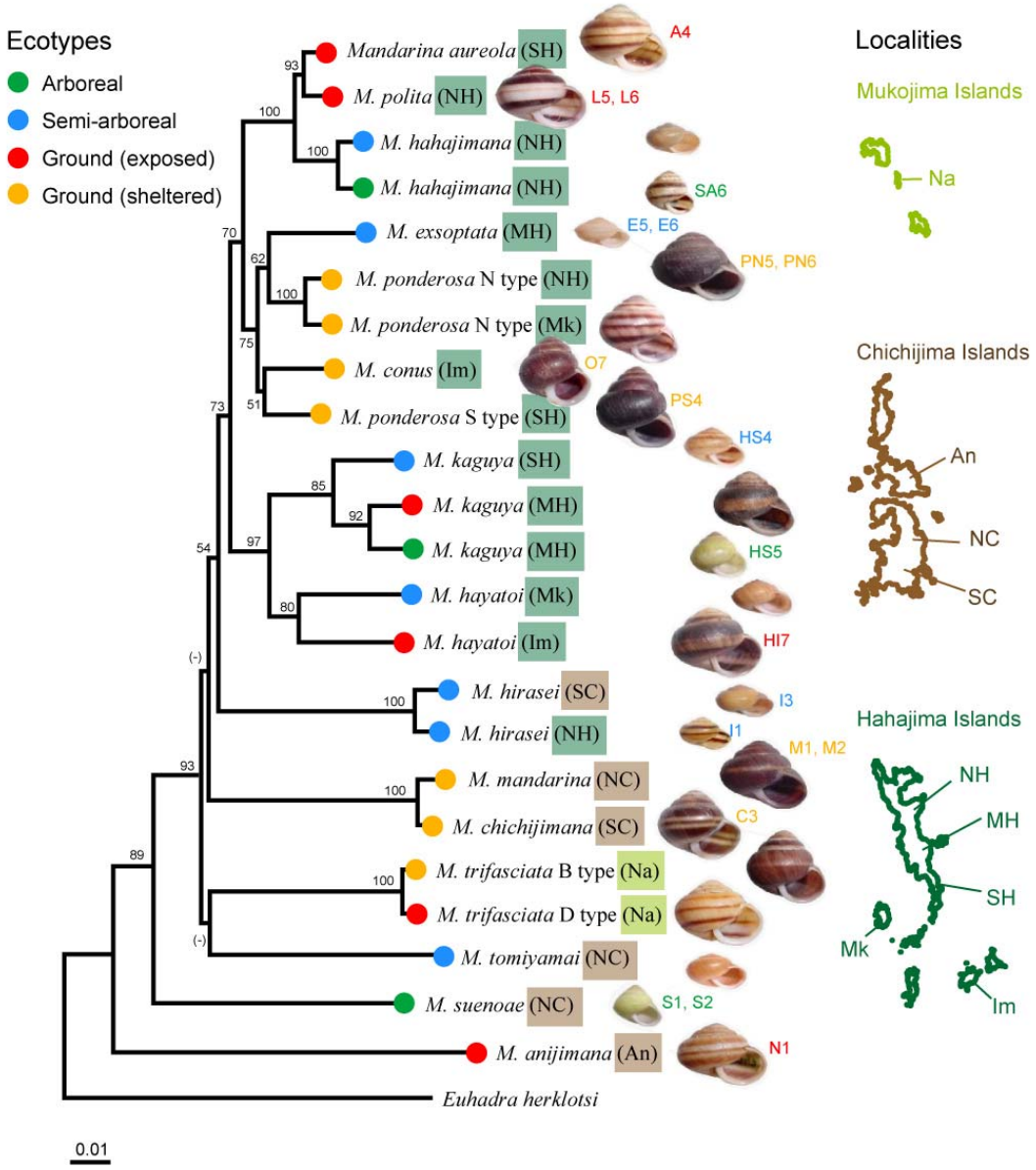


Fig. 2-13: The ecotype and phylogenetic relationship of *Mandarina* species

The tree is based on mitochondrial DNA (≈1,000 bp 16SrRNA and ≈600 bp 12SrRNA). Ecotypes of arboreal, semi-arboreal, ground (exposed), and ground (sheltered) are indicated by green, blue, red and yellow dots respectively. Localities of the species are shown in parentheses. The codes and colors correspond to those in the map. Codes beside each picture of shell correspond to those in Fig. 2-15 which represent morphological type of shell. (Revised from Chiba, 1999a; 2003)

In recent years, molecular phylogenic studies using DNA analyses have revealed that species of the genus *Mandarina* evolved from a common ancestor on the mainland of Japan (Chiba, 1999a; Davison et al., 2005), and that the *Boninosuccinea* species are closely related to groups found on the Marquesas Islands. Molecular phylogenic studies utilizing mitochondrial DNA show the extremely distinctive history of adaptive radiation of

Mandarina that reached the islands of Ogasawara (Fig . 2-13). In each of these island groups there are unique histories of repeated speciation that occurred to adapt to various ecotypes. The progenitor species from the mainland of Japan that reached the Chichijima Island Group have diversified into arboreal, semi-arboreal, and ground ecotypes. While one lineage radiated to the Mukojima Islands Group, another ancestral lineage of the semi-arboreal *Mandarina hirasei* radiated to the Hahajima Island Group. The progenitor species that reached the Hahajima Island Group again diversified into arboreal, semi-arboreal, and ground ecotypes (Fig. 2-14). The ecotype divergence occurred at least four times independently in different lineages. The species that diversified in each of lineage are morphologically similar to each other when they belong to the same ecotypes. This kind of parallel adaptive radiation suggests a close relationship between the species diversification and life habit divergence (Chiba, 1999a; Chiba, 2004).

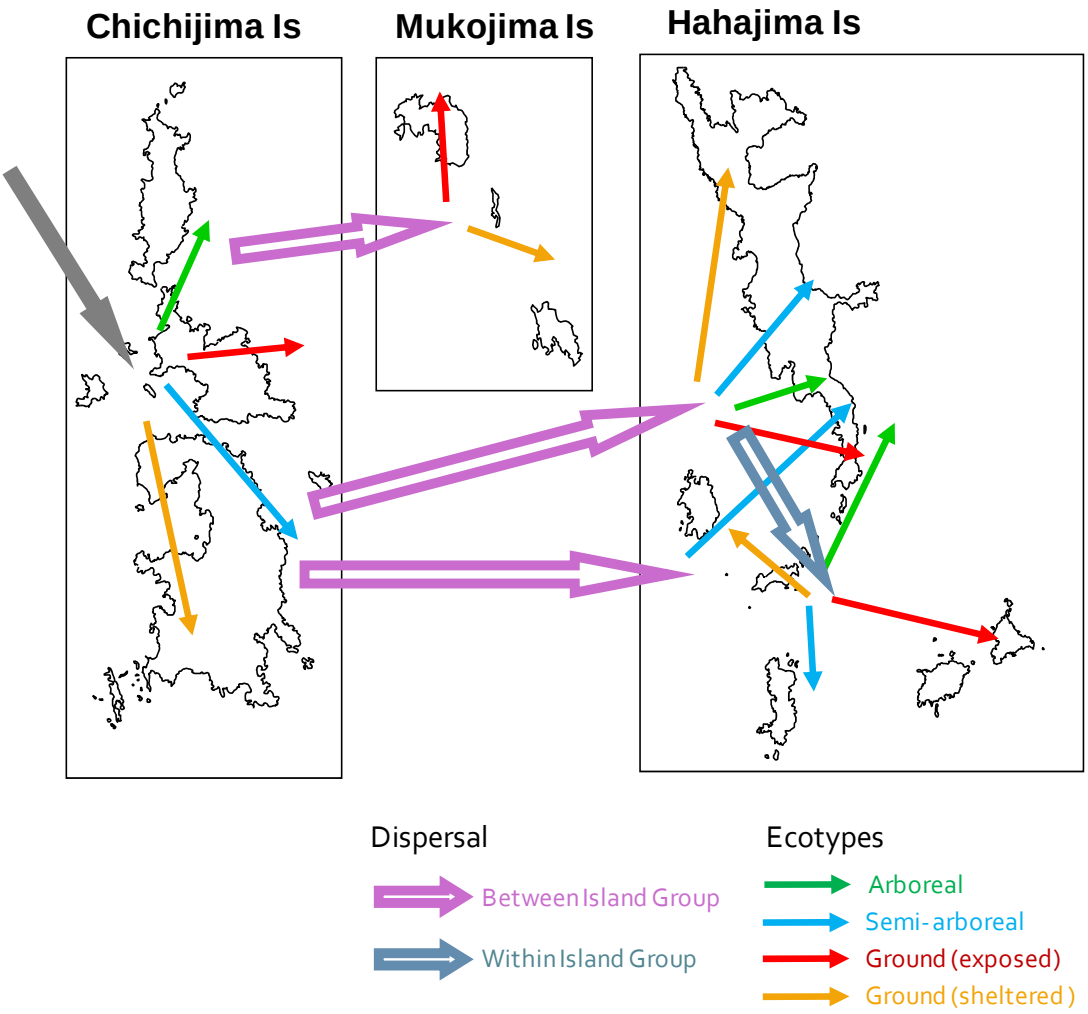


Fig. 2-14 The adaptive radiation of genus *Mandarina* and geographical relations

Estimated radiation routes of *Mandarina* based on the phylogenetic relationship by Chiba (1999a: Fig. 2-13)

Adaptive radiation in land snails

Many examples of adaptive radiation can be observed on the Ogasawara Islands. Sympatric species radiation accompanying ecotype diversification is a unique case, which has not been approved in the past. The availability of open niches on the Ogasawara Islands is expected to have greatly influenced this speciation. There are 19 extant species in the genus *Mandarina*. If fossils are included, there are a total of 29 documented species. The distinct diversity within this genus can be largely attributed to adaptive radiation accompanying ecotype divergence. Feeding and resting places differ among sympatric species of *Mandarina* (Chiba, 1996). These species can be categorized according to their ecotypes: ground ecotypes, which feed on litter; arboreal ecotypes, which feed on fresh leaves in trees; and semi-arboreal ecotypes, which not only inhabit trees but also descend to the ground. Furthermore, where two species of ground ecotype snails coexist, they separate into two distinctive ecotypes: those that rest or estivate at the bottom of litter ("sheltered"), and those that rest near or on the surface of litter ("exposed") (Chiba, 1999b). Such variations in habitat arereflected in the shapes and colors of their shells: shells of arboreal species are higher but smaller, semi-arboreal species flatter, and ground species higher, which can be considered as a convergent evolution. The adaptive radiation occurred repeatedly on different island groups, and those with similar life habits acquire similar morphologies even if snails inhabit different islands and belong to different lineages (Fig. 2-21; C hiba, 1999b).

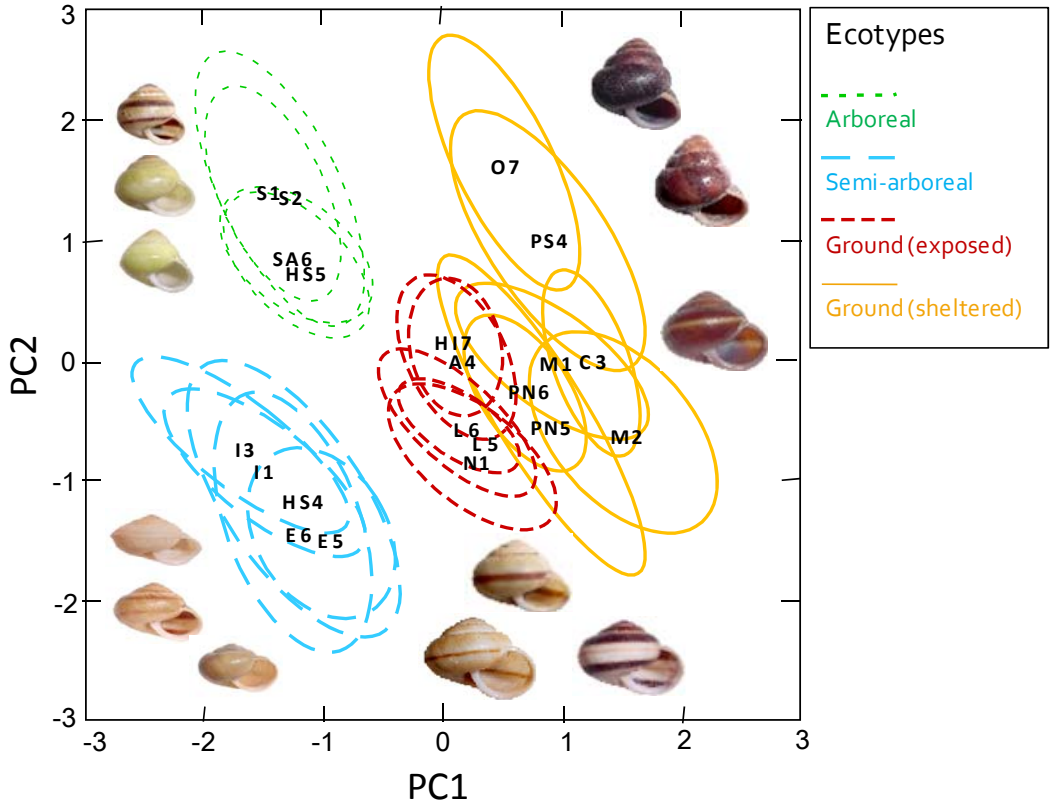


Fig. 2-15 Morphological similarities in *Mandarina* on each ecotype from ecotypes

Groupings according to shell morphology based on principal component analyses. PC1 is an index representing shell size, and PC2 height of spire and apertural length. Each ellipse shows standard deviation (centered on the means). The ellipse center indicates species codes (see Fig. 2-13) and surrounded by representative examples of shell morphology. (Revised from Chiba, 2004)

Land snails in the genus *Ogasawarana* are also endemic to the Ogasawara Islands. This genus includes 15 documented and several undocumented species. They are relatively small, with a diameter of 4 mm to 7 mm. This genus also shows distinct morphological and ecological diversification, and is a typical example of adaptive radiation. On Anijima, for example, there are four sympatric species. While *Ogasawarana discrepans* and *O. optima* are mainly found on the underside of leaves at the top layer of litter, *O. capsula* inhabits the bottom layer of litter as well as soil layer. *O. nitida*, on the other hand, is found on the live leaves of the screw pines (*Pandanus boninensis*) rather than on the ground.

Species in the genus *Hirasea* also have remarkable divergence in shell morphology. This genus contains 14 documented species as well as several subspecies. Extreme morphological differences are found among the species that belong to this same genus. Notable examples include *Hirasea operculina*, which has an extremely flat shell, and *H. diplomphalus*, which has a planospiral shell with a sunken spire. There are few other land snails in the world in

which speciation accompanied by such distinct morphological diversification can be observed within a single genus. This shows that the diversification in shell morphology is closely related to divergence in habitats. For example, there are three sympatric species on Anijima: *H. operculina* (contact lens shape) that attaches itself to the underside of fallen leaves near the surface of litter; *H. chichijimana* (conical shape), which occurs at the bottom of litter; and *H. diplomphalus* (grinding mortar shape), which occurs underneath litter in the spaces between small hard pebbles in the soil. Such diversity is a result of these snails adapting to their environments and life habits (Fig. 2-16; Chiba, 2009).

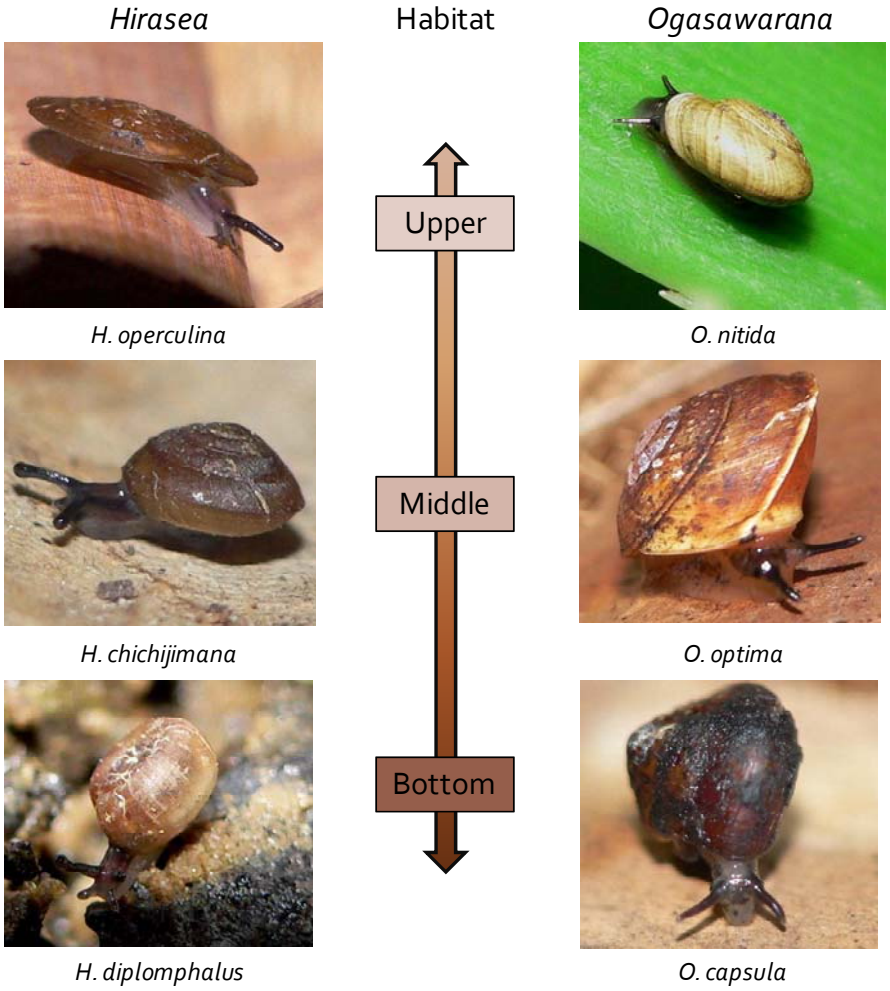


Fig . 2-16 The relationship between habitat and shell morphology

In addition to *Mandarina*, closely related sympatric species of *Hirasea* and *Ogasawarana* show diversification in shell morphology in association with their habitats. (Photos: Satoshi Chiba)

Past and present speciation in land snails

The limestone terrain of the Ogasawara Islands has helped preserve fossils. Through a comparison of the fossil record with extant species, temporal changes in lineage evolution and species diversification can be traced from the past to the present.

The Pleistocene strata from Chichijima to Minamijima, as well as on Hahajima contain diverse fossils of *Mandarina*. Fig. 2-17 shows the selected fossil species that are particularly abundant on Chichijima and Minamijima. Each fossil group was dated by the Carbon-14 dating method and examined for morphological changes over time. The figure indicates that around 20 thousand years ago, rapid morphological changes occurred more or less simultaneously to all species. At about the same time, the *Mandarina nola* lineage became extinct. This suggests that the morphological changes in *Mandarina* follow a punctuated equilibrium pattern, with periods of stability and rapid change. Moreover, the changes occurred synchronically throughout all lineages (Chiba, 1998).

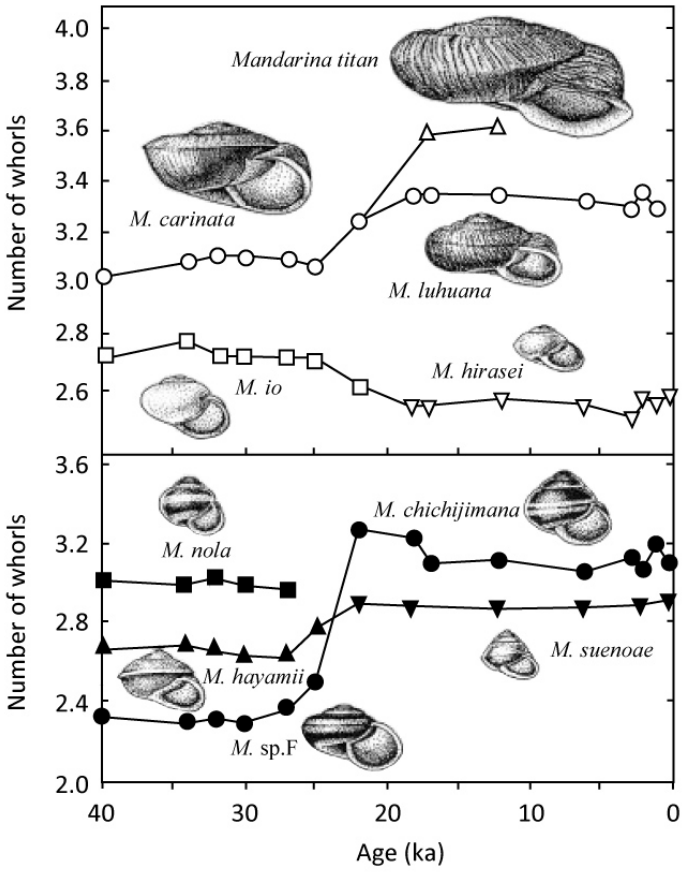


Fig. 2-17 Temporal changes in shell morphology in *Mandarina*

Temporal changes in shell morphology and speciation from fossil sequences through 40 thousand years on Chichijima. and Minamijima. The vertical axis shows the number of whorls. Each symbol represents the mean value of the species on each time. (Revised from Chiba, 1998)

There are also current examples of the evolutionary process occurring in *Mandarina*. For instance, reproductive isolation is currently occurring in *Mandarina hayatoi*, between arboreal and ground ecotypes on some islands in Hahajima Island Group. Such examples are seen in other species of *Mandarina* as well, and these examples represent the early stages of adaptive radiation accompanied by ecotype change (Davison and Chiba, 2006). In addition, hybrid populations between the two species occur in the upland areas located in the boundary zone of their discrete distributions on both Hahajima and Chichijima. These hybrid zones are likely to have emerged when the uplands in the central part of the islands lost their function as barriers during the evolution of the reproductive isolation. This indicates that these species were in the process of allopatric speciation. Specimens of hybrids between the two species not only exhibit intermediate characteristics between these parent species but also have features different from them, a phenomenon whereby hybridization drives increased diversity (Chiba 1993, 2005). Furthermore, a high level of genetic divergence among local populations occurs even without geographical barriers in the species of *Mandarina* on Hahajima because of their extremely low dispersal ability. For instance, radical changes in morphological and genetic characteristics are found within a distance of a few hundred meters in *M. aureola* on the southern parts of Hahajima (Fig. 2-18).

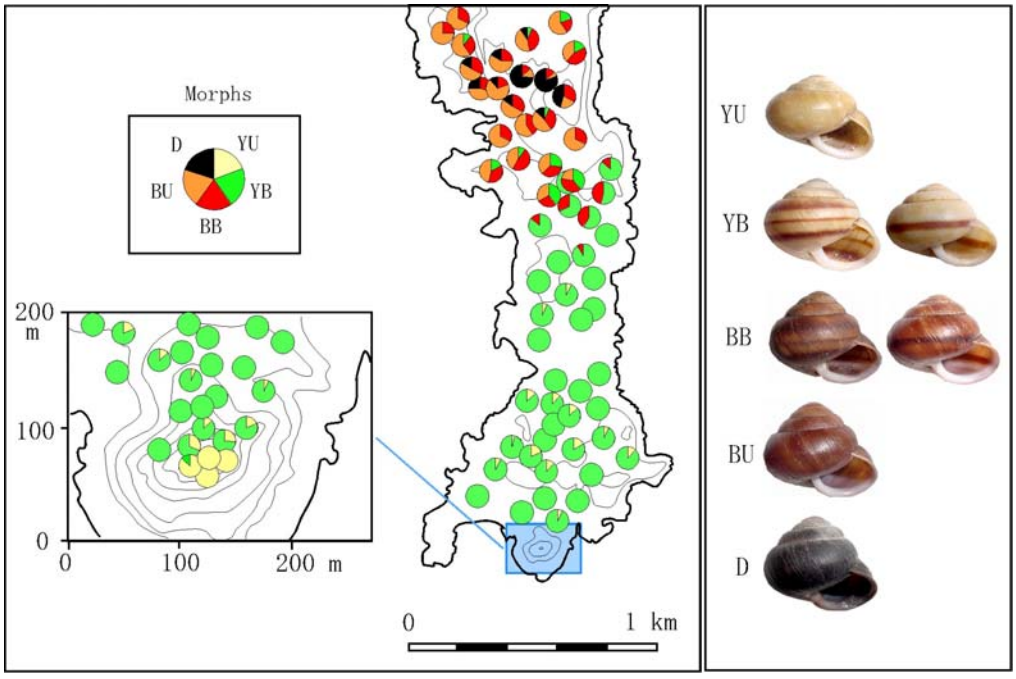


Fig. 2-18 Geographic variations in *Mandarina aureola* on the southern parts of Hahajima

The pie charts indicate the proportion of each distinctive morph (YU, YB, BB, BU, D) in each population. The geographical patterns show that divergence of population occurs within a small area even in the absence of geographical barrier. (Revised from Chiba 1993)

There are also groups that have changed their life habits to adapt to recent environmental changes. For example, one group of *M. hayatoi* on a satellite island (Anejima) has begun to live on alien species of agave cacti (*Agave americana*), and as a result has developed shell morphologies different from other groups. This suggests that the evolution of this species is still in progress. Likewise, one species belonging to the genus *Ogasawarana* has peculiarities where it occurs in the litters of an alien species of sheoak (*Casuarina equisetifolia*). This species has a morphology suggesting juvenilized (neotenic) *O. discrepans* and is thought to be an adaptation of this species to recent environmental changes.

The above examples attest to the significant value of the Ogasawara Islands in that they show evidence of past and ongoing evolutionary processes.

Diversity as a result of adaptive radiation

At present, 104 species of land snails native to the Ogasawara Islands have been recorded, and of them, 98 species, or 94%, are endemic to Ogasawara (Chiba, 2009). There are seven endemic genera (*Ogasawarana*, *Boninena*, *Conacmella*, *Boninosuccinea*, *Hirasea*, *Hirasiella,* and *Mandarina*). *Ogasawarana*, *Hirasea,* and *Mandarina* in particular have achieved significant evolution and diversification on the islands, differentiated into many species. The IUCN Red List (2008) includes 24 species (six CR, ten EN, and eight VU). In addition, there are 46 species on the MOE Red List (2007) (27 CR+EN, 16 VU, and three NT), which is evidence of the high value of the Ogasawara Islands as a habitat for threatened land snails. It is thought that the two single species in the *Hirasiella* and *Conacmella* genera, as well as 19 other endemic species, are extinct, leaving five endemic genera and 72 endemic species (endemic ratio: 91%).

Biogeographic characteristics of land snails

< Chichijima Island Group >

Because the Chichijima Island Group is covered with a diverse range of vegetation, from sclerophyllous scrub to subtropical rainforest, these are habitats for a land snail fauna with species compositions unique to each. A distinctive land snail fauna can even be seen under the shrubs hugging the dry, rocky areas of ridges. About 40 species of land snails endemic to Ogasawara occur on Anijima, and species of *Hirasea*, for example, have altered their habitats based on subtle differences in their respective environments (Chiba, 2009).

In addition, evidence of evolutionary processes in the land snails of the Ogasawara Islands can be observed from different perspectives. Hybridization has occurred in two species of the genus *Mandarina* in the uplands of Chichijima, which is an indication of increased

diversity through hybridization (Chiba, 2005). The processes of synchronized morphological changes which occurred in multiple *Mandarina* species can also be observed in Pleistocene fossils found from the southern part of Chichijima to Minamijima (Chiba, 1998).

< Hahajima Island Group >

The subtropical rain forests on Hahajima, especially where a cloud belt forms, are rich in communities of arboreal land snails. In particular, there are many species in the area where limestone terrain has formed, and some species are endemic to this area. Several species of land snails thought to be extinct have been rediscovered on a small peninsula that is separated from the rest of Hahajima by a steep precipice (Chiba et al., 2007).

Many examples of adaptive radiation in *Mandarina* can be observed on the Hahajima Island Group. *Mandarina* species have dispersed from the Chichijima Island Group to the Hahajima Island Groups several times, and for each time speciation occurred repeatedly to adapt to different ecotypes (Chiba, 1999a; Chiba, 2004). Reproductive isolation is occurring even now in several species of *Mandarina* among different ecotypes, and these examples represent the early stages of adaptive radiation (Davison and Chiba, 2006). A hybrid zone is constituted between the two species of *Mandarina* in the upland area of Hahajima. In addition, a high level of genetic and morphological divergence is observed among populations within a small area in the absence of any geographical barrier. Some poputlations of *M. hayatoi* are found on alien species of agave cacti and they have developed shell morphologies different from other populations. This is thought to be evolutionary changes as a result of recent environmental alteration.

< Mukojima Island Group >

Damage by feral goat grazing has caused the decline of forests in the Mukojima Island Groups, but land snails are still found on the southwest part of Mukojima and on Nakōdojima's Mt. Byōbu (Byōbuyama). Several of these species, such as *Mandarina trifasciata* and *Boninena hiraseana hiraseana*, are endemic to the Mukojima Island Groups. A few smaller species have seen drastic drops in numbers, but in recent years their populations are gradually recovering.

< Kazan Island Group >

Recent researches are revealing the existence of hitherto unknown distinctive species of land snails on the Kazan Island Group. Particularly on Minami-iwoto, which has a poor forest-floor litter layer but a well-developed cloud belt forest in higher altitude areas, there are many arboreal land snails, including species endemic to Minami-iwoto (Chiba, 2007). The existence of a rich land snail fauna on an island with volcanic ash soil and poorly

developed forest litter may hold the key that unlocks the secrets of the diversification of land snails on oceanic islands.

2.a.4.7 Other invertebrates of note (soil animals)

Among soil animals in the Ogasawara Islands, woodlice are noted for their high densities, and they include many endemic species, such as *Ligia boninensis* and *Alloniscus boninensis* (Aoki, 1992). However, researches on non-insect arthropods in the Ogasawara Islands have just begun. Hence, there are many species that have yet to be named, and future study is expected. The soil animal species of the Ogasawara Islands considered to be significant (despite their small size) are described below from the standpoint of biogeography or biological evolution.

Terrestrial *Ligia*

To date, 13 species, nine genera, and seven families in Isopoda have been recorded from the Ogasawara Islands. There are two species in the family Ligiidae, namely *Ligia boninensis* and *L. yamanishii*, both of which are endemic to the Ogasawara Islands (Nunomura, 1991, 1999).

L. boninensis is an exclusively terrestrial species that lives only in the uplands on Hahajima. It is 15 mm in length and is characterized by short second antenna (Nunomura, 1999). This species is found only around Mt. Chibusa on Hahajima (462.6 m), and there are concerns that its distribution area is limited and numbers of individuals may decline as a result of being preyed upon by alien cane toads (*Bufo marinus*) (personal communication with Horiguchi). There are 36 described *Ligia* species in the world. Of these, there are only seven species of terrestrial *Ligia* and most of the other species occur only in limited areas of the tidal zone near the shore (Taiti et al., 2003).

It is known that littoral *L. exotica* takes in seawater through the anus, a process through which this species prevent body desiccation and maintain internal salinity levels at 4%, which is close to that of seawater (Horiguchi et al., 2007). *L. exotica* has developed morphologies adapted to life on land, but it is known that this species' internal body environemnt maintains salinity levels close to the sea-dwelling *Bathynomus doederleinii*. Unlike littoral *L. exotica*, however, the terrestrial *L. boninensis* of Ogasawara maintains internal salinity levels close to those of the inland-dwelling *Armadillidium vulgare* and *Porcellio scaber*, which is about 1.5% (Horiguchi et. al., 2008; personal communication with Horiguchi and Hariyama).

Furthermore, one species of *Ligia* was found at upstream riverbank (altitude 50m) on

Chichijima, as well as from mouth (altitude 12m) to the middle part of a river (altitude 35m) and at its headwaters (altitude 150m) on Anijima (personal communication with Horiguchi and Hariyama, personal communication with Sasaki). Since this species has been found in such freshwater environments as rocks at the riverbank and in water, it is highly possible that this species is undescribed.

The above shows that *Ligia* species on the Ogasawara Islands have adapted to three types of environments, namely shores, upstream riverbanks, and inland, respectively. It means that *Ligia* has developed a system for modulating salinity within their bodies and moved from littoral to inland areas. Again, this is another example of how the Ogasawara Islands have scientific importance in providing clues to help understand these evolutionary processes.

Pseudoscorpions

Estimates place the number of pseudoscorpion species inhabiting the Ogasawara Islands at over ten, but only eight species in seven genera of six families have been confirmed (Sato, 1984, 1991a, 1991b). Six species are endemic to the Ogasawara Islands: *Ditha ogasawarensis*, *Tyrannochthonius similidentatus*, *Cheiridium aokii*, *Haplochernes boninensis*, *Metagoniochernes tomiyamai*, and *Chernetidae* sp. (Sato, 1991a, 1991b).

There are about 3,000 known species in Pseudoscorpions in the world, with about 60 species recorded in Japan (Sato, 1992a). *M. tomiyamai*, which is endemic to the Ogasawara Islands, is notable for being the largest pseudoscorpion species in the world. It ranges from 4.8 to 5.6 mm in length (Sato, 1991a), and males have pedipalps three times longer than their body length, making it an extraordinarily distinctive species of pseudoscorpion in terms of morphology (Sato, 1992b, 2006). *M. tomiyamai* was confirmed to inhabit Ototojima, Hahajima, and Chichijima in the 1990's (personal communication with Kishimoto), but it is now found on Anijima in the leaf sheaths and trunks of *Pandanus boninensis* and other very specific environments; its number are now surmised to be very small (Sato, 1991b).

There are only three species in the genus *Metagoniochernes* in the world: *M. milloti* in Madagascar, *M. picarridi* in the Congo, and *M. tomiyamai* in the Ogasawara Islands. Such distribution of this genus is extremely unique from a zoogeographical viewpoint (Sato, 1991a). Also interesting is the fact that *M. tomiyamai* of the Ogasawara Islands is the only species in this genus found in Asia. Given the distance of the Ogasawara Islands from Africa, *M. tomiyamai* is a globally rare species (Sato, 1991a).

2.b History and development

2.b.1 History

2.b.1.1 Before World War II

The Ogasawara Islands are traditionally said to have been discovered in 1593 by Sadayori Ogasawara. In 1675, Ichizaemon Shimaya of Nagasaki Prefecture, under orders from the Edo Shogunate, spent about 20 days exploring the islands of Ogasawara. He placed wooden plaques on Chichijima and Hahajima claiming the islands as Japanese territory, after which he returned. Time passed and the islands remained uninhabited. Then, in the 1800s, foreign whaling vessels began to stop over the Ogasawara Islands. In the 1820s, warships and research ships from different countries also started to visit the islands and left records of their research. The copperplate engravings by Quito Ritz, an ornithologist, are particularly precious for recording the natural environments of the islands before human settlement.

The first settlement on the Ogasawara Islands began with migration to Chichijima in 1830 by five Westerners and more than 10 natives of Hawaii and other Pacific islands. They made their living by gathering fruits and vegetables, catching marine products such as turtles, and supplying them together with water to whaling vessels (Kato and Hamanaka, 1995). This was followed by surveys and pioneering efforts by the Edo Shogunate and later by the Meiji government. In 1876, the islands were internationally recognized as Japanese territory.

In the late Taisho and early Showa eras, the subtropical climate was exploited to grow fruits and maintain a supply of vegetables during winter. The fishery industry grew, with bonito, tuna, whale, and coral the chief products. At its height, the population of the islands exceeded 7,000 people.

At the same time, in the years leading up to World War II, the strategic value of the Ogasawara Islands increased for Japan and, in 1939, a Japanese navy air squadron base was built on Chichijima. In 1944, as the tide of war turned against Japan, all island residents (6,886 persons) except for military personnel were forcefully evacuated to the mainland of Japan.

2.b.1.2 After World War II

Since 1945, after the end of the war, Ogasawara fell under the control of the allied occupation forces represented by U.S. troops. The following year, former island residents of American or European descent were allowed to return to the islands, meaning that Chichijima was occupied exclusively by the U.S. military and these islanders. The goats that were released on the Chichijima and Mukojima Island Groups to provide food for residents increased, further degrading the vegetation. Hahajima was left abandoned for 23 years,

during which time invasion of *Bischofia* that had been planted before the war advanced.

The islands were returned to Japan in 1968, after which former island residents began to return. On August 20, 1970, the Ogasawara Islands Reconstruction Plan was announced, based on the Act on Special Measures for the Ogasawara Islands Reconstruction (enacted in December, 1969). The Plan included the land use plan, which designated the areas for residents, agriculture, and nature conservation. The Law was initially due to expire after five years, but this was extended to 10 years in order to facilitate the comprehensive reconstruction of the islands. However, being separated from the mainland of Japan by a vast expanse of ocean, the population failed to settle, and industry did not sufficiently develop. For these reasons, in 1979 the Act on Special Measures for the Ogasawara Islands Reconstruction was revised as the Act on Special Measures for the Ogasawara Islands Development and laid out the Ogasawara Islands Development Plan. This law was again amended in 1989 to the Act on Special Measures for the Ogasawara Islands Promotion and Development and remains in force to this day.

Under the land use plan, scenic areas of outstanding natural beauty, areas that should be conserved for their value in terms of geology and topography, areas inhabited by animals and plants of high scientific value, etc., were designated as protection areas. On October 16, 1972, the Nature Conservation Bureau of the Environment Agency designated more than 30 islands together with their surrounding marine areas, exept Iwoto, Okinotorishima, Minami-torishima and parts of Chichijiam and Hahajima, as Ogasawara National Park. In 1975, under the Nature Conservation Law, the entire area of Minami-iwoto was independently designated as the Minami-iwoto Wilderness Area, and thus removed from Ogasawara National Park (Kato and Hamanaka, 1995).

Table 2-4 Chronological outline

Year	Historical events
Prehistoric	Stone implements and bone tools have been unearthed suggesting Micronesian peoples may have inhabited or temporarily stayed in Ogasawara.
1543	The Spanish galleon *San Juan* sights (but does not land) a group of uninhabited islands (the Kazan Island Group), which were called Los Volcas.
1593	According to legend, Lord of Fukashi (Matsumoto) Castle of Shinano Province Sadayori Ogasawara has discovered the Ogasawara Islands.
1639	The Dutch vessels *Engel* and *Graft* pass the waters off the Ogasawara Islands. While they did not land, they recorded the coordinates on a map and called two islands Graft (present-day Chichijima) and Engel (present-day Hahajima).

Year	Historical events
1670	Kan'emon, captain of a vessel from Asakawaura of Kaifu Commandry, province of Awa (Tokushima Prefecture) is stranded with his surviving crew on Hahajima. After repairing the vessel, they return home, where they are questioned about the island by the shogunate.
1675	On orders from the shogunate, Ichizaemon Shimaya leads an expedition that surveys the islands, makes maps, etc.
1727	Shimaya's expedition to the Ogasawara Islands is taken up in Engelbert Kaempfer's *History of Japan*.
1727	Sadato Ogasawara petitions the shogunate claiming ownership of the islands.
1824	The British whaler *Transit* (captained by American James Coffin) lands at Hahajima.
1827	The HMS *Blossom* (commanded by Captain Fredrick W. Beechey) visits the Mukojima and Chichijima Island Groups. He erects bronze plaques at Suzaki on Chichijima declaring the islands British territory.
1828	The Russian battleship *Admiral Senyavin* (commanded by Litke) visited the islands. Botanists and ornithologists took specimens home with them.
June 26, 1830	American Nathaniel Savory, together with four other Westerners and about ten natives of Pacific Islands such as Hawaii, settle at Chichijima.
1853	Commodore Matthew Perry stops off at Chichijima on his way to Japan, meets with Savory, and purchases land from him for supplies of coal. Records from the time report that there were 31 inhabitants on Chichijima.
1853	With guidance from Commodore Perry, an autonomous government is created on Chichijima. Nathaniel Savory is elected Chief Magistrate, while James Motley and Thomas Webb are elected Councilmen.
1861	Foreign affairs magistrates Tadanori Mizuno, Taichi Tanabe and others visit the islands on the *Kanrin Maru* and declare them Japanese territory. Manjiro Nakahama (a.k.a John Manjiro) served as interpreter between the Japanese officials and settlers from other countries. Sakunosuke Obana remained as the head of the local administration. Settlers subsequently arrive en masse from Hachijojima island.
1862	The shogunate sends 38 settlers on the Choyo Maru from Hachijojima.
1863	Circumstances at home cause the shogunate to cease settlement activities. Officials and civilians are ordered to evacuate.
November 21, 1875	The *Meiji Maru*, a vessel of the new government, sends a survey team made up of foreign ministry official Taichi Tanabe and others to Chichijima and Hahajima.
1876	Ogasawara comes under the jurisdiction of the Home Ministry.The government reasserts to foreign countries its territorial claim over and right to govern Ogasawara. Since there were no protests from other countries, the islands officially become Japanese territory.An ocean liner is set up to travel from Tokyo to Chichijima (three times a year).
1880	Jurisdiction shifts from the Home Ministry to the TMG. A representative office of the Tokyo Government is established for Ogasawara (which would later

Year	Historical events become the Ogasawara subprefectural government).
1881	Sugar beet cultivation begins at Kitafukurozawa. Liner runs are increased to four times a year.
1891	Kazan Island Group is placed under the jurisdiction of the Ogasawara subprefectural government, and Iwoto officially becomes Japanese territory.
1895	The Ogasawara Church (a member of the Anglican-Episcopal Church of Japan) is constructed on the property of the Gonzales in Omura, Chichijima.
1914	German possessions in the South Pacific pass to Japan and interaction once again thrives between the Ogasawara Islands and islands to the south.
1920	The Japanese Imperial Army begins stationing personnel in Ogasawara. The Chichijima Fort Command Post was established in the following year.
1932	The lagoon that had previously allowed only canoe traffic between Suzaki and Yagiyama is reclaimed, and construction on the Suzaki airstrip begins. It is completed in 1937.
1937	The "flying boats" that travel once a month to islands in the South Pacific begin to use Chichijima as a stopover. The Japanese Navy prohibits photographs of Ogasawara from being taken.
June 12, 1944	Many islanders have left for the mainland of Japan on their own initiative, but from this day forward the military orders mandatory evacuations.
June 15, 1944	The bombing of Chichijima and Hahajima by American carrier-based aircraft begins.
July 29, 1944	The last mandatory evacuees leave Chichijima.
August 18, 1945	An American destroyer enters Futami Port and disarms Japanese soldiers.
September 3, 1945	Aboard the USS *Dunlap*, the Japanese military personnel at Ogasawara sign surrender documents. The military element led by Yoshio Tachibana officially surrenders.
Early February, 1946	Soldiers and other military personnel on the islands leave for the mainland of Japan.
April, 1946	Ogasawara Islands residents file a plea with General MacArthur to return to the islands.
October 19, 1946	Only 126 islanders, all of whom are of Western descent, are allowed to return to the islands.
1956	The U.S. military establishes the Admiral Radford School.
1960	The Chile Earthquake Tsunami hits Chichijima, causing substantial damage, especially in Omura.
1965	A group of former Japanese islanders travel to Ogasawara to visit graves.
June, 1968	The U.S. military leaves and the islands are returned to Japanese control.
August 20, 1970	The Ogasawara Island Reconstruction Plan was announced, based on the Act on Special Measures for the Ogasawara Islands Reconstruction.

Year	Historical events
October 16, 1972	More than 30 islands except Iwoto, Okinotorishima, Minami-torishimaand parts of Chichijima and Hahajima, together with their surrounding marine areas are designated as Ogasawara National Park. Seven marine spots of exceptional scenic beauty are designated and protected as Marine Park.
May 17, 1975	Minami-iwoto is independently designated the Minami-iwoto Wilderness Area under the Nature Conservation Law, at which time it was removed from Ogasawara National Park.
May, 2003	The Ogasawara Islands are selected to be nominated as a World Natural Heritage Site.
January, 2007	As a signatory to the Convention Concerning the Protection of the World Cultural and Natural Heritage, Japan inscribes the Ogasawara Islands on its tentative list for World Natural Heritage Sites.

2.b.2 Interactions with humans (industry)

The main industries of the nominated property are agriculture, fishery, and tourism. Farming in the area takes advantage of the warm climate to grow fruits, vegetables, and ornamental plants (Table 2-5). Single rod-and-line fishing for bottom-dwelling fish was once the mainstay of fisheries in the area, but in recent years long-line tuna fishing is being conducted (Ogasawara Village, 2005). Ecotourism, in which visitors experience the natural environment, history, and culture of the area, is being promoted as the main form of tourism.

2.b.2.1 Use of agricultural land

In the agricultural areas outlined by the Land Use Plan, 26.9 ha of agricultural land on Chichijima and 39.5 ha of agricultural land on Hahajima were developed as part of the Agricultural Production Infrastructure Development carried out from fiscal 1969. Farm roads, agricultural dams for the irrigation of fields, and an intake weir were also built, together with 20-ton capacity reservoir tanks for the agricultural fields of each farmer. Furthermore, through a project carried out from fiscal 1989 to 1996 designed to get former residents of Iwoto to return to Ogasawara, 3.2 ha of farmland was developed in Komoridani, in addition to farming sections developed in the Nakanodaira and Hyogidaira areas. Despite these steps, the idle farmland is increasing because of more abandonment of farming, aging of farmers, lack of successors, and other reasons. At present, the total amount of land being farmed is 11.9 ha on Chichijima and 22.7 ha on Hahajima (Table 2-6; TMG, Ogasawara Subprefecture Office, 2008).

Table 2-5 Total production value of agricultural products (unit: thousand yen)

Section	Vegetable	Fruit	Flower	Other crops	Livestock products	Total
Chichijima	7,017	6,817	239	563	6,515	21,151
Hahajima	25,033	33,649	3,315	3,521	2,570	68,088
Total	32,050	40,466	3,554	4,084	9,085	89,239

(January to December, 2007)

Table 2-6 Farming area and the number of farmers

Section	Farming area (are)				No. of Farmers
	Total	Field	Orchard	Pasture	Total
Chichijima	1,193	785	408	0	25
Hahajima	2,271	1,500	690	81	41
Total	3,464	2,285	1,098	81	66

(From the 2007 roster of delegates for the Agricultural Committee elections)

2.b.2.2 Fishery

The fisheries industry before the World War II flourished, yielding bonito (*Katsuwonus pelamis*), tuna, flying fish, amberstripe scad whales, etc. It was a core industry for the Ogasawara Islands. After the islands reverted back to Japan, the industry had a shortage of labor, a lack of developed fisheries infrastructure, and a paucity of fishing skills. As a consequence, despite possessing superior fishing grounds, the industry as a whole declined in the area. In recent years, shared facilities and fishing ports have been built based on the Ogasawara Islands Reconstruction Plan and the Ogasawara Islands Development Plan. In addition, fishing boats have been modernized and younger fishermen have been trained, which has contributed to a stable yield, making fisheries once again a core industry for the region.

Fisheries in the past chiefly targeted flame snappers (*Etelis coruscans*), comet groupers (*Epinephelus morrhua*), and other bottom-dwelling fish using single rod-and-line fishing techniques, but with the recent development and introduction of long-line tuna fishing, trends in the fishery industry have shifted towards swordfish (*Xiphias gladius*), bigeye tuna (*Thunnus obesus*), and other fish that migrate over large areas. Moreover, markets have developed for Japanese Spanish mackerel (*Scomberomorus niphonius*) caught with trolling, mackerel scads (*Decapterus macarellus*) caught with stick-held dip-nets, and lobsters.

As for systematic instruments to manage fisheries, Ogasawara is subject to the “Tokyo

Metropolitan Government Regulations on Fisheries Adjustment", based on the Fisheries Law and Fisheries Resources Protection Law. In accordance with these regulations, a wide spectrum of control is coordinated, including fishing licenses, protection and culture of fishery resources, and fishing controls (Ogasawara Islands Branch Office, TMG, 2008). A licensed fishery is operated for the traditional capture of green turtles, and the no-fishing period and permitted size regulations apply as per the TMG Regulations on Fisheries Adjustment. In addition to these regulations, the artificial hatching and release programs that began in the Meiji era were revived after the islands reverted back to Japan. Because of these conservation measures, the number of green turtles that come to the islands is on the rise (see the column below).

In terms of fish catches, in fiscal 2007 the Ogasawara-jima Fisheries Cooperative reported 383 metric tonnes and 285,000 aquaculture seedling fish, and the Ogasawara Hahajima Fisheries Cooperative reported 226 tonnes.

2.b.2.3 Tourism

Tourism is flourishing in the nominated property, with its islands and waters endowed with rich natural resources and a subtropical climate. Ogasawara Village is currently promoting ecotourism, in which visitors experience and learn about the natural environment, history, and culture of Ogasawara, and at the same time develop an interest in their conservation (Ogasawara Village, 2005). Brief descriptions of different ecotours are as follows:

- Whale watching tours

  The Ogasawara Islands' whale watching tourism started in 1989. Tours are organized through the year to watch humpback whales or sperm whales. The whale watch is the largest sector of ecotourism operated on the Ogasawara Islands.
- Guided marine tours

  Guided marine tours include island-hopping trips to visit unique landscapes and the Marine Park Zone, and activities such as dolphin watching/swimming.
- Guided field tours

  Guided land tours began a full-scale operation about 10 years ago. Guides provide interpretation of endemic animals, plants and ecosystems.
- Battle sites tours

  These guided tours feature visits to the former radar site, searchlight, and other historic battle sites, while tour guides provide information on the history of Ogasawara.
- Birding tours

  Birding tours are mainly operated on Hahajima where Bonin honeyeaters occur.

Participants can observe wild birds, including endemic and endangered bird species. In recent years, birding tours are also conducted on Torishima and Mukojima Island Group using boats.

・Night tours

There are guided night tours to observe the endemic Bonin flying fox and a luminous mushroom (*Mycena chlorophos*).

・Ecotours for vegetation restoration volunteer activities

These are ecotours combined with volunteer programs for vegetation restoration, including Bischofia removal on Hahajima and planting endemic species such as *Elaeocarpus photiniaefolius*.

Column

Conservatoin status of Green turtles (*Chelonia mydas*)

The global populations of green turtles (*Chelonia mydas*) once decreased sharply due to marine catches (including adults and eggs) and habitat degradation (Seminoff, 2004). The situation was the same with the sea turtle population using the waters off the Ogasawara Islands (Kurata, 1980; Horikoshi et al., 1985). However, owing to conservation efforts such as strict catch restrictions (limits on catch numbers and fixed catching seasons), the number of green turtle eggs laid on the Ogasawara Islands is now increasing (Chaloupka et al., 2007; Everlasting Nature of Asia, 2008, Fig. 2-19).

At present, most of the beaches used by green turtles in the nominated property are conserved as National Park. Those beaches are in relatively good condition for sea turtles to lay eggs, and additional conservation efforts are also made to protect individual nests. In order to avoid unnecessary human intervention in sea turtle reproduction, eggs are artificially protected only in cases where eggs have been laid in clearly poor conditions or when there is a high probability that a nest will be destroyed by natural disasters. In such cases the eggs are removed from the nest and transferred to a safe place. Once hatched, the hatchlings are released in conditions that are close to their natural state. The number of protected individuals varies from year to year. In 2007, as an example, 10,787 eggs were transferred from 119 nests, of which 7,986 eggs hatched (a hatching rate of 74%, Everlasting Nature of Asia, 2008). In addition, “headstarting”, an attempt in which some of the hatchlings are nurtured for a certain period of time (five months or longer in Ogasawara) before being released, is practiced to reduce their initial mortality (Everlasting Nature of Asia, 2008).

Attempts have also been taken at the shores of Omura Beach, where many turtles lay eggs. This site is located close to the local community area, so such measures are promoted as turning off the nearby park lights and installing an enclosure bund to prevent female turtles from entering areas with unsuitable beaches for nesting, but there are still instances seen of female turtles coming ashore to lay eggs, returning to the sea, and releasing their eggs into the seawater. Further measures are needed to minimize the influence of humans (Everlasting Nature of Asia, 2008).

Numbers of eggs laid and hatching conditions have been monitored continually since 1977 (Everlasting Nature of Asia, 2008). In fact, there are no other instances in the world of ecological data on groups of green turtles being recorded for such a long period of time. In addition, to collect information on migration routes and breeding histories, the tracking of individuals is conducted using tag-and-release methods as well as the attachment of satellite tracking devices (Japan Fisheries Resource Conservation Association, 1999; Everlasting Nature of Asia, 2008). It is now clear that individuals hatched in Ogasawara make their way north all the way to the waters off the mainland of Japan to feed.

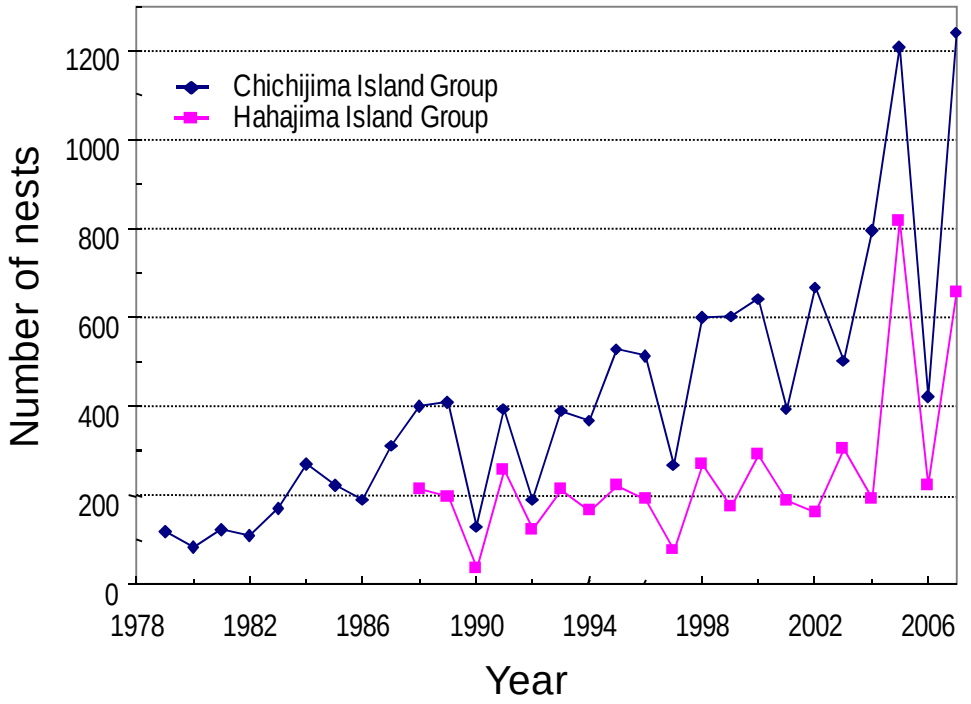


Fig. 2-19 Changes in the number of green turtle nests on the Chichijima and Hahajima Island Groups (Re-edited from Everlasting Nature of Asia, 2008）

3. Justification for Inscription

3.a Criteria under which inscription is proposed

3.a.1 Criterion (viii)

3.a.2 Criterion (ix)

3.a.3 Criterion (x)

3.b Proposed Statement of Outstanding Universal Value

3.c Comparative analysis

3.c.1 Comparative analysis on geological value

3.c.2 Comparison with other island groups in terms of their ecological/biological features and biodiversity

3.d Integrity

3.d.1 Inclusion of all key elements

3.d.2 Appropriate scope and adequate size

3.d.3 Site free of any adverse effects of development and neglect

3.d.4 Justification of a serial approach to achieve site integrity

3.a Criteria under which inscription is proposed

The Ogasawara Islands are an oceanic island arc that formed on oceanic crust, far from any continent, and have never been part of a continent. Their scale is rather small, yet they:

- offer a valuable record of the evolutionary processes of the earth,
- clearly demonstrate the processes of evolution in their flora and fauna including adaptive radiation, and
- contain a very high level of biological diversity for their small size.

As such, the property meets criteria (viii), (ix), and (x) as specified in paragraph 77 of the Operational Guidelines.

3.a.1 Criterion (viii)

The Ogasawara Islands provide a unique insight into the initial phases of the process of continent formation, a process which repeatedly took place in the Earth's geological history. More specifically, this is a process how oceanic island arcs began to form and took shape in response to the initiation of subduction beneath an oceanic plate. A series of varying volcanic activity and magma compositions records the evolutionary process from a juvenile oceanic arc to an establishment of a stable subduction zone with continental middle crust. The Ogasawara Islands are the only place on earth that preserve perfect exposures on land of the evolutionary processes of an island arc over millions of years, being an outstanding example presenting significant on-going geological processes.

The island arc formation in the Ogasawara Islands began with submarine volcanic activity of boninite in the Chichijima and Mukojima Island Groups; this initial stage of subduction of the Pacific Plate started about 48 million years ago. As subduction progress, the condition of mantle such as temperature and pressure has changed, and accordingly, erupted magma has changed. About 45 million years ago, there was a period of calc-alkaline andesite volcanic activity, followed by the eruptions of primitive basalt and andesite (44 million years ago) which formed the Hahajima Island Group. By about 40 million years ago, the subduction zone had largely taken the shape we see today. After the opening of the back-arc basin about 15 million years ago, basaltic volcanism formed the presently active Quaternary volcanic islands (the Kazan Island Group). The andesitic middle crust characteristic of continental crust continues to develop below the Izu-Ogasawara Arc, and this unique area continues to contribute to elucidating the mechanisms involved in continent formation throughout the earth's history.

3.a.2 Criterion (ix)

On the Ogasawara Islands, one can observe the process of unique speciation resulting

from various mode of evolution including long-term isolated evolution and adaptive radiation, and the islands have high level of endemism. The Ogasawara Islands are an outstanding example of the on-going evolutionary processes in oceanic island ecosystems.

For example, the prominent examples of speciation through adaptive radiation are seen among the land snails. By comparing fossils species with extant species, one can track historical changes in evolutionary sequences and diversity in species. Seven endemic genera are recognized among the land snails and their endemic ratio reaches 94%. One of the endemic genus *Mandarina* in particular, has a large number of endemic species, and they show examples of sympatric adaptive radiation, i.e. morphological changes among species reflecting divergent habitats, e.g. arboreal and ground ecotypes, as well as adaptive radiation among island groups.

The various mode of speciation showing the characteristic evolution on oceanic islands are seen in the plant species, including adaptive radiation to the varying climates and topographies of different islands, diminished seed dispersal capacities, development of mechanisms to promote cross-pollination (e.g. dioecism), and the transformation of herbs into woody plants. As a result of these speciation, the characteristic habitats of the Ogasawara Islands, sclerophyllous scrublands and subtropical rain forests, encompass a particularly large number of endemic plant species, and the endemic ratio of tree species in the sclerophyllous scrublands is 81%.

Further, the Ogasawara Islands have important examples indicating how some marine species evolved into terrestrial species. There are some endemic aquatic species which progressively shifted their habitat, firstly living in coastal ocean, then brackish water, and eventually fresh water. Also, among soil invertebrates, there is a unique species that is considered to be adapted to the terrestrial life from marine life.

Another distinctive characteristic of oceanic island ecosystems in the Ogasawara Islands is taxonomic disharmony, which means the complete absence of certain categories of species and the extreme over-representation of others. The vegetation, for example, is marked by a quite large ratio of ferns on the one hand, but on the other hand very few gymnosperms and absolutely no species in the beech family (which is a typical plant family on mainland Japan). As for native land animals, there is only one mammal species, two reptiles, and no amphibians whatsoever. The insect fauna of the order Coleoptera consists of large ratios of jewel beetles and tumbling flower beetles, but no native species of phytophagous Scarabaeidae or leaf beetles.

Further, Minami-iwoto is an oceanic island of pristine condition and is invaluable for what it has to teach us about the development and evolution of biodiversity and

ecosystems on an oceanic island. Because of all these interesting ecological characteristics on the Ogasawara Islands, researches into evolutionary processes in oceanic islands are on-going in various fields.

3.a.3 Criterion (x)

The Ogasawara Islands have a rich diversity of species of fauna and flora including endemic ones within a limited area of land, and provide habitats for many endangered species of global significance. The islands are invaluable for the conservation of biodiversity in the northwest Pacific region.

Climatically, the Ogasawara Islands fall within the subtropical zone. While the annual variation in temperature is small, the islands receive little precipitation. In addition, differences in altitude, aspect and wind direction result in a variety of localized micro-climates. These diverse climatic conditions and topographical features have facilitated the formation of unique ecosystems for each island group. For example, Chichijima Island Group is characterized by sclerophyllous scrub forests and Hahajima Island Group by subtropical rain forests. Also, the origins of biota reaching the Ogasawara Islands are quite diverse, including from Oceania, Southeast Asia, and the main island of Japan. Thus, a diverse biota has uniquely evolved in these isolated islands, and the Ogasawara Islands have a large number of species of fauna and flora per unit area of land, including many endemic and rare species.

For example, 441 taxa (including species, subspecies and varieties) of native vascular plants grow in the nominated property, of which 161 taxa are endemic (an endemic ratio of 36.5%). Based on this large number of native and endemic plant species, the Ogasawara Islands are listed as a Centre of Plant Diversity (CPD Site PO1) by WWF/IUCN (Davis et al., 1995). The Red List 2007 compiled by the Ministry of the Environment (MOE), Japan lists 137 taxa of plants in the Ogasawara Islands, making the islands an important habitat for endangered plant species.

A remarkable number of 104 native taxca of land snails have been recorded, of which 98 are endemic. For the insect fauna, 1,406 taxa have been recorded to date, 362 of which are endemic (with an endemic ratio of 25.7%). There are a large number of beetles in particular, 457 taxa are recorded. Further, as a result of evolution unique to each island or island group, the islands are home to many insect species, such as *Chlorophorus kusamai*, which is endemic to Mukojima Island Group, *Morion boninense*, which is endemic to Hahajima Island, and *Satozo minamiiwoensis*, endemic to Minami-iwoto Island.

BirdLife International has recognized the islands as one of the Endemic Bird Areas of the World, because they are the habitats for the endemic Ogasawara Islands honeyeater

(*Apalopteron familiare*) and the endemic subspecies of Japanese wood-pigeon (*Columba janthina nitens*). In addition, each of five serial component groups of the nominated property is identified as Important Bird Area. Among the 14 species of seabirds breed in the nominated property, Matsudaira's storm-petrel (*Oceanodroma matsudairae*) breeds only on one island in the world, Minami-iwoto, although it has wide home range from the African coast through Southeast Asia to the western Pacific Ocean. The black-footed albatross (*Phoebactria nigripes*) breeds on both the Ogasawara Islands and Hawaiian Islands, but the Hawaii group differs genetically from the one which breeds in the Ogasawara Islands (Eda et al., 2008). These examples show that the Ogasawara Islands are important habitats not just for the endemic land birds but for wider-ranging seabirds as well.

The Ogasawara Islands also provide irreplaceable habitats for 57 species ranked as vulnerable (VU), endangered (EN), or critically endangered (CR) on the IUCN Red List (2008). These include the Bonin flying fox (CR), the black-footed albatross (EN), an endemic dragonfly *Boninthemis insularis* (CR), and an endemic land snail *Hirasea chichijimana* (EN).

3.b Proposed Statement of Outstanding Universal Value

The Ogasawara Islands are oceanic islands located 1,000 km away from the main islands of Japan. Geologically, the islands are unique in the world in that they provide a rare opportunity to directly observe, on land, the normally hard-to-observe phases of the development of an oceanic island arc. Their large areas of exposed rock strata tell the tectonic story from the beginning of plate subduction 48 million years ago, through transitional periods, and into a stable phase 40 million years ago. The islands are the subject of the world's latest research into the development of island arcs, and are extremely valuable from a scientific perspective in that they provide insights into the evolutionary history of the earth, especially the mechanisms behind the formation of continents.

Biologically and ecologically, the Ogasawara Islands are peculiar island ecosystems with many endemic species as a result of unique processes of adaptive radiation and speciation on the oceanic islands formed in the way mentioned above. The Ogasawara Islands preserve the common characteristics of isolated oceanic islands, and offer the opportunity to witness the ongoing evolutionary process of speciation. They are also valuable as one of the few isolated land masses in the northwest Pacific Ocean region conserving globally significant species, making it very important to maintain this characteristic island ecosystem.

In short, the Ogasawara Islands preserve a valuable source of information on the evolution

of the earth and the life on it.

3.c Comparative analysis

3.c.1 Comparative analysis on geological value

< Comparison among oceanic island arcs >

There are many places in the world where oceanic plates are subducted under continental plates. However, most examples of oceanic island arcs that have developed where one oceanic plate is subducted under another oceanic plate, are located in the western Pacific Ocean; for example, the New Britain-New Hebrides and Tonga-Kermadec island arcs, in addition to the Izu-Ogasawara (Bonin)-Mariana (IBM) arc (Fig. 3-1, Table 3-1).

Among these oceanic arcs, only a few have land exposures of a series of volcanic rocks that represent the development of a subduction zone from its birth to the present day. Boninite-series rocks in particular, which develop during the initial stages of formation of subduction zones, most commonly exist under water and are usually covered with younger strata, making them difficult to observe *in-situ* on land. In the New Britain-New Hebrides and Tonga-Kermadec arcs, for example, most of boninite lies below the seafloor and there are very few places where boninite is exposed on land.

In the IBM arc, with the beginning of plate subduction, volcanism with similar magma compositions to the boninite-series rocks of the Ogasawara Archipelago simultaneously occurred over a broad area. However, the boninite is observed on land only in the Ogasawara Islands. This is because that the submarine volcanoes (which became current Mukojima and Chichijima Island Groups) forming a volcanic front in the Palaeogene, upraised due to the subduction of Ogasawara Plateau into the subduction zone. The rocks exposed on the Izu Islands, as well as on Saipan and Guam of the Mariana Islands, are only the product of either the transitional period or ‘steady-state’, ongoing arc volcanic activity, and the boninite are found only under sea bottom.

Only in the Ogasawara Islands can a series of volcanic materials that represents the full chronological development of the oceanic island arc be seen on land; these rocks grade from boninite and high-magnesium (Mg) andesite, followed by primitive arc tholeiite and calc-alkaline andesite magmas, to ordinary arc basalt-andesite.

< Comparison with other areas where similar rocks to boninite occur >

High-Mg andesites, including boninite, have formed in subduction zones found in a number of island arcs, including the Aleutian-Alaska arc, Kamchatka-Chishima (Kurile) arc, and the

Southwest Japan arc. They are also known from ophiolites and greenstone belts in Cape Vogel, Papua New Guinea; Nepui Pass and Massif de Koh in New Caledonia; Arakapas, Limassol in Cyprus (Troodos ophiolite), Sohar region in the northern Oman mountains (Oman ophiolite); Baja California in Mexico; the Canadian Appalachia (including Gros Morne National Park, a World Heritage Property); Tasmania to the southeast of Australia; and other sites (Fig. 3-1, Table 3-1).

However, in these areas the geological records are fragmentary or lost because tectonic disturbances and metamorphism have modified the primary mineralogy and chemical compositions. Furthermore, complicated histories have obscured the original geological settings in which these geological features were formed, including how the magmas changed their chemical compositions with the establishment of the subduction zone and maturation of the arc. In addition, in many cases geological relationships between their individual rock types are not always clear because of poor outcrops. The boninite of Papua New Guinea, for example, is not observable in outcrops, but rather only as residual boulders (Dallwitz, 1967). As for the Oman ophiolite, there are conflicting models leaving ambiguity around the tectonic setting of its boninitic magma genesis.

In contrast, on the Ogasawara Islands the primary geological features (such as structures and stratigraphy) are extremely well-preserved and exposed. They span several millions of years since the beginning of subduction, and have not been destroyed by subsequent tectonic disturbance and metamorphic processes.

< Comparison with other World Heritage sites with outstanding tectonic features >

The Ogasawara Islands constitute a part of the Pacific Ring of Fire, and the most constituent rocks of the islands are arc volcanic ejecta. The Nishinoshima Island and the Kazan Island Group are made up of much younger Quaternary volcanoes. However, the geological value of the nominated property does not lie in its volcanic features. There are many World Heritage properties with volcanoes as principal feature of outstanding universal value (OUV), such as the Volcanoes of Kamchatka and Tongariro National Park; these sites have characteristics typical of active volcanoes including: topography, diversity, scale, distinctive depositional structure, and hydrothermal phenomena. The geological value of the Ogasawara Islands lies in their record of the evolutionary history of the earth. Their rocks show just how an oceanic island arc above oceanic crust developed since the initiation of plate subduction, and how continental crust, which is the ultimate building block of continents, came into being. In this respect, the Ogasawara Islands fall under the theme of ‘tectonic and structural features’ proposed in the IUCN geological thematic study (Dingwall et al., 2005) and possess important geological features not seen at other world heritage sites with volcanic properties.

In the IUCN thematic study, other than the Gros Morne National Park mentioned above, Macquarie Island (Australia), Uluru-Kata Tjuta National Park (Australia), and the Three Parallel Rivers of Yunnan Protected Areas (China) are listed as examples of a heritage site with 'tectonic and structural features' as one of principal features of OUV. These three sites do not have a relationship, however, with the subduction zone process. Macquarie Island is made up of oceanic crust and mantle that has been thrust up to the surface along a transform fault. Uluru-Kata Tjuta National Park is characterized by huge sandstone monoliths created by the folding of the strata. The Three Parallel Rivers of Yunnan Protected Areas is the place where two continental plates collide and a variety of rocks including ophiolites show the evidence of the evolution of the Tethys seas. Accordingly, these areas differ from the Ogasawara Islands in terms of both the processes behind its formation and its constituent rocks. Macquarie Island and Uluru-Kata Tjuta National Park represent the results of tectonic activity for a relatively short period, while the Three Parallel Rivers of Yunnan Protected Areas and the Ogasawara Islands encompass relatively long-term tectonic activities.

Ophiolites outcrops can be found in other natural World Heritage properties such as Tasmanian Wilderness (Australia) and Te Wahipounamu – Southwest New Zealand (New Zealand); however, there is no other area like the Ogasawara Islands that shows the tectonic history for several million years.

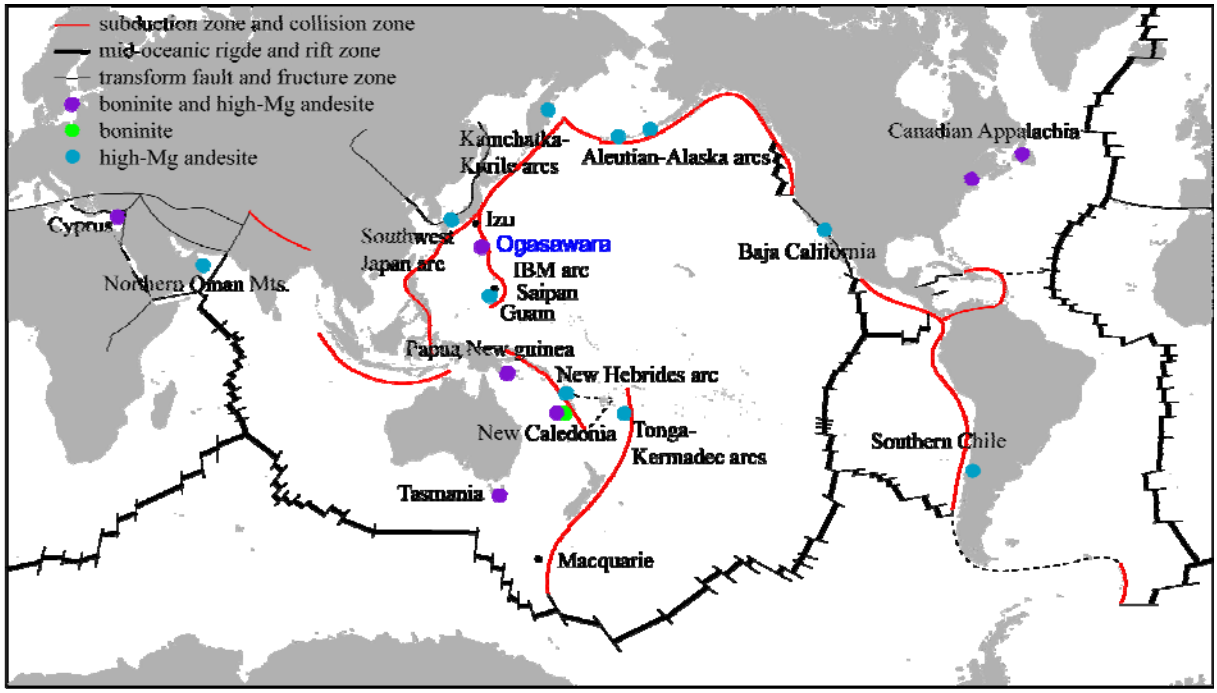


Fig. 3-1 Major plate boundaries and distribution of boninite and high-Mg andesite. (modified from Umino, 2008b)

Table 3-1 Global comparison of sites with rocks containing Boninite of high-Mg Andesite

Area	Location	Geologic body, current tectonic setting	Condition of Boninite[1)] outcrop on land	Condition of other high-Mg Andesite[2)] outcrop on land	Tectonic setting of formation of Boninite or high-Mg Andesite, or mechanism	Era of volcanism	Note	References
Oceanic Island Arcs								
Izu Islands	IBM (Izu-Bonin-Mariana Arc)	Island arc	None	None	Current volcanic arc	Pleistocene-Holocene	Eocene-Oligocen high-Mg andesite at the bottom of sea under the fore-arc	Wood et al. (1981)
Ogasawara ridge	IBM	Fore-arc	Present (widely exposed, primary structure is well preserved, fresh, not metamor-phosed)	Present	Volcanic front in incipient stage of a subduction zone	Eocene	Type locality of boninite: Ogiura, Chichijima. Boninite also found on the landward slope of trench – Hahajima seamount.	Ishiwatari et al. (2006), Ishizuka et al. (2006)
Saipan Island	IBM	Fore-arc	None	None	Volcanic front in incipient stage of a subduction zone	Eocene	Boninite found at the bottom of sea (landward slope of trench)	Bloomer & Hawkins (1987), Dietrich et al. (1978), Reagan et al. (2008)
Guam Island	IBM	Fore-arc	None	Present (primary structure is well preserved, not metamor-phosed)	Volcanic front in incipient stage of a subduction zone	Eocene	Boninite found at the bottom of sea (landward slope of trench)	Bloomer & Hawkins (1987), Reagan & Meijer (1984)
Fore-arc of Tonga-Kermadec island arcs	Tonga-Kermadec arcs	Fore-arc	None	Present	Possibility of melting of hydrous mantle at the arc splitting	Estimated to be in late Tertiary	Boninite found at the bottom of sea (landward slope of trench)	Falloon et al. (1989)
Hunter Ridge protoisland arc	New Hebrides arc	Not clear	None	Present	Subductionbeneath the mantle heated by hot asthenosphere raised under the spreading centre of the North Fiji Basin	Not clear	Boninite found at the bottom of sea (back arc side)	Meffre et al. (1996)
Other Island Arcs								
Adak Island, Near Island, Aleutian Ridge	Aleutian-Alaska arcs	Island arc	None	Present (Adakite)	Subducted oceanic rigde axis was splited	Miocene		Rogers & Saunders (1989)
Shiveluchi Volcano	Kamchatka-Kurile arcs	Island arc	None	Present (Adakite)	Subducted oceanic rigde axis was splited	Holocene		Churikova et al. (2001)
Setouchi Zone	Southwest Japan arc	Island arc	None	Present (Sanukitoid)	Hot slab subduction by opening of the Japan Sea	Miocene		Tatsumi & Maruyama (1989)

Area	Location	Geologic body, current tectonic setting	Condition of Boninite[1] outcrop on land	Condition of other high-Mg Andesite[2] outcrop on land	Tectonic setting of formation of Boninite or high-Mg Andesite, or mechanism	Era of volcanism	Note	References
Continental Arc								
Austral Volcanic Zone	Southern Chile	Continental arc	None	Present	Subduction of the oceanic ridge	Holocene		Rogers & Saunders (1989)
Baja California	Mexico	Continental arc	None	Present	Subduction of the oceanic ridge	Miocene-Holocene		Rogers & Saunders (1989)
Ophiolites								
Cape Vogel	Papua New Guinea	Ophiolite	Present (boulder stones only)	Present	Because of complexity, development of the geological structure are not clear.	Paleocene-Eocene		Dallwitz (1967)
Nepui Pass	New Caledonia	Ophiolite	Present (small scale outcrops)	None	Not clear	Paleocene-Eocene	Border with neighboring rock bodies at fault	Cameron (1989), Sameshima et al. (1983)
Massif de Koh	New Caledonia	Ophiolite	Present (boulder stones only, no outcrops, modified)	Present	Hot asthenosphere was upwelled, preceded by the spreading back-arc, and caused melting of upper- mantle	Permian-Triassic	greenschist facies metamor-phic rocks	Cameron (1989), Meffre et al. (1996)
Arakapas, Limassol	Cyprus Island	Ophiolite	None	Present	Obduction/fore-arc spreading	Cretaceous	Troodos ophiolite	McCulloch & Cameron (1983)
Sohar	Northern Oman mountains	Ophiolite	None	Present	Temporal subduction zone caused by obduction/fore-arc spreading	Cretaceous	Oman ophiolite	Ishikawa et al. (2002)
Dundas Trough	Tasmania	Nappe (accretionary complexes of continent- arc collision)	Present (changed into greenschist facies metamorphic rocks)	Present (changed into greenschist facies metamophic rocks)	Not clear	Cambrian		Brown & Jenner (1989)
Gros Morne Newfound-land	Canadian Appalachia	Ophiolite	Present (changed into greenschist facies metamorphic rocks)	Present (changed into greenschist facies metamorphic rocks)	Oceanic crust, mantle, Mohorovicics discontinuity	Cambrian-Ordovician	Betts Cove ophiolite, Bay of Island ophiolite, Pacquet Harbour Complex	Coish (1989)
Thetford Mines Complex	Canadian Appalachia	Ophiolite	Present (changed into greenschist facies metamorphic rocks)	Present (changed into greenschist facies metamorphic rocks)	Oceanic crust, mantle, Mohorovicics discontinuity	Cambrian-Ordovician		Coish (1989)

1) Glassy bronzite andesite without plagioclase; 2) Including “boninite” in a broad sense

3.c.2 Comparison with other island groups in terms of their ecological/biological features and biodiversity

3.c.2.1 Domestic comparisons

In Japan, other than the Ogasawara Islands, the islands with rich endemic biota and unique ecosystems include Nansei Islands which are continental islands. One of the islands of Nansei Islands, Yakushima, is inscribed on the World Heritage List based on the criteria (vii) and (ix). Its main value for criterion (ix) rests on the outstanding vertical distribution of vegetation and not on the evolution in an isolated ecosystem. The Amami Archipelago and the Ryukyu Islands, that are included in the Nansei Islands, are rich in endemic and rear species with great biodiversity, yet they exhibit a completely different set of ecological and biological processes from the Ogasawara Islands.

Other oceanic islands in Japan include the Daito Islands (Kitadaito, Minamidaito and Okidaito Islands: total area of about 43.6 km^2). The Daito Islands, however, are uplifted coral reef islands. Like the Ogasawara Islands, the Daito Islands have many endemic species, but their natural environment has not been preserved to the degree of that of the Ogasawara Islands, where one can observe ongoing adaptive radiation and speciation.

3.c.2.2 Global comparison of ecological and biological features of evolution

According to Udvardy's biogeographic classification system (1975), the Ogasawara Islands belong to the Micronesian Province of the Oceanian Realm (5.2.13). Currently, there is no World Heritage property in this province. There are 25 natural sites listed on the World Heritage list that belong to the same biome, i.e. mixed island system, and about 45 island natural heritage properties when one includes those that do not belong to the 'mixed island system' biome.

Of these 45 island natural heritage sites, there are 16 properties that were inscribed based on criterion (ix), and which consist of oceanic islands or islands having histories of isolation comparable in length to oceanic islands. When one excludes the areas with completely different climatic conditions such as subpolar regions, or islands whose main value lies in the marine ecosystem around them, the following seven sites remain (Table 3-2, Fig. 3-2). All of these sites feature evolutionary processes or ongoing evolution, but the scale and contents vary.

- The Galápagos Islands (Ecuador) (criteria (vii), (viii), (ix) and (x)):

  Located in the eastern Pacific, the site is famous for research into biological

evolution and for its extensive examples of adaptive radiation (especially giant tortoise and finches). A large number of tourists visit the site every year, and because of severe problems relating to human settlement and the introduction of alien species, Galápagos is currently inscribed on the list of World Heritage in Danger. The major difference of the Ogasawara Islands from this site is the former's lack of large scale islands and multiple origins of biota (most of the biota in Galápagos originated from the South American continent). Consequently, the processes of evolution observed and the species involved are different from the Ogasawara Islands.

- East Rennell (Solomon Islands) (criterion (ix)):

  The property occupies about half of Rennell Island, which is located in the Southern Pacific. The marine, coastal and forest ecosystems are well preserved, and it plays a role as a stepping-stone in the migration and evolution of bird species in the western Pacific. East Rennell is called "a true natural laboratory for scientific study". The property is a high coral island with a major feature being a large brackish lake with many endemic species. The lake occupies more than 40% of the property and is the largest lake in the Pacific region. Its characteristic ecosystem is different from the Ogasawara Islands, and unlike Ogasawara, there are many fields where little research work has been done.

- Aldabra Atoll (Seychelles) (criteria (vii), (ix) and (x)):

  Located in the western Indian Ocean, it shows distinct evolutionary features in giant tortoises and flightless birds. Aldabra Atoll is a small group of tropical atoll and they are flat islands with mangrove forests, scrubs and grasslands. There are large differences in its ecosystems and evolutionary processes compared with the subtropical and volcanic origin Ogasawara Islands.

- Vallée de Mai Nature Reserve (Seychelles) (criteria (vii), (viii), (ix) and (x)):

  This site is a relatively small scale reserve (20ha) on Praslin Island which is located in the western Indian Ocean. There are six endemic palm species found in the property, showing an earlier stage in the evolution of the world's flora. There also are many endemic or endangered species, and it is called a "living museum". There are no known examples of adaptive radiation over several islands (such as seen in Ogasawara and other islands).

- The Laurisilva of Madeira (Portugal) (criteria (ix) and (x)):

  Located in the eastern Atlantic, southwest of Portugal, this property preserves a

large area of laurel forest previously widespread in Europe. It has rich biodiversity and many of plants and animals are unique to the laurel forest. The variety of evolutionary processes is poor compared to the Ogasawara Islands because of its longer history of human development and lesser number of islands.

- Garajonay National Park (in Canary Islands of Spain) (criteria (vii) and (ix)):

  Located in the eastern Atlantic, off the African continent and south of the Madeira Archipelago, this park also has an old-type laurel forest. The site features the many examples of woodiness in herbaceous plants and many endemic species. The Canary Islands is rather close to the African continent, and they do not have the characteristics of evolutionary processes in the long-isolated oceanic islands as seen in the Ogasawara Islands.

- Alejandro de Humboldt National Park (Cuba) (criteria (ix) and (x)):

  This national park is located in eastern Cuba in the western Atlantic region. It worked as a refuge site during the glacial era. Also, it is an excellent example of ongoing processes in the evolution of species and communities adapting to the toxic rocks. The area becomes an isolated "island" because of the special geological features, but its ecological processes are different from that of true isolated oceanic islands.

Further, another four sites are compared;

- The Hawaiian Islands (USA):

  Located in the middle of the Pacific Ocean, the islands are famous for the evolutionary research carried out here into an oceanic island system isolated by great distance from the continents. The Hawaiian Islands have many unique endemic species. Hawaii Volcanoes National Park located on the largest island, Hawaii, is a World Heritage property based on the geological value of its volcanoes. The value of Hawaiian biological evolution was not recognized in the inscription because of the degree of anthropogenic change and the severe impact of invasive alien species on the indigenous ecosystems. The Ogasawara Islands differ from this site in the lack of any large scale islands and the absence of Hawaii's long history and intensity of development pressure.

- Papahanaumokuakea Marine National Monument (The Northwestern Hawaiian Islands of USA, listed on the tentative list and to be discussed with respect to the inscription at the 34th World Heritage Committee in 2010):

This site comprises a chain of small scale islands located to the northwest of the Hawaiian Islands. The site is nominated for a mix of cultural and natural values, and the natural value is focused on the breeding sites of seabirds and the rich diversity of marine life. The islands are located at similar latitude as the Ogasawara Islands but the land scale of each island is smaller, and their terrestrial evolutionary processes are not as diverse as in the Ogasawara Islands.

- The Kermadec Islands (New Zealand, listed on the tentative list):

  These islands are a volcanic island arc situated 1000km north-east of the North Island of New Zealand in the southern Pacific. They have rich marine biodiversity and on land, many endemic species and examples of adaptive radiation are seen. This site has similar conditions as the Ogasawara Islands though it is in the southern hemisphere. Successful control programs on invasive alien species have been progressively conducted for more than 15 years. Research work on its terrestrial ecosystems is not as far advanced as in the Ogasawara Islands.

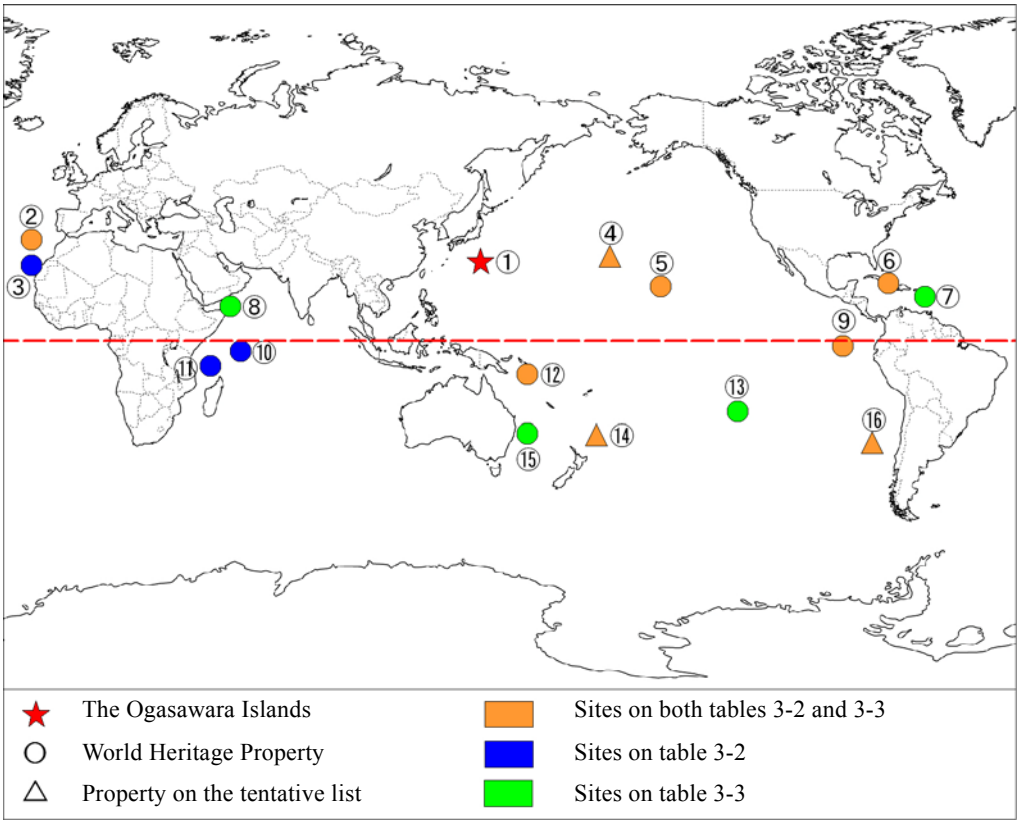
- The Juan Fernández Islands (Chile, listed on the tentative list):

  Located in the southeast Pacific, off Chile, this site has many endemic species and even an endemic family. It has diverse origins of species, including South America, Antarctic, Asia and Australia. The major geographical differences from the Ogasawara Islands are the shorter distance from a continent and the smaller number of islands involved.

Table 3-2 Geographical comparisons regarding criterion (ix)

Area	Latitude	Distance from a continent (km)	Age of islands (million years)*	Area of the largest island (km^2)	Highest peak (m)	Number of islands (>1km2)	References
Ogasawara Islands	24-28°N	1,000	3 - 5	24	916	11 +	
Madeira Archipelago	32-33°N	650		741	1,862	4	Wikipedia, map
Canary Islands	28-29°N	96	12 - 20	2,034	3,718	7	Whittaker and Fernández-Palacios (2007), Wikipedia
Northwestern Hawaiian Islands	22-30°N	ca.4,000	7 - 30	6	275	4 +	State of Hawaii et al. (2009)
Hawaiian Islands	19-23°N	4,000	0.5 - 70	10,337	4,206	8+	Whittaker and Fernández-Palacios (2007), Loope et al. (1988)
Cuba	20-21°N	150		110,000	1,974	1	Wikipedia, map
Galápagos Islands	2°S-2°N	800	3 - 4.5	4,670	1,707	19 +	Whittaker and Fernández-Palacios (2007), Loope et al. (1988)
Seychelles Islands (Inner Islands)	4-5°S	1,300		153	912	41	WCMC, Wikipedia
Aldabra Atoll	9-10°S	640	0.125	116	8	4	WCMC, Wikipedia
Rennell Island	11-12°S	ca.2000	2.5	684	180	2	Gov. Solomon Islands (1997)
Kermadec Islands	29-32°S	1,100	0.5 - 1.5	29	516	15	DOC (2006), Anthoni (2002)
Juan Fernández Islands	33 -34°S	667	2 - 4	50	916	3	Stuessy et al. (1998), Chilean Government (1994), Wikipedia

* Here, age does not mean the year after the creation of islands but it means estimated periods during which the islands stand constantly above ocean.



1. Ogasawara Islands
2. Madeira Archipelago
3. Canary Islands
4. Northwestern Hawaiian Islands
5. Hawaiian Islands
6. Cuba
7. Dominica
8. Socotra Archipelago
9. Galápagos Islands
10. Seychelles Islands
11. Aldabra Atoll
12. Rennell Island
13. Henderson Islands
14. Kermadec Islands
15. Lord Howe Island Group
16. Juan Fernández Islands

Fig. 3-2 Map of the areas for comparison (The areas on tables 3-2 and 3-3.)

The evolutionary process on oceanic islands is affected by the magnitude of geological and temporal isolation, the size and number of islands, the complexity of their ecosystems and other factors. When the distance from continental landmasses is large, the frequency of introduction of new species or individuals will be less, the disproportion of the species composition of fauna and flora will be greater, and the number of endemic species will be larger. When the size and number of islands is large, or the ecosystem is complex, speciation will be promoted; consequently, the number of endemic species will be large and the island will be relatively rich in biodiversity. When the duration of isolation is longer, this evolutionary process will proceed further. The typical isolated oceanic islands with this rich biodiversity and high levels of endemism are the Hawaiian Islands and the Galápagos Islands.

In comparison, Table 3.2 shows that the Ogasawara Islands have the following characteristics:

- their geological and temporal isolation is comparatively large,
- they lack any large sized island or any island with high altitude, and
- they consist of many small islands spread over a distance of 400km, with an interval of 30 - 150 km between each group in the archipelago.

In general, smaller islands have fewer species, and more of them are likely to become extinct. Compared with the Hawaiian Islands or the Galápagos Islands, the Ogasawara Islands are at a disadvantage in the survival and evolution of their biota since the archipelago lacks any large island with complex ecosystems though their geological isolation is as great as others. In spite of these disadvantages, many species have reached the Ogasawara Islands, survived, and progressed through a unique evolution. The Ogasawara Islands rival the Hawaiian Islands or the Galápagos Islands in scientific research outcomes which have given valuable insights into the diverse evolutionary processes in terrestrial ecosystems involving multiple islands. The Ogasawara Islands maintains fairly good state of conservation, and are indeed precious laboratories of evolution.

3.c.2.3 Global comparison of numbers of species and endemic species

Using a similar comparison approach to the previous section, 17 of the currently-listed oceanic island natural heritage sites are inscribed based on criterion (x). When one excludes the subpolar regions or islands whose main value lies in their marine ecosystem, this number is reduced to the following seven sites. All these island sites feature biodiversity in the terrestrial ecosystem, but the degree and attributes vary.

- The Galápagos Islands (Ecuador) (criteria (vii), (viii), (ix) and (x)),
- Henderson Island (UK) (criteria (vii) and (x)),
- Lord Howe Island Group (Australia) (criteria (vii) and (x)),
- Socotra Archipelago (Yemen) (criterion (x)),
- The Laurisilva of Madeira (Portugal) (criteria (ix) and (x)),
- Alejandro de Humboldt National Park (Cuba) (criteria (ix) and (x)), and
- Morne Trois Pitons National Park (Dominica) (criteria (viii) and (x)).

Furthermore, the same additional four sites as in the previous section were included in the comparison (Table 3-3, Fig. 3-2). Unfortunately, for some properties, detailed information on the number of species could not be found and consequently direct comparison was not possible.

Table 3-3 Geographical features of the sites chosen for comparing the number of species

Area	Latitude	Distance from a continent (km)	Age of islands (million years)*	Terrestrial Area (km^2)	References
Ogasawara Islands	24-28°N	1,000	3 - 5	80**	
Madeira Archipelago	32-33°N	650		797	Wikipedia, map
Northwestern Hawaiian Islands	22-30°N	ca.4,000	7 - 30	14	State of Hawaii et al. (2009)
Hawaiian Islands	19-23°N	4,000	0.5 - 70	16,504	Whittaker and Fernández-Palacios (2007), Wikipedia
Cuba	20-21°N	150		110,000	Wikipedia, map
Dominica	15-16°N	550		754	Wikipedia, map
Socotra Archipelago	12-13°N	250	6	2,775	Yemen Government (2006)
Galápagos Islands	2°S-2°N	800	3 - 4.5	7,856	Whittaker and Fernández-Palacios (2007), Loope et al. (1988)
Rennell Island	11-12°S	ca.2000	2.5	684	Gov. Solomon Islands (1997)
Henderson Island	24°S	4,800	0.38	37	Brooke et al. (2004), Wikipedia
Kermadec Islands	29-32°S	1,100	0.5 - 1.5	33	DOC (2006), Anthoni (2002)
Lord Howe Island Group	31-32°S	700	6.5 - 7	15	Australian Government (1981, 2002), Whittaker and Fernández-Palacios (2007)
Juan Fernández Islands	33 -34°S	667	2 - 4	100	Stuessy et al.(1998), Chilean Government (1994), Wikipedia

* Here, age does not mean the year after the creation of islands but it means estimated periods during which the islands stand constantly above ocean. For the Socotra Archipelago, it means the year after its separation from the continent.

** The terrestrial area of the Ogasawara Islands used for comparison includes the whole Chichijima and Hahajima Islands as well as Iwoto Island which is outside of the nominated property, in accordance with the area covered by the data used.

The number of species on any islands has a close relationship with the area of the islands and their distance from the continents. The number will increase as the area increases, and it will decrease as the distance increases. Generally, it is known that the number of species

increases exponentially with island area (the logarithms of each form a linear function with a positive slope) (MacArthur and Wilson, 1967). So, in comparing island size and number of species, consideration was given to the above issue and comparisons have been made by drawing the following graphs with exponential axes. As a result, it is apparent that the Ogasawara Islands have more number of species in plants, land snails and insects than other oceanic islands as explained below, and that the Ogasawara Islands are oceanic islands with high biodiversity.

< Plants >

Table 3-4 compares the total numbers of plant species, numbers of endemic species, and numbers of species per unit area for the different island groups. The table included the Canary Islands because they have high plant diversity though not included in the table 3-3. The Hawaiian Islands have 1,113 species of vascular plants, 988 of which are endemic, giving a high endemic ratio of 88.8%. Other island groups with more plant species overall and more endemic species compared to the Ogasawara Islands are the Canary Islands, the Galápagos Islands and Socotra Archipelago, yet these four island groups are up to many hundreds of times larger in area than the Ogasawara Islands.

When considering the relationship of the area and the number of vascular plant species by graph (Fig. 3-3), the Ogasawara Islands plot clearly higher in both the number of total species and endemic species than those relationship in other islands (the regression line in the graph). Further, when one looks at the number of plant species on each island of the Ogasawara Islands, it can be seen that the level of each individual Ogasawara island is in the same range as that of the Lord Howe Island Group which is recognized as small islands of extremely high biodiversity.

Table 3-4: Comparison of the numbers of overall species and endemic species of vascular plants for a range of oceanic islands.

Area	Number of species	Number of endemic species	Endemic ratio	No. of species/ area (km^2)	No. of endemic species/ area (km^2)	References
Ogasawara Islands	441 N	161	36.5	5.5	2.01	Nature Conservation Bureau, MOE (2004)
Minami-iwoto	129	32	24.8	36	8.89	
Kita-iwoto	132	46	34.8	24	8.21	
Anijima	184	95	51.6	23	12.03	
Ototojima	186	84	45.2	36	16.15	
Chichijima	356	129	36.2	15	5.38	
Hahajima	278	122	43.9	14	6.10	
Madeira Archipelago[1)]	793	118	14.9	1.0	0.15	Whittaker and Fernández-Palacios (2007)
Canary Islands[2)]	1,300	570	43.8	0.2	0.08	Whittaker and Fernández-Palacios (2007)
Northwestern Hawaiian Islands[3)]		6			0.43	State of Hawaii et al. (2009)
Hawaiian Islands[4)]	1,110 N	956	86.9	0.1	0.06	Loope et al. (1988)
Socotra Archipelago	825	307	37.2	0.3	0.11	Yemen Government (2006)
Galápagos Islands	541 N	229	42.3	0.1	0.03	Loope et al. (1988)
Rennell Island		10			0.01	Gov. Solomon Islands (1997)
Henderson Island	71	10	14.1	1.9	0.27	Brooke et al. (2004)
Kermadec Islands	115 N	23	20	3.5	0.70	DOC (2006)
Lord Howe Island Group	241	105	43.6	16.1	7.00	Australian Government (2002)
Juan Fernández Islands	210 N	127	60.5	2.1	1.27	Davis et al. (1995)

N: number of native species.
Figures for the numbers of species include subspecies and varieties.
1) World Heritage Property is “Laurisilva of Madeira” which is about 19% of the islands.
2) World Heritage Property is “Garajonai National Park” which is about 0.5% of the islands, and “Teide National Park” which is about 2.6% of the islands. Total area of the islands is 7,447 km^2.
3) “Papahanaumokuakea Marine National Monument” covers the whole area and is listed on the tentative list.
4) World Heritage Property is “Hawaii Volcanoes National Park” which covers about 5.6% of the islands.

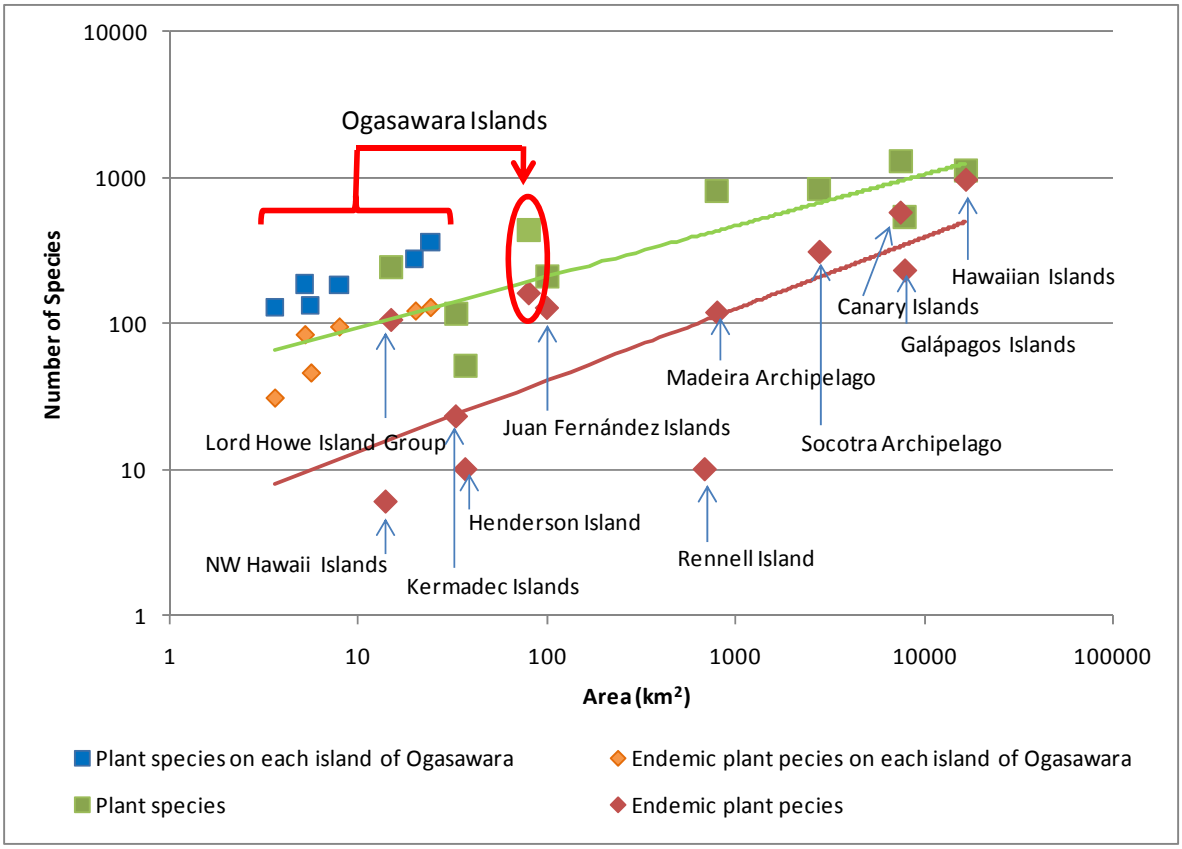


Fig. 3-3 Number of plant species by area of islands (on a logarithmic scale)

< Land snails >

Table 3-5 shows the numbers of native species and endemic species of land snails on oceanic islands. In general, the endemic ratio of land snails is high in oceanic islands, but the ratio is over 90% for the Ogasawara Islands, which is equivalent to that of the Hawaiian Islands or the Galápagos Islands. Also, Fig.3-4 shows that the number of species is very high in the Ogasawara Islands when considering the small area of the islands, indicating a high degree of speciation in land snails has taken place on the Ogasawara Islands. In this respect, the Ogasawara Islands are equivalent to the Lord Howe Island Group, well known as small islands of high biodiversity.

Furthermore, the important characteristic of land snails on the Ogasawara Islands is that the extinction rate for endemic species is far lower than for the other oceanic islands (Table 3-5). When one considers that human settlement and alien species have devastated land snails on most Pacific islands, such as Hawaii (extinction rate: 90%) and Tahiti (extinction rate: 90%), the land snails in the Ogasawara Islands with their high survival rate (extinction rate: about 22%) are extremely important.

Table 3-5: Numbers of overall native land snail species, endemic species, and extinction rates for groups of oceanic islands.

Area (country)	Number of native species / Number of endemic species	Endemic ratio (%)	Reference for No. of species	Terrestrial areas (km²)	No. of native species / area (km²) / No. of endemic species / area (km²)	Extiction rate of endemic species	Reference for Extinction rate
Ogasawara Islands (Japan)	104 / 98	94.2	Chiba (2009)	80	1.30 / 1.23	22%	Chiba (2009)
Chichijima	51 / 30 *	58.8 *	Chiba (2009)	24	2.13 / 1.25	---	
Hahajima	53 / 43 *	81.1 *	Chiba (2009)	20	2.65 / 2.15	---	
Anijima	35 / 30 *	85.7 *	Chiba (2009)	8	4.43 / 3.80	---	
Madeira Archipelago (Portugal)	194 / 171	88.1	Cameron and Cook (1992)	797	0.24 / 0.21	---	
Canary Islands (Spain)	260 / 210	80.8	Ibanez et al. (1997)	7,447	0.03 / 0.03	---	
Northern Mariana Islands (USA)	16 / ---	---	Kurozumi (1994)	1,590	0.01 / ---	50%	Kurozumi (1994)
Hawaiian Islands (USA)	768 / 748	97.4	Cowie et al. (1995)	16,504	0.05 / 0.05	90%	Lydeard et al. (2004)
Socotra Archipelago (Yemen)	96 / 91	94.8	Yemen Government (2006)	2,775	0.03 / 0.03	---	
Galápagos Islands (Ecuador)	83 / 80	96.4	Tye et al. (2002)	7,856	0.01 / 0.01	---	
Rennell island (Solomon islands)	27 / 9	33.3	Gov. Solomon Islands (1997)	684	0.04 / 0.01	---	
Western Samoa Islands (Samoa)	62 / 42	67.7	Cowie and Robinson (2003)	3,007	0.02 / 0.01	---	
Society Islands (France)	ca 160 / ca 140	87.5	Lydeard et al. (2004)	1,539	0.10 / 0.09	90%	Coote and Loeve (2003)
Henderson Island (UK)	16 / 8	50.0	Preece (1995)	37	0.43 / 0.22	---	
Norfolk Island (Australia)	68 / ---	---	Ponder (1997)	36	1.89 / ---	---	
Lord Howe Island Group (Australia)	69 / ---	---	Ponder (1997)	15	4.60 / ---	---	

* The figures indicate the number of species or ratio of species endemic to the Ogasawara Islands on each island (not the species endemic to each island).

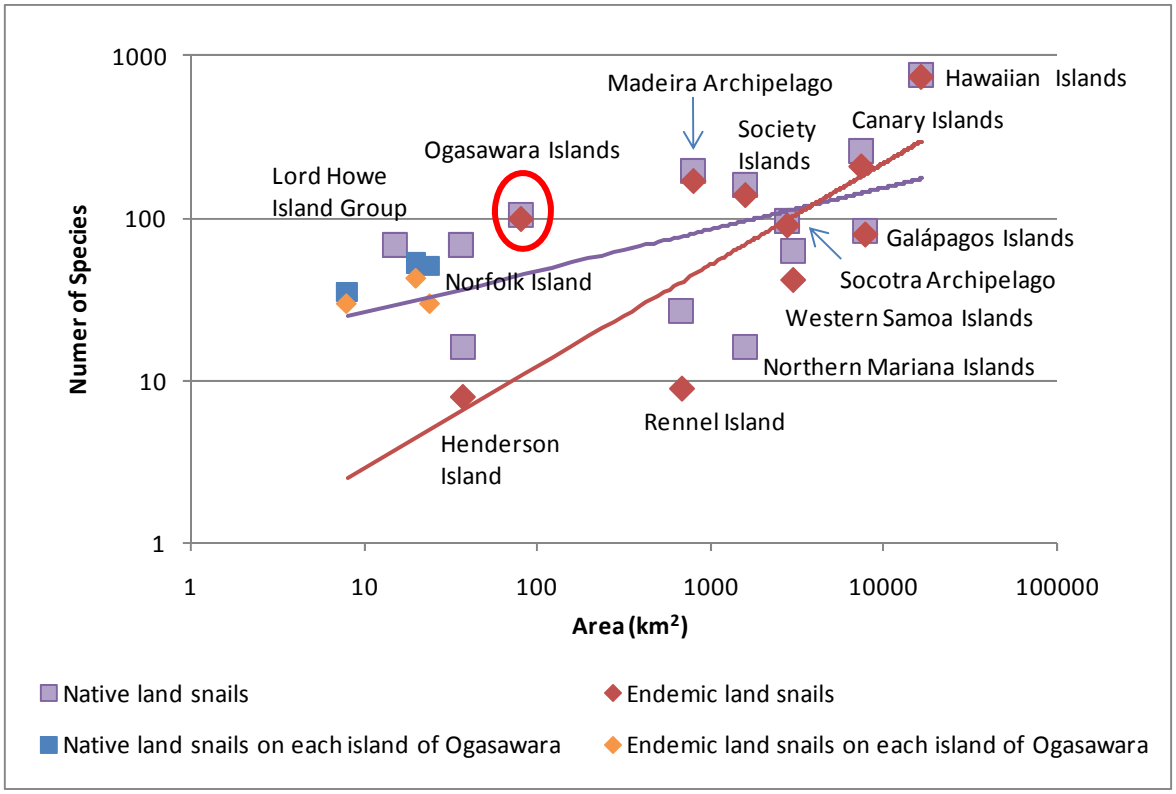


Figure 3-4: The relationship between island area and land snail species numbers on different island groups

* The number of species includes the extinct ones. (Figure produced with the assistance of Satoshi Chiba)

< Insects >

The insect fauna of the Ogasawara Islands consists of 1,406 species. There are a limited number of islands where detailed surveys have been conducted and detailed information on insect fauna is available. When comparing with other oceanic islands that the data are available, the number of insect species in the Ogasawara Islands is next to the Hawaiian Islands and the Galápagos Islands, and far more than Rennell Island of Solomon Islands or Socotra Archipelago which are much larger (Table 3-6). Considering the relationship between the area and the number of species (Fig. 3-5 left), the diversity of insect fauna of the Ogasawara Islands is clearly higher than the other islands.

Insect fauna is diverse and the featured species differ depending on the islands; for example, Rennell Island is reported to have 246 species of moths. One useful insect richness indicator is the number of beetles (order Coleoptera), as there is a relative wealth of research on them throughout the world (Table 3-6). The number of endemic beetle species for the Ogasawara Islands is comparatively low, but considering the scale of islands, the total number of species is about the same level as that for the Lord Howe Island Group or the Hawaiian

Islands and is far higher than that for the Galápagos Islands (Fig. 3-5 right).

Table 3-6: Comparison of numbers of species of insects

Area	Insecta					Coleoptera					References
	Number of species	Number of endemic species	Endemic ratio (%)	Number of species/ area (km^2)	Number of endemic species/ area (km^2)	Number of species	Number of endemic species	Endemic ratio (%)	Number of species/ area (km^2)	Number of endemic species/ area (km^2)	
Ogasawara Islands	1,406	362	25.7	17.58	4.53	457	145	31.7	5.71	1.81	
Madeira Archipelago						c.900	c.351	39.0	1.13	0.44	Peck (2006)
Canary Islands						1,948	1,104	56.7	0.26	0.15	Peck (2006)
Hawaiian Islands	7,982	5,293	66.3	0.48	0.32	1,872	1,278	68.3	0.11	0.08	Nishida (1997)
Socotra Archipelago	600			0.22							Yemen Government (2006)
Galápagos Islands	2,059	1,071	52.0	0.26	0.14	486	266	54.7	0.06	0.03	Peck (2006)
Rennell Island	731			1.07		180	45	25.0	0.26	0.07	Gov. Solomon Islands (1997)
Society Islands						473	256	54.1	0.31	0.17	Nishida (2008)
Henderson Island	180	36	20.0	4.86	0.97						Brooke et al. (2004)
Lord Howe Island Group	1,089	420	38.6	72.60	28.00	464	277	59.7	30.93	18.47	Centre for Biodiversity and Conservation Research (2003)
Juan Fernández Islands						235	190	80.9	2.35	1.90	Peck (2006)

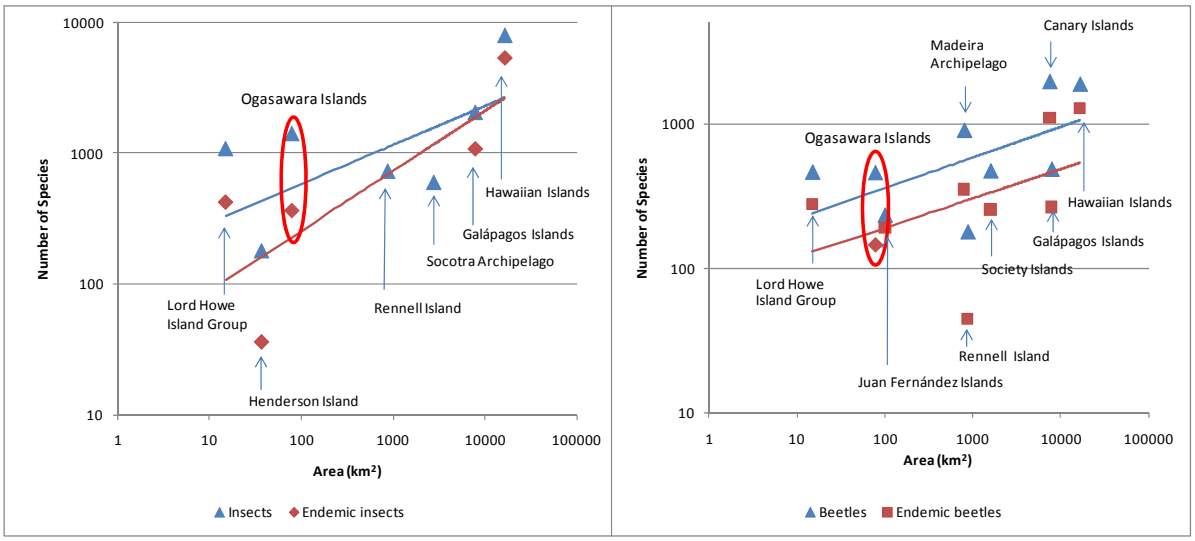


Fig. 3-5 Species numbers for insects (left) and beetles (right) by area of islands

< Birds>

There are 195 species of birds that have been recorded on the Ogasawara Islands. This number is second to the Hawaii Islands' 336 species, and is higher than other oceanic islands in the Pacific and Socotra Archipelago in the Indian Ocean (Table 3-7). All the areas listed on table 3-7 except for the Kermadec Islands are designated as Endemic Bird Area by BirdLife International.

However, some of these numbers include alien or vagrant species, and it is likely that the method of aggregate calculation is different for each island group. So, the number of endemic species and the number of breeding birds were compared, since they are assumed to better reflect the value of the property (Table 3-7). The Ogasawara Islands have relatively high number of breeding seabirds compared to the other islands.

Table 3-7 Comparison of number of bird species

Area	Number of recorded species	Number of extant endemic species	Number of breeding landbirds	Number of breeding seabirds	References
Ogasawara Islands	195	1	8	14	
Northwestern Hawaiian Islands	172	4		21	State of Hawaii et al. (2009)
Hawaiian Islands	336	40	39	13	Pyle (2002)
Lord Howe Island Group	129	4	18	14	Australian Government (2002)
Socotra Archipelago	182	6	31	10	Yemen Covernment (2006)
Galápagos Islands	58	34	29	18	Tye et al. (2002), Rothman, R., Galapagos Online Tours
Rennell Island	83	4	38	5	Gov. Solomon Islands (1997), Avibase
Henderson Island	32	4	4	12	Brooke et al. (2004)
Kermadec Islands	35	5	2	14	DOC (2006)
Juan Fernández Islands	58	5	9	6	Oikonos, Avibase

3.d Integrity

As described below, the nominated property includes all of the elements necessary to demonstrate the World Heritage value of the serial island site. Furthermore, the necessary area to maintain its value over the long term and to completely attest to its significance has been strictly protected by law, it is being adequately managed for conservation, and thus it fulfills the condition of integrity for inscription on the World Heritage List as specified in Paragraph 88 of the Operational Guidelines.

3.d.1 Inclusion of all key elements

3.d.1.1 Criterion (viii) (Operational Guidelines, Para. 93)

The nominated property includes all the typical terrestrial areas, namely those containing well-preserved strata exposed on land spanning several millions of years, including the beginning of the oceanic plate subduction period, as well as the whole series of rocks showing the typical formation processes of an oceanic island arc. Furthermore, the site is situated at the modern-day volcanic front and includes Kita-iwoto Island as well as Nishinoshima Island where one can witness ongoing volcanic activity.

3.d.1.2 Criterion (ix) (Operational Guidelines, Para. 94)

The nominated property includes most of the sclerophyllous scrub and subtropical rain forests and other habitats which are distinctive elements of the ecosystems of the different island groups. The areas chosen are inhabited by many endemic species of plants, land snails and other organisms which exhibit the kinds of unique adaptive radiation and speciation that are distinctive of these oceanic islands. The areas nominated are large enough for the purposes of conserving these ecosystems and the organisms living in them over the long term.

3.d.1.3 Criterion (x) (Operational Guidelines, Para. 95)

Although the nominated property is comprised of small islands, it includes areas that serve as habitat for 57 globally important endangered species on the IUCN Red List (2008), including the Bonin flying fox (CR), *Boninthemis insularis* (CR), and *Ogasawarana yoshiwarana* (CR). The islands are important breeding grounds for albatrosses, boobies, terns, and other seabirds. The nominated property includes habitats for endemic species that are very important for biodiversity, including most of the important areas containing sclerophyllous scrub with high degrees of endemism.

3.d.2 Appropriate scope and adequate size

The ‘Ogasawara Islands’ is the collective term for the Ogasawara Archipelago, Nishinoshima Island, the Kazan Island Group, Okino-torishima Island, and Minami-torishima Island. Administratively, they are part of Ogasawara Village of Tokyo Metropolitan Government (TMG). Because Minami-torishima is an uplifted coral reef and differs in the way it was formed from the rest, it has been removed from the nominated property. Some populated areas of Chichijima and Hahajima Islands, as well as Iwoto and Okino-torishima Islands, have also been removed from the nominated property on the grounds that they have been substantially altered by human activity.

As a result, the geographical scope of the nominated property covers areas in which - although they may have been subject to human influence for short periods of time in the past - the processes of nature are well-preserved. Essentially, the nominated site consists of those areas with little human influence that preserve the topography and oceanic island ecosystems unique to the Ogasawara Islands (Operational Guidelines, Para. 90).

3.d.3 Site free of any adverse effects of development and neglect

As described in “5.b.Protective Designation”, the nominated property is subject to the most stringent protection measures out of all the protected natural areas in Japan, and this guarantees long-term, appropriate protection. Specifically, Minami-iwoto Island is both a Wilderness Area (IUCN Protected Area category Ib) protected under the Nature Conservation Law, as well as a Preservation Zone (IUCN Protected Area category Ia) of the Forest Ecosystem Reserve protected under the National Forest Administration and Management Bylaw. Minami-iwoto is also designated as a Restricted Entry Zone by the Nature Conservation Law and is remaining unaffected by human influence, leaving its natural environment untouched.

The other components of the nominated property are designated as Preservation Zone of the Forest Ecosystem Reserve, or Special Protection Zone or Class I Special Zone of National Park (IUCN Protected Area category II) protected under the Natural Parks Law.

The surrounding areas of the nominated property include the areas with legal regulations such as Special Zones or Ordinary Zone of National Park as well as Preservation Zone or Conservation and Utilization Zone of Forest Ecosystem Reserve.

Since around the end of the 1990’s, in order to prevent any adverse effects of external influences on the nominated property, various protection measures have been undertaken. These have been applied both inside and outside the nominated area, and have included:

- control of invasive alien species by cooperation and coordination of all stakeholders including relevant authorities, scientists, NGOs, and citizens
- the implementation of ecotourism based on the voluntary rules
- awareness-raising campaigns held on the passenger ferry to the islands
- monitoring and implementation of species conservation program for endangered species

The "Ogasawara Islands Management Plan (2009)" links these numerous conservation management efforts in an attempt to comprehensively conserve ecosystems over a wide area, both inside and outside of the nominated property. The World Heritage Management Area, a target area of the management plan is shown in Fig. 1-6. The conservation measures are detailed in "4.b Factors Affecting the Property".

With these protective arrangements, the Ogasawara Islands are properly protected. One of the evidence of proper protection is low extinction rate of the land snails. The populations of land snails of many Pacific islands have been devastated by the impact of development and invasive alien species. In contrast, however, low extinction rate of the land snails of the Ogasawara Islands indicating that the islands' land snail habitats have been extremely well preserved.

3.d.4 Justification of a serial approach to achieve site integrity

For the following reasons, the serial nomination of the Ogasawara Islands is justified:

- The component parts demonstrate the complete series of evolutionary processes of an oceanic island arc. In addition, all the elements exhibit diverse ecological features within the same biogeographic zone. As the example of adaptive radiation between the island groups shows, a mere part of the nominated area would not be sufficient to represent the value of the whole.

- Among the component parts, there exist functional links due to the correlations among geological formation processes and the movement and spread of biota.

- The protection of the islands' natural heritage is the responsibility of multiple management organizations. But, just as with other natural World Heritage sites in Japan, the management organizations coordinate with each other under the Regional Liaison Committee and manage the area according to the prescriptions of a single management plan with the advice from the Scientific Council.

4. State of Conservation and factors affection the Property

4.a Present State of Conservation

4.a.1 Plants

4.a.2 Mammals

4.a.3 Birds

4.a.4 Insects

4.a.5 Land snails

4.b Factors Affecting the Property

4.b.1 Development pressures

4.b.2 Environmental Pressure

4.b.3 Natural Disasters and Precautions

4.b.4 Visitor/Tourism Pressures

4.b.5 Number of inhabitants within the property and the surrounding area.

4.a Present State of Conservation

As mentioned in "2.b History and Development", people started to live on the Ogasawara Islands in the late 19th century, and since then the vegetation of the islands have been altered by deforestation, controlled burning, and cultivation. In addition, the area suffered the effects of World War II, and the introduction of alien species such as goats (*Capra hircus*) for food and Bischofia (*Bischofia javanica*) for fuel (Toyoda, 2003); these actions resulted in the extinction of some native and endemic species, and the population reduction of many others.

However, the whole area of the nominated property is currently designated a protected area based on domestic legislation and bylaw. Some of the species in the area have been protected as Natural Monuments or National Endangered Species of Wild Fauna and Flora. For the latter, species conservation programs are underway based on the law (cf. 5.c Means of Implementing Protective Measures). Tremendous efforts are underway to control invasive alien species with the cooperation of relevant organizations, and nature restoration projects are being implemented to actively rehabilitate the area to something like its original natural state (cf. 4.b Factors Affecting the Property). The current state of conservation of major biological attributes of the nominated property is outlined in the following sections.

4.a.1 Plants

4.a.1.1 Sclerophyllous scrub

The sclerophyllous scrub covering the gentle slopes atop Chichijima island (locality: Mt. Chuosan -Higashidaira area and Yoakedaira area) and Anijima islnad (whole area) have so far not been largely disturbed by human activity. Current distribution area is around 477 ha on Anijima (about 60% of the island) and 481 ha on Chichijima. (about 20% of the island).

In Ogasawara Islands, 69 endemic species have been confirmed in sclerophyllous scrub. This translates into the high endemic ratio of 67% (80.6% for woody plants) (cf. 2.a.3. Plants).

Most of the sclerophyllous scrublands are legally protected, and current threats include drought, typhoon, and grazing impacts of feral goats. Measures being undertaken against these threats are outlined in "4.b Factors Affecting the Property".

4.a.1.2 Threatened Endemic Plant Species

Among the endemic plant species, a survey shows that while *Calanthe hattorii* grows well,

the number of wild individuals of *Melastoma tetramerum* and *Crepidiastrum grandicollum* has decreased and are critically endangered in some areas (Nature Conservation Bureau, Ministry of the Environment (MOE) and the Tokyo Metropolitan Government (TMG), 2006). For monitoring purposes, almost all wild individuals are counted in some scrub species and others (Table 4-1).

Table 4-1 Examples of endangered tree species (the individual numbers of which in the wild are almost known).

Species	Number of individual plants	Reference
Rhododendron boninense	1 on Chichijima	South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005
Pittosporum parvifolium	ca. 6 on Chichijima and a few on Anijima	South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005
Malaxis boninensis	ca.8 on Chichijima	Nature Conservation Bureau, MOE and TMG, 2005
Claoxylon centenarium	ca. 10 on Hahajima	Fujita, 2004
Stachyurus macrocarpus var. *prunifolius*	15 on Hahajima	Abe & Hoshi, 2008
Symplocos kawakamii	ca. 12 on Chichijima	Nature Conservation Bureau, MOE and TMG, 2005
Eurya japonica var. *boninensis*	ca. 28 on Chichijima and a few on Anijima	ex. Oi et al. 1999
Stachyurus macrocarpus	68 on Chichijima and a few on Anijima	Abe et al., 2008
Pittosporum chichijimense	ca. 195 on Chichijima	South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005
Symplocos pergracilis	ca. 328 on Chichijima and a few on Anijima	South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005
Metrosideros boninensis	353 on Chchijima and 2 on Anijima	Nobushima, 2000

Among these species, declines in numbers are reported for *Malaxis boninensis*, *Symplocos kawakamii*, *Stachyurus macrocarpus*, and *Eurya japonica* var. *boninensis* (South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005; Oi et al., 1999). Further, declines in the number of individuals in their major habitats are reported in *Symplocos pergracilis*, *Pittosporum chichijimense*, *Gardenia boninensis*, *Euodia nishimurae*, and others (Shimizu, 1999). Diminishing distribution and decline in the number

of individuals are also reported for *Callicarpa glabra* and *Callicarpa parvifolia* (Toyoda, 2003).

It is of real concern that almost no fruition or seedlings have been observed recently among many of the endangered plants and they cannot alter a generation. The causes of this serious situation are considered to be:

- the impacts of dryness,
- typhoons or other climatic factors,
- increased shading by alien trees,
- breeding incapability because of the small population size,
- illegal collection,
- impacts from alien animals including feral goats,
- decline in the number of pollinators, and others.

(ex. Fujita, 2004; South Kanto Regional Office for Nature Conservation, Nature Conservation Bureau, MOE, 2005; Shimizu, 1999)

Under the endangered species conservation program, the TMG, the Koishikawa Botanical Gardens of the University of Tokyo, and other organizations commissioned by the MOE conduct a wide variety of projects. These include a current status survey and study of their growth characteristics, re-introduction or transplantation of species to appropriate habitats, and the prevention of feeding damage by alien species such as feral goats and black rats. The Review Committee on the Conservation Program for the Endangered Plant Species of the Ogasawara Islands was established by the MOE to give advice and coordinate these projects.

The following examples illustrate the successful effect of these projects, to date:

- 324 *Melastoma tetramerum* survived out of 1,045 planted between 1984 and 2006,
- 65 *Rhododendron boninense* survived out of 500 planted between 1986 and 2006, and
- 92 *Calanthe hattorii* survived out of 227 planted between 1990 and 2002.

The Forestry Agency also studies the status of endangered plant species, and removes invasive alien plants which suppress endangered species, as well as undertakes patrols for the prevention of illegal collection of plants.

4.a.2 Mammals

4.a.2.1 Bonin flying fox

Research into the present status of the Bonin flying fox (*Pteropus pselaphon*) is conducted

by the Ogasawara Village and a local nonprofit organization (NPO). Habitats confirmed to date are on Chichijima, Hahajima , Kita-iwoto , Iwoto , and Minami-iwoto in the Ogasawara Islands. There have been sporadic reports of this species on islands surrounding known habitats, such as Anijima, but established habitats in such places have not been confirmed (Abe et al., 1994).

In terms of the Chichijima population, after nearly becoming extinct following the war, the number recovered to a certain extent in the 1990's and have continued to remain around 100 in recent years (see Table 4-2). On Hahajima, the population was relatively abundant in the postwar period but it decreased due to the reduction in nesting places caused by redevelopment after the retrocession of the islands to Japan. Currently, only a small number of individuals have been confirmed. Inaba (2001) reported 26 individuals on Kita-iwoto, and another study in 2008 also estimated the population size there as a few dozen (Institute of Boninology, 2009). The flying fox was not found on Iwoto. in 1966 (Hasuo, 1969), but several individuals were confirmed during a survey conducted in January 2008 (Ogasawara Islands Branch Office, TMG, 2008). On Minami-iwoto, a survey conducted in 1982 confirmed about 100 individuals (Ishii, 1982), and in the next survey conducted a quarter century later, in 2007, at least 100 individuals were also confirmed on the island (Suzuki et al., 2007).

On inhabited Chichijima, the area that flying foxes use frequently overlaps with human activity areas, such as agricultural land and settlements. The challenges for the conservation of this species include:

1) accumulation of ecological knowledge,
2) impacts from alien species,
3) agricultural damage caused by this species, and
4) anthropogenic disturbance such as development and eco-tourism (Inaba et al., 2002).

Given these challenges above, it is necessary to implement conservation measures which assume harmonious coexistence between humans and the flying fox in the same area.

Current conservation measures include the monitoring of populations, measures against feral cats which are the main predation pressure on this species, and measures to minimize agricultural damage by this species. Instructions on the selection and the setting methods of bat-proof nets are given to farmers, so that both the prevention of agricultural damage and the protection of this species can be achieved.

In addition, this species is protected as a natural monument designated in 1969 under the Law for the Protection of Cultural Properties. In 2009, areas of species' collective nesting

have been designated as Special Protection Zone and as Designated Special Protection Zone, based on Wildlife Protection and Appropriate Hunting Law. Certain development acts are restricted in Special Protection Zone, and acts like mere observation of fauna and flora by photographing are restricted in Designated Special Protection Zone. Additionally in the same year, the species has been designated as a National Endangered Species of Wild Fauna and Flora based on Law for the Conservation of Endangered Species of Wild Fauna and Flora, by which protection efforts for this species shall be undertaken. Discussion toward formulation of this species' Rehabilitation of Natural Habitats and Maintenance of Viable Population is currently underway.

Table 4-2 Changes in the populations of the Bonin flying fox on Chichijima and Hahajima
(Compiled based on Abe et al. [1995] with additional data after 1998)

Year	Chichijima	Hahajima	Reference
1968	Very few	Several hundreds	Nakane et al., 1970
1970		Less than 50	Hasuo, 1969
1972-73	Extinct?	Hardly seen	Sato, 1991
1975	Extinct?		Chiba, 1977
1979	Extinct?	6-7	Matsumoto, 1980
1980	2 (est. 7-9)		Kaneko, 1986
1991	1-9		Sato, 1991
1992	22		Miyakawa, 1992
1993	30-40, 51 confirmed		Miyakawa, per.com.
1995	62	A few observed	Miyakawa, per.com. Takano, per.com.
1998	130-150	Less than 10	Inaba, 1999
1999	120-140		Inst. Boninology, 2003
2000	120-130		Inst. Boninology, 2003
2001	ca. 120		Inst. Boninology, 2003
2002	65-80		Inaba et al., 2002
2003	90-100		Inst. Boninology, 2003
2004	101-125		Inst. Boninology, 2004
2008	est. 100-160		Inst. Boninology, 2008

4.a.3 Birds

4.a.3.1 Endemic subspecies of Japanese wood-pigeon

Columba janthina nitens is a subspecies of the Japanese wood-pigeon endemic to the Ogasawara Islands. They have been found on islands of Mukojima, Ototojima , Anijima, Chichijima, Hahajima , Mukohjima , Anejima and Imotojima of the Ogasawara Archipelago and Kita-iwoto, Iwoto and Minami-iwoto of the Kazan Island Group (Kanto Regional Forest Office, Forest Agency, 2006; 2007; 2009). Their total population is estimated to be less than 40 (Kanto Regional Forest Office, Forest Agency, 2006).

In the Mt. Chuosan-Higashidaira area on Chichijima, one of the breeding grounds of the bird, the Forestry Agency has established a wood-pigeon sanctuary. Together with Ogasawara Nature Observation Instructor Association and other interested bodies, the Forestry Agency implements measures to conserve and maintain the suitable forest habitat of this subspecies, and to formulate rules and regulations for people entering there. In addition, the MOE is constructing feral-cat-proof fences surrounding the area including the sanctuary. The MOE, the Forestry Agency, and the Institute of Boninology jointly conduct research on the subspecies' food resources and monitoring its status, and banding individuals (Kanto Regional Forest Office, Forest Agency, 2006; 2007; 2009). This Mt. Chuosan-Higashidaira area is one of two focal areas of anti-feral cat operation.

As a part of the protection measures for this subspecies, the TMG started an artificial breeding program in fiscal 2001 at the Ueno Zoological Gardens and other facilities under its jurisdiction. At present, there are 23 birds in captivity including one founder initially captured, but the program has not yet reached a stage whereby it can implement the reintroduction of individual captive-bred birds to the wild or reinforcement of existing wild populations.

4.a.3.2 Albatrosses

The short-tailed albatross (*Diomedea albatrus*) used to breed on the Mukojima Island Group, the Hahajima Island Group, and on Nishinoshima (Ogasawara Islands Branch Office, TMG, 2001), but overexploitation in the 1930's eliminated these islands as breeding grounds. The black-footed albatross (*Diomedea nigripes*) used to breed in the whole Ogasawara Islands (Ogasawara Islands Branch Office, TMG, 2001; Chiba et al., 2007), but their breeding grounds were also reduced, and in 2001, 397 pairs were observed breeding only on the Mukojima Island Group (Ogasawara Islands Branch Office, TMG, 2001).

The current threats to albatrosses are the modified habitat environment and predation by alien species. Since 1978, the TMG has been continually monitoring the breeding status of

albatrosses (population size, the number of chicks, distribution, etc.) and their situation is improving.

In 2004, the black-footed albatross was confirmed to be again breeding on the Hahajima Island Group (Institute of Boninology, 2004); this breeding population shows a tendency to increase in number. The recent estimate of the number of breeding pairs in the nominated property is around 730 (Eda et al. 2008). The Laysan albatross (*Diomedea immutabilis*) was confirmed to breed on Torishima Island of the Mukojima Island Group in the 1970's, and then on Mukojima Today, this species continuously breeds on these two islands (Ogasawara Islands Branch Office, TMG, 2001; 2002; 2003; Institute of Boninology, 2004; 2005). The short-tailed albatross is regularly observed flying over Yomejima Island (in Mukojima Island Group) since 2000 (Ogasawara Islands Branch Office, TMG, 2008). In addition, Mukojima is expected to return as breeding ground in the future, given the fact that three semi-adult individuals of short-tailed albatross reached the island and their courtship behaviors were observed (Deguchi et al., 2009).

In cooperation with the US Fish and Wildlife Service, the MOE and the Yamashina Institute for Ornithology started a new program in 2005 to create the third breeding ground for the short-tailed albatross in the Mukojima Island Group after Izu Islands and the Senkaku Islands. The main techniques employed in this program are: translocation of chicks, the artificial rearing of those chicks, and attracting birds using physical decoys and audio mimicking devices (Deguchi et al., 2008). The artificial rearing of chicks translocated from Torishima Island of the Izu Islands to Mukojima in 2008, was successfully carried out and all ten birds fledged . Five of those birds have been fitted with transmitters and their movements are being tracked (Ozaki et al., 2008). The same efforts were continued in 2009 and 15 birds successfully fledged (Website of Yamashina Institute for Ornithology, 2009).

4.a.4 Insects

4.a.4.1 Endemic dragonflies

Five endemic species of dragonflies live in the Ogasawara Islands. They are: *Boninagrion ezoin*, *Indolestes boninensis*, *Rhinocypha ogasawarensis*, *Hemicordulia ogasawarensis*, and *Boninthemis insularis*. On Chichijima, all of these five species were found until the 1970's, but their populations decreased dramatically since the middle 1980's, and all of them are now extinct or on the edge of extinction. On Hahajima where four of these five endemic species were previously found, all but one species are extinct or nearly extinct (Karube, 2001; 2004; Yoshimura et al., 2005). The major threats to these dragonflies are the predation by the alien green anole (*Anolis carolinensis*), and drought.

Ototojima is important as the only island where all five endemic species of dragonfly are currently distributed. The MOE, the Kanagawa Prefectural Museum of Natural History, and other interested bodies are setting up artificial ponds called “dragonfly pond” on Ototojima and Anijima, so that dragonflies can breed even in the period of drought.. In those ponds, *Indolestes boninensis* and *Hemicordulia ogasawarensis* mainly breed.on Ototojim, while *Hemicordulia ogasawarensis* breeds mainly on Anijima. *Indolestes boninensis* is currently distributed only on Ototojima, and was threatened with extinction, but now it breeds steadily thanks to these dragonfly ponds. *Hemicordulia ogasawarensis*, which has a relatively high flight capacity, reappears even on Chichijima for the first time since its last confirmation in1996. Given these developments, it is expected that *Hemicordulia ogasawarensis* will recover its population which in turn will lead to the restoration of its distribution throughout Chichijima.

4.a.4.2 Endemic butterfly

Lycaenid butterfly (*Celastrina ogasawaraensis*), is endemic to the Ogasawara Islands, and was once commonly observed on both Chichijima and Hahajima. However, due to predation by the green anole, its distribution is limited to some areas in Hahajima.

Therefore, the MOE has cleared alien tress to protect the food trees of the butterfly and, in fiscal 2007 the MOE installed fences to prevent the penetration of green anoles at the butterfly’s current habitat area , where the eradication of green anoles, experimental plantation of the food trees of the butterfly are ongoing. All of these come as a part of the MOE’s efforts to conserve entomofauna there.

In fiscal 2005, relevant administrative bodies, researchers, and local NPOs jointly formed the Lycaenid Butterfly Conservation Committee to cooperate and coordinate their projects. On Hahajima, residents created the lycaenid butterfly Society and help the conservation efforts in the butterfly’s habitat. In addition, an *ex-situ* breeding program is being conducted at the Tama Zoological Park.

4.a.5 Land snails

Land snails are distributed throughout almost all of the islands in the nominated property. However, some of the populations are on the decline because of the impact of alien species, such as the predatory flatworm (*Platydemus manokwari*) and black rat (*Rattus rattus*).

On Anijima, many shells of land snails indicating the predation by black rats can be found. There are some places on the island where *Mandarina anijimana* is severely impacted by predation (Fig. 4-1). In areas where frequent predation is confirmed, the predation itself

exerts selection pressure, causing shell morphology change (Chiba, 2007). Habitat areas of land snails on Chichijima have shrunk dramatically in the past 20 years due to the predatory flatworm (Fig. 4-2; Ohbayashi et al., 2007).

Steps against these alien species are undertaken. More information is becoming available on the flatworm species that feed on snails on each island. Measures, such as washing shoe soles with salt water at inter-island travel, are taken in order to prevent alien flatworm from spreading to other islands along with human activities (see 4.b.2). Extirpation projects of black rats are being undertaken in Nishijima Island, Higashijima Island, and Mukojima using toxic bait.

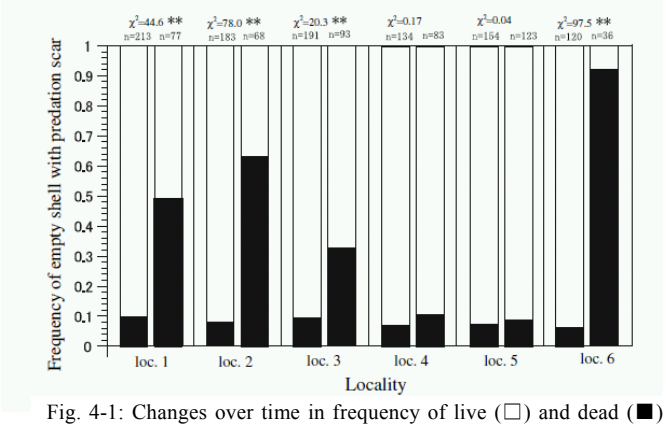


Fig. 4-1: Changes over time in frequency of live (□) and dead (■) *Mandarina anijimana* at six sites on Anijima Is. Left: 1987-1989; right: 2006 (adapted from Chiba, 2007)

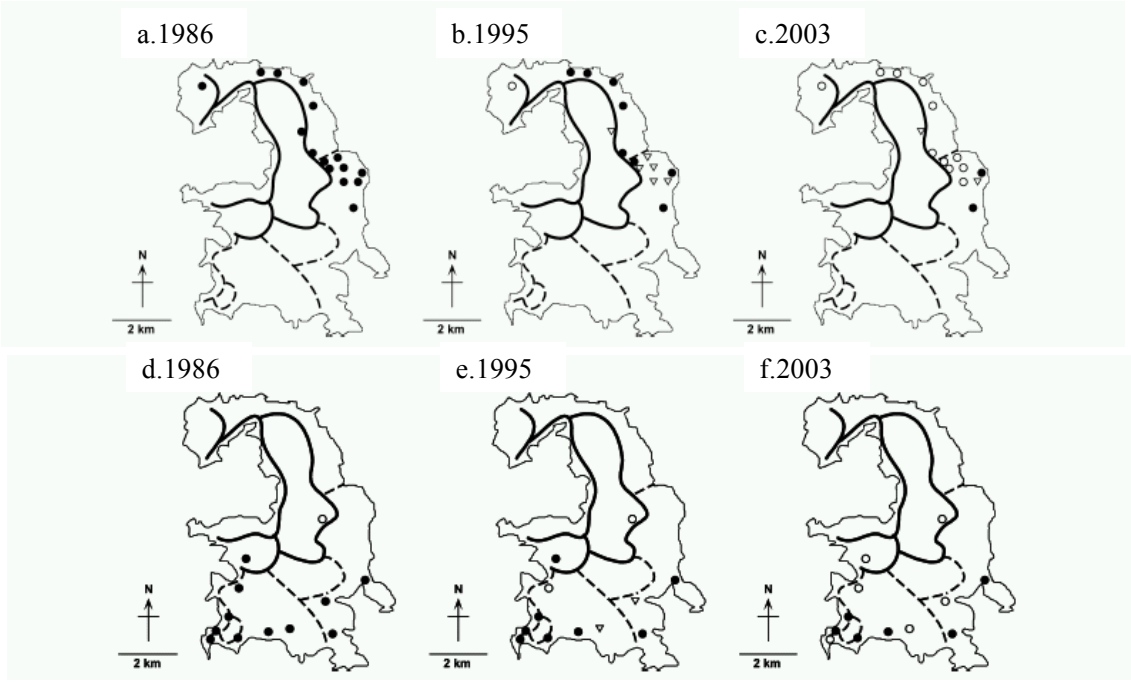


Fig. 4-2: Temporal transition in the distribution of two species of *Mandarina* on Chichijima Is
a-c: *Mandarina mandarina*; d-f: *Mandarina chichijimana*. ●: Live snails present; ○: No live snails present; ▽: Not surveyed (adapted from Ohbayashi et al., 2007)

4.b Factors Affecting the Property

4.b.1 Development pressures

All the nominated property is properly protected as designated protected areas, and there are stringent restrictions placed on development activities. Details of the legal regulations are described in "5. Protection and Management of the Property." An overview of the major development activities in the surrounding areas of the nominated property is presented below.

4.b.1.1 Establishment of air route under consideration

At present, the only way to get to and from the Ogasawara Islands is by ship of every six days. In December, 2007, Ogasawara Village conducted a questionnaire survey to ask the residents about the necessity of air route. As a result, about 70% of the respondents either replied that an air route "is necessary" or "is necessary but needs to satisfy certain requirements". Based on this result, Ogasawara Village requested the TMG to establish an Air Route Committee.

The TMG, together with Ogasawara Village, set up the Ogasawara Air Route Committee in

February 2008 to assess the feasibility of setting up an air route with giving full consideration to harmony with the natural environment. The Committee formulated an Action Plan of Public Involvement (PI) in the Ogasawara Air Route Project, to provide an opportunity for the local residents and others to express their opinions. The intent is to incorporate the expressed opinion into the project plan from the very conceptual and planning stages of the air route. The committee is to study several options in the surrounding areas of the nominated property, including a proposal to utilize the Susaki area as a candidate air route, as well as potential options provided by the development of new technology.

4.b.1.2 Road construction

The more-inhabited island of Chichijima has one prefectural road (about 21.9 km in length) and 39 municipal roads (about 11.1 km in total), while Hahajima has one prefectural road (about 13.5 km in length) and 16 municipal roads (about 3.5 km in total). The roads are nearly all paved (Ogasawara Village, 2006).

In general, road construction and maintenance involves a certain amount of environmental impact risk in the form of water contamination or the introduction of alien plant species sprayed for erosion control of road cuttings. To minimize the impacts of construction projects on the natural environment or landscapes, in August 2004 the TMG formulated the "Guidelines for Environment-conscious Public Works in the Ogasawara Islands". The guidelines lay out how to implement environment-friendly methods at the planning, design, construction, and maintenance phases in TMG ordered construction works.

4.b.1.3 River works

In Ogasawara Village, there are several river works such as enforcement of river banks and erosion control work to prevent disasters caused by overflow, mudflow or collapse of bank due to typhoon or localized torrential rain. For example, at the Yatsuse River, a relatively large-scale river in Chichijima, the river bank was reinforced in 1998 so as to prevent the damage caused by the rain-swollen river flooding over agricultural land, followed by management road construction between 1991 and 1999. Other than this, five rivers (the Omura, Okumura and Fukiage Rivers on Chichijima, and the Otani and Teppozawa Rivers on Hahajima) were designated as erosion control areas and erosion control works were subsequently carried out (Ogasawara Islands Branch Office, TMG, 2008).

In general, the disruption of riverine habitat by river improvement work and artificial construction has the potential to cause qualitative change in river water and river bed that is detrimental to native species. The TMG is trying to minimize such impacts of river works on the natural environment or landscapes with the "Guidelines for Environment-conscious

Public Works in the Ogasawara Islands" in a similar way to the road construction mentioned above.

4.b.2 Environmental Pressure

Oceanic islands generally have ecosystems consisting of unique flora and fauna, which are extremely vulnerable to alien species. In Ogasawara Islands, it is said that over 300 alien species of vascular plants have already invaded. A comparison of the composition ratios of alien plant species to the whole for each island shows that ratios for the inhabited Chichijima (43%) and Hahajima (38%) are higher, while the ratios for uninhabited islands such as Anijima (20%) and Mukohjima (19%) are lower, with the ratio for Minami-iwoto (12%) being the lowest (Nature Conservation Bureau, MOE, 2004). The major alien animal species confirmed in the Ogasawara Islands comprise six mammals, one bird, one reptile, two amphibians, four fish, four insects, three land snails, and one flatworm (MOE, 2007a).

The impacts of these alien species on biodiversity are varied in nature and extent. For example, Bischofia takes up habitats of native plant species, *Morus australis* causes disturbance at the genetic level, and feral goats and green anoles inflict feeding damage on native plants and animals.

There have been many efforts made to eliminate or control alien species problems, by the national government as well as local governments, researchers and their institutions, local NPOs, and other organizations. However, given the urgent need for measures against the serious impacts from alien species on the unique and vulnerable ecosystems of Ogasawara Islands, it was essential that effective and efficient measures be achieved through collaboration among related institutions and concerned parties.

To facilitate such collaboration, the "Basic Plan for the Conservation and Restoration of the Natural Environment of Ogasawara" (MOE, 2007) was formulated compiling fundamental concepts for the conservation and restoration of the natural environment as well as the technical methods and policies in specific efforts such as measures against alien species. In addition, the "Conservation and Management Plan for the Ogasawara Islands Forest Ecosystem Reserve" (Forestry Agency, 2008) was formulated to provide comprehensive guidance for planned measures against alien species in the Ogasawara Islands Forest Ecosystem Reserve. Based on these two plans, in 2009, the Ogasawara Islands Management Plan (MOE, Forestry Agency, Cultural Agency, TMG, and Ogasawara Village) was formulated under an agreement of the related parties at Ogasawara Regional Liaison Committee, having advice from the Scientific Council for the Ogasawara Islands World Heritage Nominated Property (established in November 2006). The management plan

describes the general policy and the way to coordinate the related organizations..

Currently, based on these plans, relevant organizations cooperate in instituting conservation measures, which have already brought successful results including the complete eradication of feral goats on all islands except Chichijima and Ototojima.

The following sections address the current state of and measures against respective alien species that have the serious impacts on Ogasawara's endemic species or unique ecosystems. Details of control strategies and measures against alien species for each island are described in the "Ogasawara Islands Management Plan" and "Ogasawara Islands Ecosystem Conservation Action Plan" (see Appendix 1).

4.b.2.1 Invasion of alien animal species

< Feral goats >

It is said that goats (*Capra hircus*) were first introduced to the Ogasawara Islands for food in 1830 by immigrants from Hawaii. There is another theory that goats were introduced by the crews of whaling ships, which had visited the islands beforehand. In 1946, during the era of American occupation following World War II, the residents of Western descent were allowed to come back to the islands, and at that time, goats for food were brought from Mukojima and Yomejima and once again released on Chichijima and other islands. In addition, Saanen goats were brought in from the main land Japan and some goats were transferred from the larger islands to the satellite islands in Ogasawara.

The goats released onto the islands became feral, foraged on native plants, and spread alien seeds which had attached to their coats. In the Mukojima Island Group, their trampling resulted in the widespread destruction of vegetation, exposing the bare land, and soil erosion. On Nakodojima Island, an island in the Mukojima Island Group where their impact was particularly extreme, soil erosion progressed to such a degree that caused large amounts of sediment runoff into the ocean. This not only had a detrimental effect on the land but also a major impact on the surrounding marine ecosystems, including coral reefs.

In 1970, the Ogasawara Islands Branch Office, TMG, initiated eradication of feral goats from Minamijima Island, which was selected first as it was the most damaged island in the Chichijima Island Group. The operation was completed the following year (1970: 18 captured; 1971: two captured). In 1997, the office began removing feral goats from the Mukojima Island Group, and in fiscal 2003 eradication was completed. In the Chichijima Island Group, there were feral goats on Chichijima, Anijima, Ototojima, and Nishijima, where efforts were likewise made to remove them. They have been completely eradicated

from Nishijima, and almost eradicated from Anijima (Table 4-3). On Chichijima, endemic and threatened plants are protected from feral goats by fencing at the same time as a survey is conducted and the feral goats are captured.

Table 4-3: Number of feral goats captured per island

Island \ FY	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nakodojima[1]	136	137	144								EC		
Yomejima[2]				79	2						EC		
Mukojima[1]				656	265	17	2				EC		
Nishijima[1]						39	2				EC		
Anijima[1]								78	161	87	61		EC
Ototojima												197[3]	92[4]

EC: Eradication confirmed; S: Conducting survey for confirming eradication

1: Operation done by TMG
2: Operation done by Institute of Boninology
3: Operation done by MOE (72 goats) and TMG (125 goats)
4: Operation done by MOE (9 goats) and TMG (83 goats) as of Oct. 2009

Gradual vegetation recovery can be observed on the islands where feral goats have been eradicated, as herbaceous plants have begun to grow again, and young woody plants of species such as *Terminalia catappa*, *Pandanus boninensis*, and *Rhaphiolepis indica var. umbellata* have begun to appear. On Minamijima where the eradication of feral goats was completed in 1971, a monitoring survey in 1993 confirms that the endemic *Ixeris longirostrata* and *Cirsium boninense* have expanded their distribution, and widely-distributed species such as *Limonium wrightii* and *Lycium sandwicense* also grow on the island (Toyoda, 2003). On the Mukojima Island Group, some endangered plant populations, including *Ficus nishimurae*, *Hedyotis grayi*, and *Cirsium boninense,* are recovering (Ogasawara Islands Branch Office, TMG, in press).

Nature restoration efforts have been undertaken in severely-eroded Nakodojima. For example, after the eradication of feral goats in 1999, local native plants have been planted to prevent soil erosion and stabilize the land. The progress of vegetation recovery is monitored regularly. The vegetation is now recovering and the number of breeding pairs of brown booby (*Sula leucogaster*, which breed on the ground) and of wedge-tailed shearwater (*Puffinus pacificus,* which breed in the burrow) are on the increase.

< Feral cats >

Cats (*Felis catus*) accompanied the first settlers to the islands, either as pets or to control

damage to crops by rats, but eventually many became feral. They live mainly on the inhabited islands of Chichijima and Hahajima Their existence has also been reported on the uninhabited islands of Anijima, Ototojima, and Mukohjima. (Kawakami, 2002), however, a survey conducted in 2008 found no cats on Anijima. (Japan Wild Life Research Center (JWRC), 2008a).

Feral cats are known predators of the threatened *Columba janthina nitens*, the endemic Bonin honeyeater, various seabirds, and the endemic Bonin flying fox. Consequently, measures against feral cats have been undertaken.

Since 1999, registration and proper husbandry of household cats are required by the Ogasawara Village Ordinance for Proper Husbandry of Household Cats, the first regulation of its kind in Japan. Based on the Ordinance, awareness-raising activities to promote the controlled husbandry of cats have been successfully implemented. To distinguish feral cats from household cats, implantation of microchips has been encouraged. With these provisions in place, the capture of feral cats became possible. The captured cats are not killed and given for adoption on the island, or shipped off the islands for taming and adoption with the assistance of the Tokyo Veterinary Medical Association.

Currently, the relevant organizations work together in capturing feral cats and promoting proper management of household cats. There are two focal areas of the capturing operation – Minamizaki area on Hahajima and Mt. Chuosan-Higashidaira area on Chichijima -- both inside the nominated property.

The Minamizaki area is a known breeding ground for seabirds including the brown booby and wedge-tailed shearwater. From the result of interview surveys conducted by the Institute of Boninology in 2005, it was found that feral cats had been preying upon wedge-tailed shearwaters in the area for several decades, and in 2004 no wedge-tailed shearwaters were observed breeding in the area. So in 2005 a seabird survey was conducted only to confirm the predation of parent birds by feral cats, which resulted in devastation of the seabirds' breeding area (Horikoshi et al., 2006).

To rectify the issue at Minamizaki, the MOE, the Forestry Agency, the TMG, the Ogasawara Village, the Ogasawara Village Board of Education, and the Institute of Boninology held deliberations and formed the Ogasawara Cat Liaison Committee in 2005. Subsequently, four feral cats were captured as an emergency countermeasure in 2005 through the cooperation of the Institute of Boninology and local volunteers. In 2006, a fence was set up around the seabirds' breeding grounds to keep out cats, and two feral cats were captured inside and outside of the fence the same year. In fiscal 2007, six were captured. As a result, for the first time in several years, successful nesting and fledging of wedge-tailed shearwaters and

nesting of brown boobies were confirmed, indicating progress towards the recovery of reproduction. In 2008, the MOE took over the project, replacing the fences with one capable of excluding both feral cats and green anoles. The MOE is continuing to monitor the feral cats both inside and outside the fences (Nakayama, 2009; Horikoshi et al., 2006; Horikoshi et al., 2009).

At Mt. Chuosan-Higashidaira area, a feral cat removal project has been carried out since 2005 to protect the breeding ground of endemic and endangered *Columba janthina nitens*. In this project, the public administrations, NPOs, and local resident volunteers worked together based on the discussions at the Ogasawara Cat Liaison Committee., As a result, 14 feral cats were captured in fiscal 2006 as well as 13 feral cats in fiscal 2008.

For the uninhabited islands, the MOE has been conducting the status survey on feral cats on Anijima and Ototojima Islands, and captured two feral cats on Ototojima (JWRC, 2009). It is planned to continue the survey and to conduct capturing operation aiming the eradication of feral cats.

< Black rats >

Black rats (*Ratus ratus*) probably reached the islands in the cargo from ships. They have been reported on almost all islands in the nominated property except islands of Minami-iwoto, Nishinoshima and Kitanoshima. The rats feed on the seeds and fruit of endemic plants such as *Elaeocarpus photiniaefolius* and *Pandanus boninensis*, having an adverse effect on the native vegetation (Hashimoto, 2009). Black rats also significantly affect the fauna of the nominated property in a variety of ways: they compete for food with endemic species including the subspecies of Japanese wood-pigeon, and prey on land snails, bird's eggs, and small birds. On the other hand, the black rat is a food source for feral cats and an endemic subspecies of common buzzard (*Buteo buteo toyoshimai*). .

On Nishijima in fiscal 2007, the Forestry and Forest Products Research Institute, and the JWRC carried out a black rat extermination project using toxic baits. Since then the island has been regularly monitored for vegetation recovery and for the existence of black rats (Makino, 2009; Hashimoto, 2009). In fiscal 2008, the MOE began two black rat extermination projects: one on Mukojima, where damages to endemic plants were concerned, and the other on Higashijima, where they have seriously damaged the seabird populations (Hashimoto, 2009). In important areas of the inhabited islands of Chichijima and Hahajima, tests are being carried out to verify the effectiveness of fences to keep out black rats.

< Feral pigs >

The ancestors of the feral pigs (*Sus scrofa*) present today were a group of 10 pigs brought

for food from Saipan to Chichijima in 1948. Descendents of that group were taken to Ototojima, which is the only place they subsequently inhabited.

Because feral pigs are omnivores, they feed on endemic land snails, insects, and green turtle eggs, and they also destroy vegetation on the forest floors by digging-up. As a result, feral pigs greatly disturbed the natural habitats of native animals and plants.

Given the possibility that feral pigs also feed on bullfrogs, another alien species on the island, the MOE put priority on the eradication of the latter. After the bullfrog population was reduced, traps and hunting rifles were used from 2005 to 2007 to get rid of feral pigs (Kanto Regional Environment Office of Japan, MOE, 2007). As of 2008, no traces of feral pigs have been detected, thus they are considered to be almost eradicated.

< Green anoles >

Green anoles (*Anolis carolinensis*) are alien reptiles originating from North America. It is thought that they were either transported to Ogasawara together with American military shipments or imported as pets. They were introduced onto Chichijima in the 1960's, and carried from Chichijima to Hahajima in the 1980's (Hasegawa et al., 1988; Suzuki, 2000). In the nominated property, they are distributed only in Chichijima and Hahajima, but have a broad distribution range within those islands.

They prey on insects, which include such threatened endemic species as a butterfly (*Celastrina ogasawaraensis*), dragonflies, a cicada (*Meimuna boninensis*), and threatened long-horned beetles. In addition, as they prey on endemic bees, they are affecting the pollination and fruition of plants. Furthermore, they compete with the endemic Ogasawara snake-eyed skink (*Cryptoblepharus nigropunctatus*), thus threatening its survival.

From 2002 to 2005, the MOE conducted a survey on the status of green anoles and field tests to establish methods for control, which showed that sticky traps were the most effective in capturing green anoles. After that, an improved trap was designed and developed to avoid bycatch of threatened birds and animals. Since the winter of 2006, measures to prevent green anoles spreading to uninhabited islands (where they do not exist) have been undertaken. Sticky traps have been placed at the port area of Chichijima, which is the "gateway" to the Ogasawara Islands. This operation is conducted with the cooperation of Ogasawara Village residents, both paid and volunteer. As a result, in the autumn of 2007, it was confirmed that the density of green anoles in the priority capture areas had fallen to 35% of that in the autumn of 2006.

Furthermore, in 2007 the MOE developed fences that are difficult for anoles to climb up. From 2008, they installed these anole-proof fences at the Shin-Yuhigaoka and Minamizaki

areas on Hahajima Is., where threatened insects such as lycaenid butterfly are distributed, and removed anoles from inside the fences.

< Bullfrogs >

Bullfrogs (*Rana catesbeiana*) were introduced into Japan in 1918, and although it is unclear precisely how, they were brought to the Ogasawara Islands sometime after that (JWRC, 2008b). Because the Ogasawara Islands have few large ponds, the confirmed bullfrog distribution is limited to the northern part of Ototojima Bullfrogs feed on aquatic insects such as endemic dragonflies as well as crustaceans such as land hermit crabs and land snails.

In 2004, the MOE began a population survey and extermination programs; basket traps and sound recording devices were used for the population survey since 2005. As of the end of 2008 from the summer of 2007, there have neither been frogs caught nor traces detected, suggesting that they have been eradicated.

< Cane toads >

The current population of cane toads (*Bufo marinus*) can be traced back to around 10 toads imported from Saipan in 1949 for control of large centipedes (*Scolopendra* sp.) and scorpions. They were released on Chichijima, where they thrived in the wild. In 1974 some were taken from Chichijima to Hahajima to control centipedes and cockroaches there (Matsumoto et al., 1984; Miyashita, 1984). They have a large impact on small animals that crawl on the ground, especially insects and isopods.

Cane toads are currently distributed on Chichijima and Hahajima, and are now subject to eradication programs together with green anoles.

< Predatory flatworm >

The predatory flatworm (*Platydemus manokwari*) is a species of terrestrial planarian that was introduced to control the alien giant African snail (*Achatina fulica*) which ruins crops. The flatworm has only been reported on Chichijima, where it has had serious consequences for the land snails throughout the island, devastating their populations and even driving some to extinction.

The flatworm has not invaded the southern part of Chichijima yet, where some endemic land snails live. The flatworm is found in Yoakeyama and Ishinoura areas which are important as land snail habitat. To protect endemic land snail species, a number of control measures against the flatworm are being studied and under trial (the MOE, 2008), including:

- Creation of bare ground or installation of electric fences as effective barriers against their intrusion,

- installation of goat-proof fences to prevent goats carrying flatworms from entering into non-infested areas,
- establishment of 'controlled utilization areas' or 'entry restricted areas' to prevent inadvertent introduction by people, and
- publicity and awareness-raising to prevent the introduction of flatworms along with human movements.

Currently, the MOE, the TMG, the Ogasawara Village, and the Hahajima Tourism Association are jointly taking measures to prevent the spread of flatworms to Hahajima and other islands in its group. These measures include the placement of brush mats to remove any mud or dirt which may contain flatworms from shoe soles in the passenger waiting room at dock and on the deck of the *Hahajima Maru* (the ferry to Hahajima), and awareness raising through posters and information brochures.

4.b.2.2 Invasive alien plant species

< Bischofia >

Bischofia (*Bischofia javanica*) was imported before 1905 for use as fuel wood for sugar production from sugarcane, which was successfully cultivated on Hahajima in 1889 (Toyoda & Kawaoka, 2005; Tanaka et al., 2009). Of all the alien plant species in the nominated property, this evergreen tree is especially invasive; it grows quickly, reaches heights of over 20 meters, and inhibits the growth of native plants once it dominates in the forest. Consequently, this tree has a major adverse impact on the forest ecosystems (Tanaka et al., 2009).

Bischofia is distributed on islands of Chichijima, Hahajima, Ototojima, and Hirashima. (Tanaka et al., 2009). In fiscal 2002, the Forestry Agency started clearing Bischofia in the national forest on Hahajima. The agency also has been conducting clearing operation in Sekimon and other areas in Hahajima since 2008, based on the Bischofia Control Plan formulated by the review committee of academic experts in fiscal 2007. At the wood-pigeon (*Columba janthina nitens*) sanctuary in Mt. Chuosan-Higashidaira area on Chichijima, clearing of Bischofia is underway based on an agreement on the management of the forest between the Forestry Agency and the Ogasawara Nature Observation Instructor Association. The clearing of Bischofia in this area is expected to be completed by the end of fiscal 2009 and the remaining seedlings will be removed after that.

In 2005, the MOE started clearing Bischofia inside the national park on Ototojima, Hirashima, and Hahajima. On Ototojima, there were 550 Bischofia trees taller than 0.5m but now, it is almost eradicated using herbicides. Eradication was also achieved on Hirashima in

2008. On Hahajima, which is larger, eradication efforts have been prioritized, beginning with areas where efforts are most effective, such as ecologically important areas and sites where invasion is still in its early stages. In fiscal 2006, herbicide injection was employed to clear Bischofia from the Higashidai area and the southern tip of Minamizaki area on Hahajima, and in some areas mature trees have successfully been eradicated. Using an amino acid herbicide whose safety has been established, eradication and monitoring are ongoing (South Kanto Sub-region Nature Conservation Office, Nature Conservation Bureau, MOE, 2005; Tanaka et al., 2009).

< Casuarina >

Casuarina (*Casuarina equisetifolia*) is an evergreen tree that is suited to dry conditions and can grow even in poor soils. They grow quickly and their litter covers the ground, inhibiting the germination and growth of other plants thus adversely affecting the forest ecosystem. In the nominated property, Casuarina has a wide distribution throughout the Chichijima Island Group and Hahajima Island Groups.; its distribution is expanding especially on Anijima and Ototojima.

In order to address the problems caused by Casuarina, since fiscal 2006 the MOE has been conducting its experimental eradication, together with *Pinus luchuensis*, another alien species, on the gentle slopes in the inland areas of Anijima. At the same time, the Forestry Agency conducted surveys of the distribution and standing stock of Casuarina and other species in national forests on the Ogasawara Islands. The agency began eradication programs on Hahajima in fiscal 2007 and Anijima and other islands in fiscal 2009. The Ogasawara Wildlife Research Society (NPO) is likewise working to eradicate the species on Chichijima.

< Leucaena >

Leucaena (*Leucaena leucocephala*) is widely-distributed in the Ogasawara Archipelago. It was introduced in the 19th century as a shade tree for coffee and other crops, and after World War II it expanded in distribution, particularly in abandoned fields. Once Leucaena forest has established, plagioseresuccession will be observed for the long-term (Yoshida and Oka, 2000), thereby affecting the restoration of native forest ecosystems.

After the mass death of Leucaena on Chichijima triggered by the emergence and infestation of a psyllid *Heteropsyra cubana* in 1980's, the plant has been on an overall decline (Yamamura et al., 1999). However, the distribution of Leucaena on Mukojima and Nakodojima expanded after the eradication of feral goats. In 2008, the TMG started an eradication operation targeted at Leucaena as well as alien bamboo and dwarf bamboo species on Mukojima and Nakodojima.

4.b.2.3 Genetic disturbance

There is always a possibility of causing genetic disturbance by introducing a closely related species from outside or by translocating an endemic species within the Ogasawara Islands. Such an example of genetic disturbance of an endemic species caused by the introduction of the closely related species in the Ogasawara Islands is intercross of the mulberry *Morus boninensis* with *Morus australis*. The number of *Morus boninensis* was reduced by overexploitation before World War II, and currently only 19 individuals remain on Chichijima, 110 on Hahajima (including planted individuals), and 35 on Ototojima. There has been no regeneration for some time and mature trees are suffocated by the shade of Bischofia and by other factors. The tree is therefore listed as critically endangered (CR) on the Red List of the MOE. Furthermore, intercross with *Morus australis*, which was introduced before the war for the purpose of silk cultivation, is progressing and maintenance of a genuine population is of grave concern.

For the purpose of *Morus boninensis* conservation, a study was conducted to understand the current extent of genetic disturbance and a genetic marker was developed to identify the genuine tree from the intercrossed. A research on propagation techniques is also ongoing.

4.b.3 Natural Disasters and Precautions

4.b.3.1 Landslides

Landslides caused by earthquakes or heavy rain pose adverse effects on marine life and its habitat due to the flows of mud and rock debris into coastal waters. The effects of landslides are particularly evident on the eastern coast of Hahajima. In 1997, a typhoon brought massive rainfall to the area caused large-scale collapse of landforms, including parts of the limestone terrace (Oka, 2004), which drastically changed the topography there. Bare hillsides still remain exposed.

4.b.3.2 *Tsunami*

Tsunami records for Chichijima list the Ogasawara Earthquake Tsunami of 1826, the Showa Tonankai Earthquake Tsunami of 1944, and the Chile Earthquake Tsunami of 1960. The latter two earthquakes were recorded as the magnitude ranged from 7.9 to 8.5 on the Richter scale and their tsunamis reached three to four meters in height (TMG website on disaster prevention).

In the event of simultaneous Tonankai/Nankai earthquakes (a major earthquakes off

Honshu-Shikoku with predicted magnitude of 8.65 on the Richter scale), the ensuing tsunami is expected to travel from Honshu and reach the Ogasawara Islands an hour and a half later, and sea level is expected to rise up to 13.8 meters on the coast of Chichijima and 15.4 meters on Hahajima (TMG, 2005).

4.b.3.3 Droughts

Severe droughts struck the Ogasawara Islands in 1980 and 1990, causing extensive damage to vegetation and serious water shortages for island residents. In 1980, the period from May to October became dry and subhumid, especially there was no rainy season for the first three months of the period until late July, meaning an extended dry period. In the most affected areas of Mt. Chuosan ridge near Higashidaira in Chichijima, this lack of water is reported to have caused the death of 50 to 70% of the trees making up forest canopies (Shimizu, 1982). The drought situation in 1990 was similar. Except humid period in late May, dry period is dominant and frequent throughout the summertime(Iijima, 2004).

The occurrence of such droughts potentially threatens the species which live in fresh and brackish water, especially aquatic insects such as the endemic dragonflies that spend a part of their lifecycle in water. As mentioned before, the setting up of artificial “dragonfly ponds” has achieved some success.

4.b.3.4 Typhoons

Because they are located close to the center of high-pressure area, the Ogasawara Islands are less susceptible to the effects of typhoons than the Ryukyu Islands. However, in case a typhoons approaches, , relatively a strong typhoon make landfall with its strength maintained due to high seawater temperature around Ogasawara Islands. For example in 1983, Typhoon No. 17 caused many trees to fall on Hahajima, leading to the rapid expansion of alien Bischofia (Shimizu, 1988). It is considered that damages from several other strong typhoons accelerated the intrusion and growth of Bischofia (Tanaka et al. 2009). In addition, a powerful Typhoon No. 25 of 1997 severely affected rare plant species there. The most shattering was the impact to the eastern shore area where *Melastoma tetramerum* grows, and the surviving trees of *Melastoma tetramerum* suffered serious damage (Nature Conservation Bureau, MOE and the TMG, 2006).

There are a range of concerns when typhoons approach nearby or hit directly the islands, such as:

- direct wind and seawater damage to endemic plants,
- adverse effects on the fruit bearing (Kanto Regional Forest Office, 2008),
- intrusion of alien species,
- disturbance of the feeding and resting sites for the endemic animals such as Bonin

honeyeater and Bonin flying fox.

It is empirically observed that seawater damage caused by typhoons has a great impact not only on the growth of intolerant plants but also on insects (Takakuwa, 2004). Landslides potentially damage not only the habitats of terrestrial endemic fauna and flora, but also the habitats of marine life in coastal areas through mud and rock debris cast into the ocean.

4.b.3.5 Climate change

There are many reports on the long-term changes in climate at the Ogasawara Islands (e.g. Oka et al., 2001; Iijima et al., 2005; Yoshida et al., 2006a). An analysis of the temperature and precipitation data spanning the past 78 years on Chichijima (Yoshida et al.,2006b) shows that the mean annual temperature after 1945 has been 0.4 to 0.6 ºC higher than before. Furthermore, the annual rainfall after 1968 (when the islands were returned to Japan) has decreased by about 20% compared to pre-1945 levels. The same report also points out that after 1968, the summer months marked by water shortages have tended to be longer, and that there is a possibility that long-term climate changes characterized by longer and drier periods result in major changes to the ecosystem.

Further accumulation and analysis of meteorological data is necessary in order to forecast the changes to the island ecosystem expected to occur as a result of future climate change. In the nominated property, the Japan Meteorological Agency has installed weather stations on Chichijima and Hahajima, and continuously collects meteorological data. The Chichijima Weather Station began its observations in May 1906 (Yoshida et al., 2006b), and continues to collect data at the same site to this date except a roughly two-decade blank (from 1944 to 1968) caused by World War II,. In recent years meteorological data can be accessed through the Internet and other media. In addition, the TMG and some research institutions have installed automatic weather stations on other islands including Anijima and Nakodojima and climatic data is continuously observed.

The MOE conducts long-term collection of basic environmental data for the early detection of any qualitative or quantitative degradation in Japan’s natural environment by setting up about 1,000 monitoring sites throughout the country. Some of these monitoring sites are within the nominated property, including a sand beach on Chichijima, the Mukojima Island Group, and the Sekimon area of Hahajima.

4.b.4 Visitor/Tourism Pressures

4.b.4.1 Impacts of Tourism

Most tourists come to the Ogasawara Islands to learn about Ogasawara's unique natural features and history. They enjoy diving, sea kayaking, whale watching, trekking, visiting historical sites, and other activities in the natural surroundings. Because of the limited accessibility, the number of visitors to the islands for sightseeing purpose is not large (around 17,000 per year). With public transportation, tourists can visit only Chichijima and Hahajima, and the number of visitors excluding the residents to Hahajima is only around 6,000 to 7,000 per year. Usually tourists depend on tour operators or guides for their activities, because of limited transportation availability and the local knowledge and facility-based nature of their activities. Consequently, tourists are well managed. With the current scale of tourism, there have been no observed negative impacts on the ecosystem of the islands. However, there are potential impacts including introduction of alien species, illegal collection of endangered species and other damage to the islands' ecosystem.

4.b.4.2 Utilization rules

In order to promote tourism while conserving the rich natural environment, the concepts of ecotourism have been adopted, and conservation activities are promoted through voluntary rules.

In 1999, with the aim of protecting the valuable Ogasawara fauna and flora for future generations, the MOE laid out basic rules for utilization, called the "Ogasawara Country Code". The Code consists of 10 basic rules, such as: "1. Hand over the valuable Ogasawara to future generations," "2. Never litter; take trash back with you," "3. Do not deviate from the paths," and "4. Do not collect, bring in, or take away any animals and plants." To raise awareness of these rules among visitors, the codes are listed in a booklet called the *Ogasawara Rulebook*, a compilation of various codes of conduct for tourists in the Ogasawara Islands (Ogasawara Ecotourism Association, 2005).

In July 2002, the TMG established the Guidelines for the Protection and the Appropriate Use of Nature on the Islands of Tokyo (Governor's Decision Making), and designated Minamijima and the Sekimon area of Hahajima as the first Nature Conservation Promotion Areas. For each Promotion Area, rules for proper use are set to regulate the number of visitors per day, tourism routes, timeframes, and so on. To enter the Promotion Area, tourists have to be accompanied by a Tokyo Nature Guide and follow his or her instructions. The TMG and Ogasawara Village concluded an agreement concerning implementation of this system, and from April 2003, in these two areas, eco-tourism based on the Rules for Appropriate Use in Ogasawara Islands started (TMG website).

In 2002, the TMG started training and certifying the Tokyo Nature Guides, who play a practical role in ecotourism in the Nature Conservation Promotion Area. As of March 2008, the number of certified guides is 204 for the Minamijima and 31 for the Sekimon area. The TMG conducts training courses for applicants for a guide license as well as the renewal courses for licensed guides (Ogasawara Islands Branch Office, TMG, 2008). Further, there are whale-watching interpreter license systems (licensed by the Ogasawara Whale Watching Association) and Hahajima Forest Guide system (certified by Hahajima Tourist Association). These guides are informed of potential negative impacts caused by the introduction of alien species along with the tourists, and whenever tourists move between islands guides are encouraged to ensure that the tourists wash the shoe soles to remove flatworms contained in dirt.

Based on the Conservation and Management Plan for the Ogasawara Islands Forest Ecosystem Reserve, the Forestry Agency introduced utilization rules in September 2008. The intention was to reduce impacts on the endemic ecosystems from the recreational use. Under the rules, entry into the Preservation Zone of the Forest Ecosystem Reserve is, in principle, restricted to the designated routes so as not to impact the threatened animals and plants. In addition, the rules stipulate that even when entering these designated routes, visitors are obliged to be accompanied by a guide who has been issued an entry permit upon completion of a training course on conservation and proper use of the habitats of threatened species.

Furthermore, many organizations have established their own rules as a part of ecotourism promotion in Ogasawara Islands, and local tourism associations and operators are committed to comply. Table 4-4 shows a list of voluntary rules compiled in the *Ogasawara Rulebook* (Ogasawara Ecotourism Association, 2005; Ogasawara Ranger Office for Nature Conservation, MOE, 2007).

Table 4-4: Voluntary rules in practice on the Ogasawara Islands

Names of rules	Listing organizations
Marine life prohibited to catch	Industry section, Ogasawara Islands Branch Office, TMG
Marine park map: The protection of marine wildlife	Civil and Industry sections, Ogasawara Islands Branch Office, TMG
Ten rules for the coexistence with nature: The Ogasawara Country Code	MOE
Whales: Autonomous rules of the Ogasawara Whale Watching Association	Ogasawara Whale Watching Association/Ogasawara Village Tourist Association

Names of rules	Listing organizations
Sea turtles: Guidelines for what to do when encountering a turtle while night watching	Ogasawara Village Tourist Association
Spotted and barred knifejaws: Catch & release guidelines	Ogasawara Hahajima Fisheries Cooperative
Albatrosses: Rules for watching, and what you can do for the birds	Producers of the pamphlet *Making Ogasawara Full of Albatrosses*
Green Pepe – About the Nagatani green Pepe -	Ogasawara Village Tourist Association/ Guide Section, Ogasawara Village Tourist Association/Bonin Flying Fox Society
Bonin flying fox: Watching guidelines	Ogasawara Village Tourist Association/ Guide Section, Ogasawara Village Tourist Association/Bonin Flying Fox Society
Akagashira-karasubato *Columba janthina nitens*: Rules of the Higashidaira wood-pigeon sanctuary	National Forest Division, Ogasawara General Office / Ogasawara Nature Observation Instructor Association
Rules for the appropriate utilization of Minamijima and Hahajima's Sekimon area: Ecotourism for Minamijima and Hahajima's Sekimon area by the TMG	TMG
Guidelines for Hahajima's Sekimon area	Hahajima Nature Guide Administration Council

4.b.5 Number of inhabitants within the property and the surrounding area.

There are no permanent residents within the nominated property.

The numbers of inhabitants in the surrounding area as of June 1, 2009 are;

Chichijima: 2,009 persons (1,086 households)

Hahajima: 453 persons (235 households)

Total: 2,462 residents (1,321 households).

(General Affairs Division, Policy Office, Ogasawara Village, 2009).

5. Protection and Management of the Property

5.a Ownership

5.b Protective designation

5.c Means of implementing protective measures

5.d Existing plans

5.e Property management plans or other management systems

5.f Sources and levels of finance

5.g Sources of expertise and training

5.h Visitor facilities and statistics

5.i Presentation and promotion of the property

5.j Staffing levels

5.a Ownership

National forest, which is under the authority of the Forestry Agency, accounts for about 80% of the nominated property. Other than the national forest, the property includes state-owned land administered by the Ministry of Finance, the Ministry of the Environment (MOE), etc., and land owned by the Tokyo Metropolitan Government (TMG) and Ogasawara Village, as well as privately owned land. Contact information for the MOE, the Forestry Agency, the TMG and Ogasawara Village, which are the major owners of the land, is listed in Section 8 below.

5.b Protective designation

The nominated property is appropriately protected according to domestic laws and systems. The main protected area systems for the nominated property encompass the following: the Minami-iwoto Wilderness Area, Special Protection Zone and Class I Special Zone of the Ogasawara National Park, Preservation Zone of the Ogasawara Islands Forest Ecosystem Reserve, and Natural Monument. Table 5-1 shows detailed information on the protected areas, such as designation date and legal foundation maps of each of the protected areas are shown in Figs. 5-1 through 5-3.

As for the surrounding areas of the nominated property, marine parts are designated as the Marine Park Zone and Ordinary Zone of the Ogasawara National Park, and Wildlife Protection Area, while terrestrial parts include the Special Zone of the Ogasawara National Park, Preservation Zone of the Ogasawara Islands Forest Ecosystem Reserve, and Wildlife Protection Area.

Table 5-1 Designation details for protected areas in the nominated property

Name of protected zone (Date of designation)	Legal foundation (Date of promulgation)	Objectives of system
Minami-iwoto Wilderness Area (May 17, 1975) Restricted Entry Zone (June 2, 1983) 367 ha	Nature Conservation Law (June 22, 1972)	Areas that are in particular need of protection to maintain their virgin natural environments that are not influenced by human activities
Ogasawara National Park (October 16, 1972) Total terrestrial area : 6,629 ha (area extended by notification on November 12, 2009) Special Protection Zone : 4,934 ha Special Zone: 1,677 ha	Natural Parks Law (June 1, 1957)	Places of natural scenic beauty representing the natural beauty of Japan as designated by the Minister of the Environment for the purpose of protecting natural landscapes and promoting its use as a resource for health, recreation and education of the people

Name of protected zone (Date of designation)	Legal foundation (Date of promulgation)	Objectives of system
Ordinary Zone: 18 ha Total marine area: 121,380 ha Marine Park Zones: 780 ha Ordinary Zone: 120,600ha		
Ogasawara Islands Forest Ecosystem Reserve (April 1, 2007) Total area: 5,580 ha Preservation Zone: 5,319 ha Conservation and Utilization Zone: 261 ha	Law on the Administration and Management of National Forests (June 23, 1951) National Forest Administration and Management Bylaw (January 21, 1999)	Areas to preserve natural forests in virgin condition in order to maintain a natural environment of the forest ecosystem, protect plants and animals, preserve genetic resources, develop forest operation and management technique, and promote scientific research etc.
Ogasawara Archipelago National Wildlife Protection Area (March 31, 1980) Total area: 5,899 ha (including marine area; area extended on November 1, 2009)Special Protection Area: 1,331 ha	Wildlife Protection and Appropriate Hunting Law (July 12, 2002)	Areas designated to prohibit the capture of wildlife and the collecting of bird eggs, to ensure their stable existence, and protect birds by conserving, managing, and maintaining habitats for diverse wildlife
Nishinoshima National Wildlife Protection Area(August 1, 2008) 29 ha（entire area is designated as Special Protection Area）	Same as above	Same as above
Kita-iwoto National Wildlife Protection Area (designated by notification on November 1, 2009Total area: 860ha (including marine are) Special Protection Area: 557ha	Same as above	Same as above
National Natural Monuments: Minami-iwoto (November 12, 1972) Submerged Karst at Minamijima (March 28, 2008)	Law for the Protection of Cultural Properties (May 30, 1950)	Animals, Plants, and geological features and minerals of high scientific value for the country

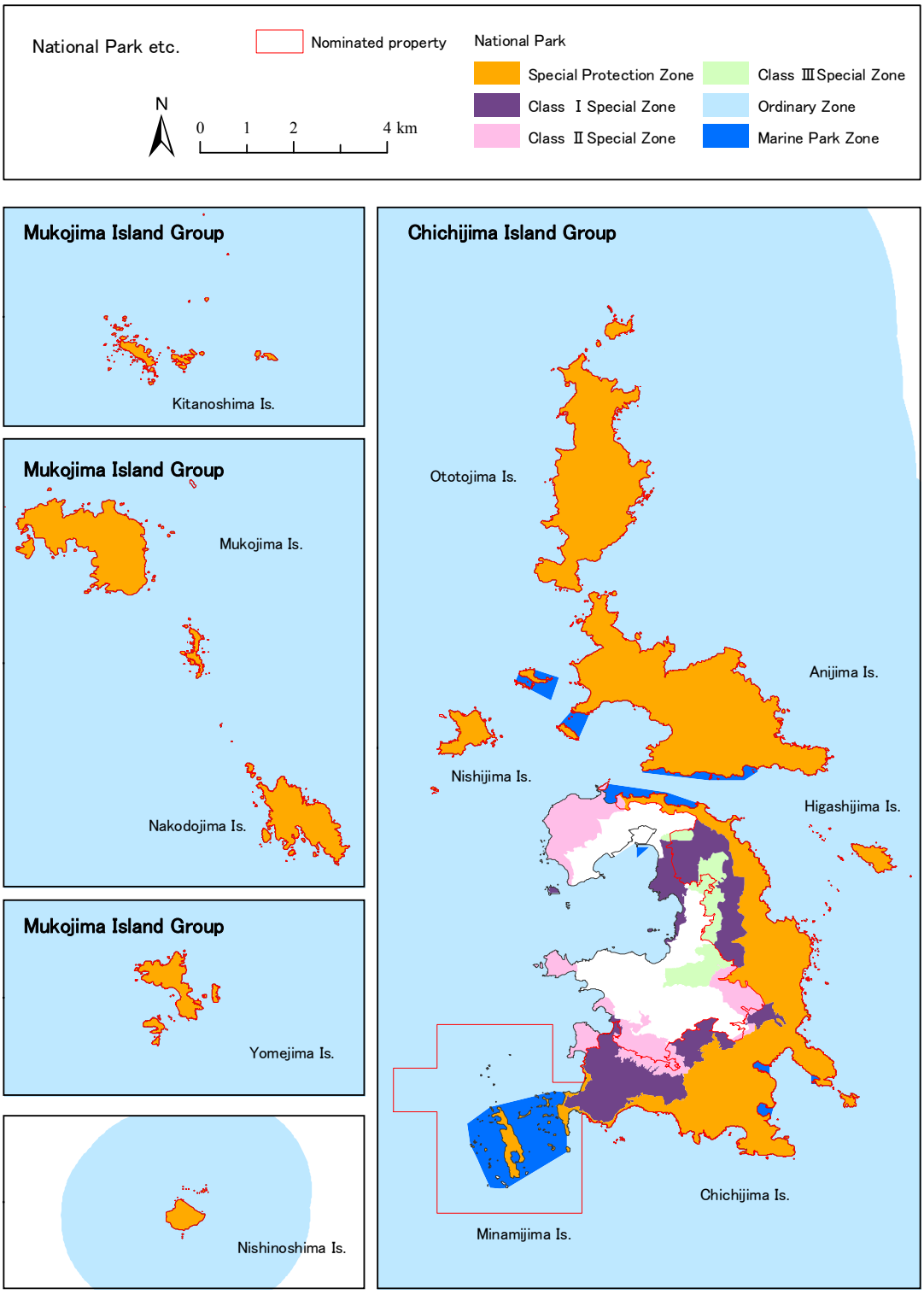


Fig. 5-1-1 Ogasawara National Park
(Mukojima Island Group, Chichijima Island Group, and Nishinoshima)

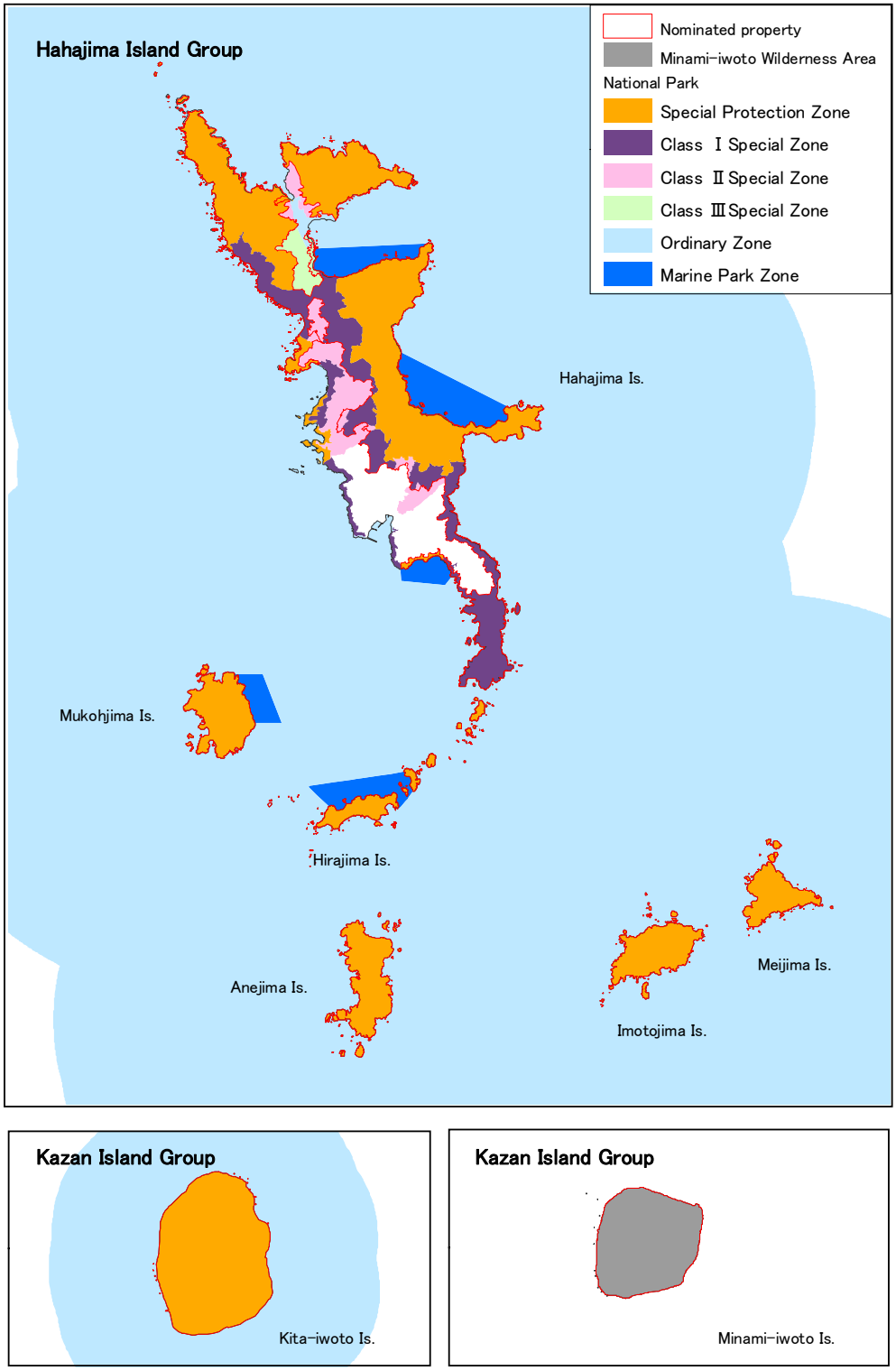


Fig. 5-1-2 Minami-iwoto Wilderness Area and Ogasawara National Park
(Hahajima Island Group, Kita-iwoto, and Minami-iwoto)

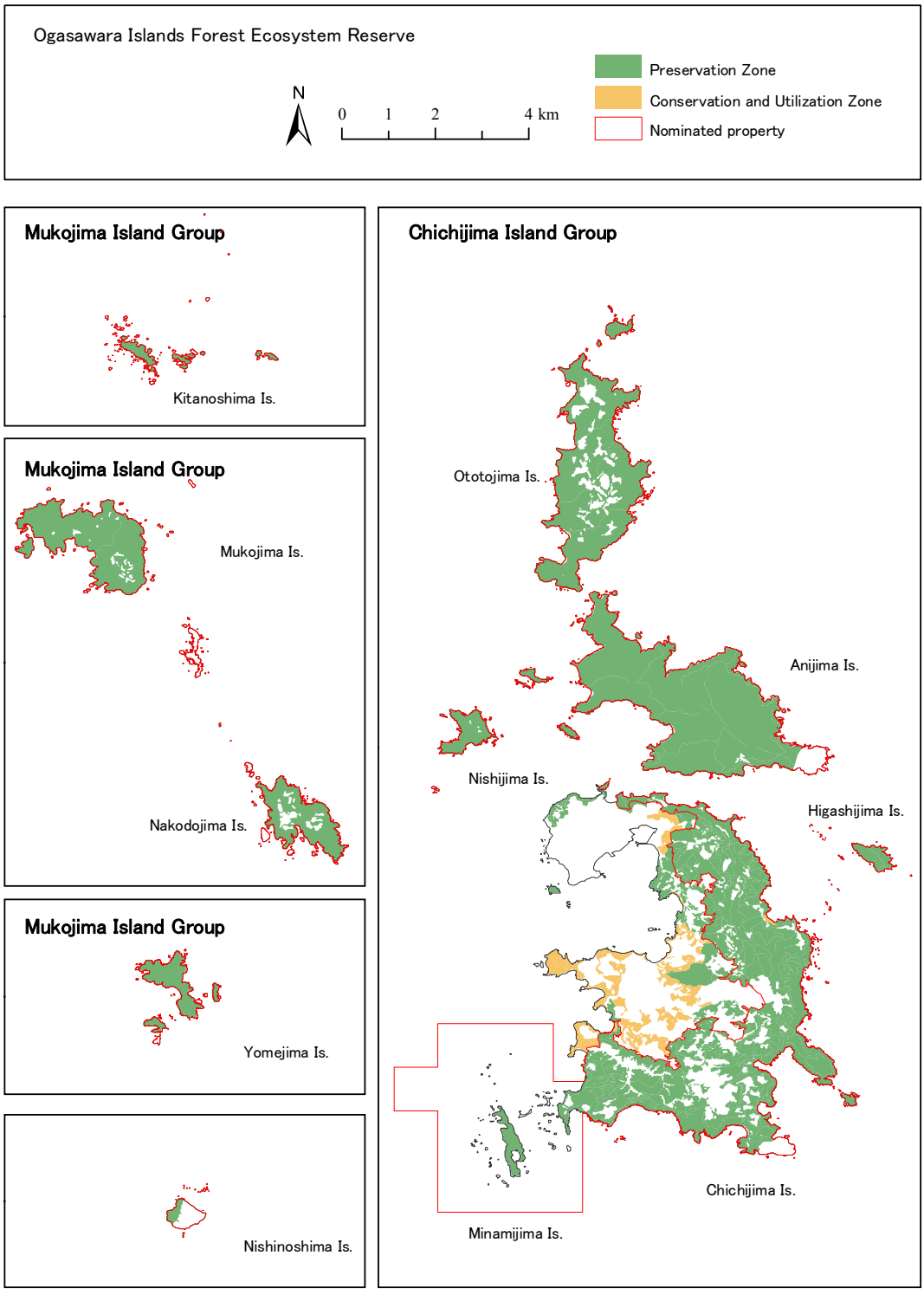


Fig. 5-2-1 Ogasawara Islands Forest Ecosystem Reserve
(Mukojima Island Group, Chichijima Island Group, and Nishinoshima)

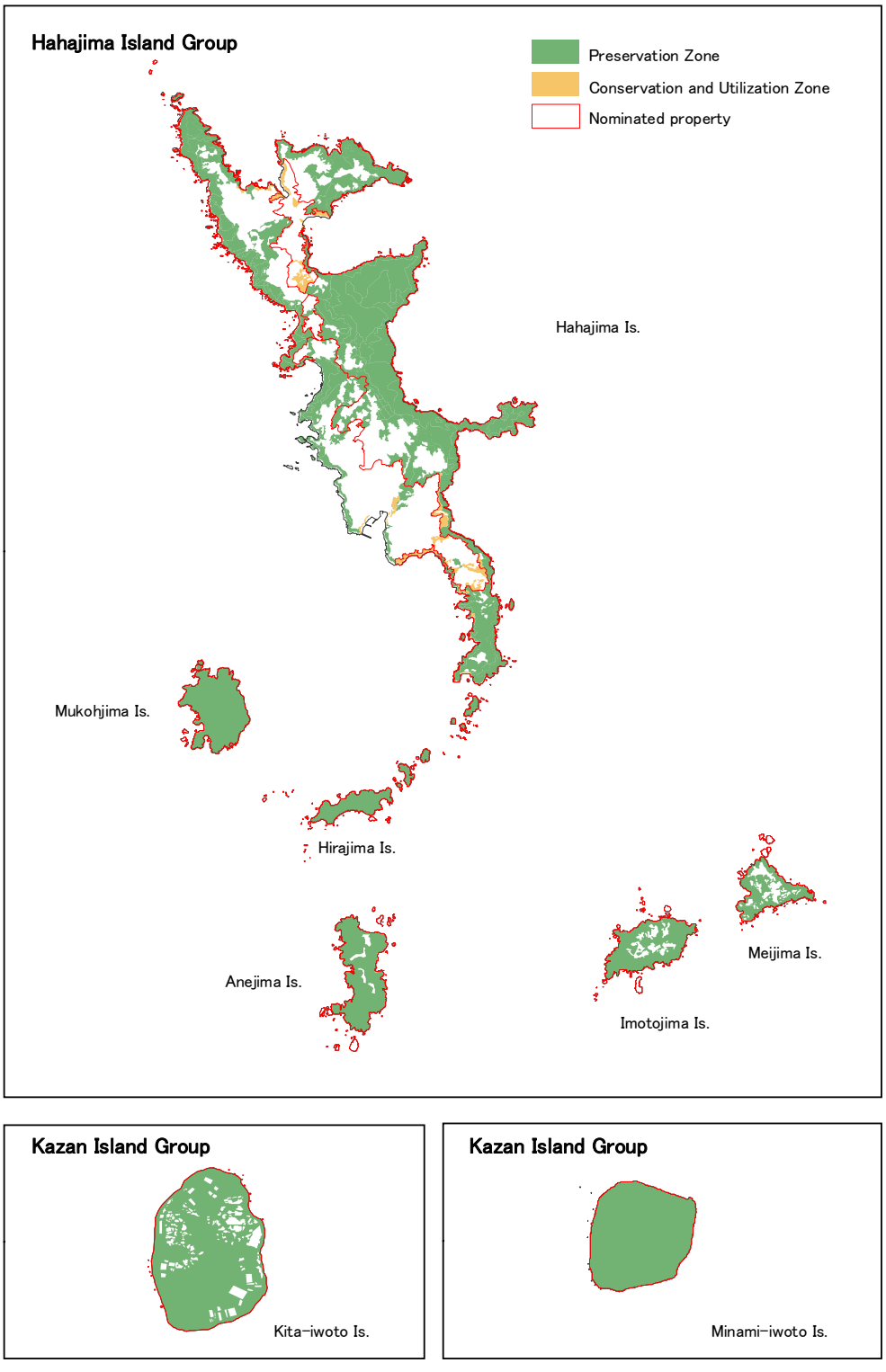


Fig. 5-2-2 Ogasawara Islands Forest Ecosystem Reserve
(Hahajima Island Group, Kita-iwoto, and Minami-iwoto)

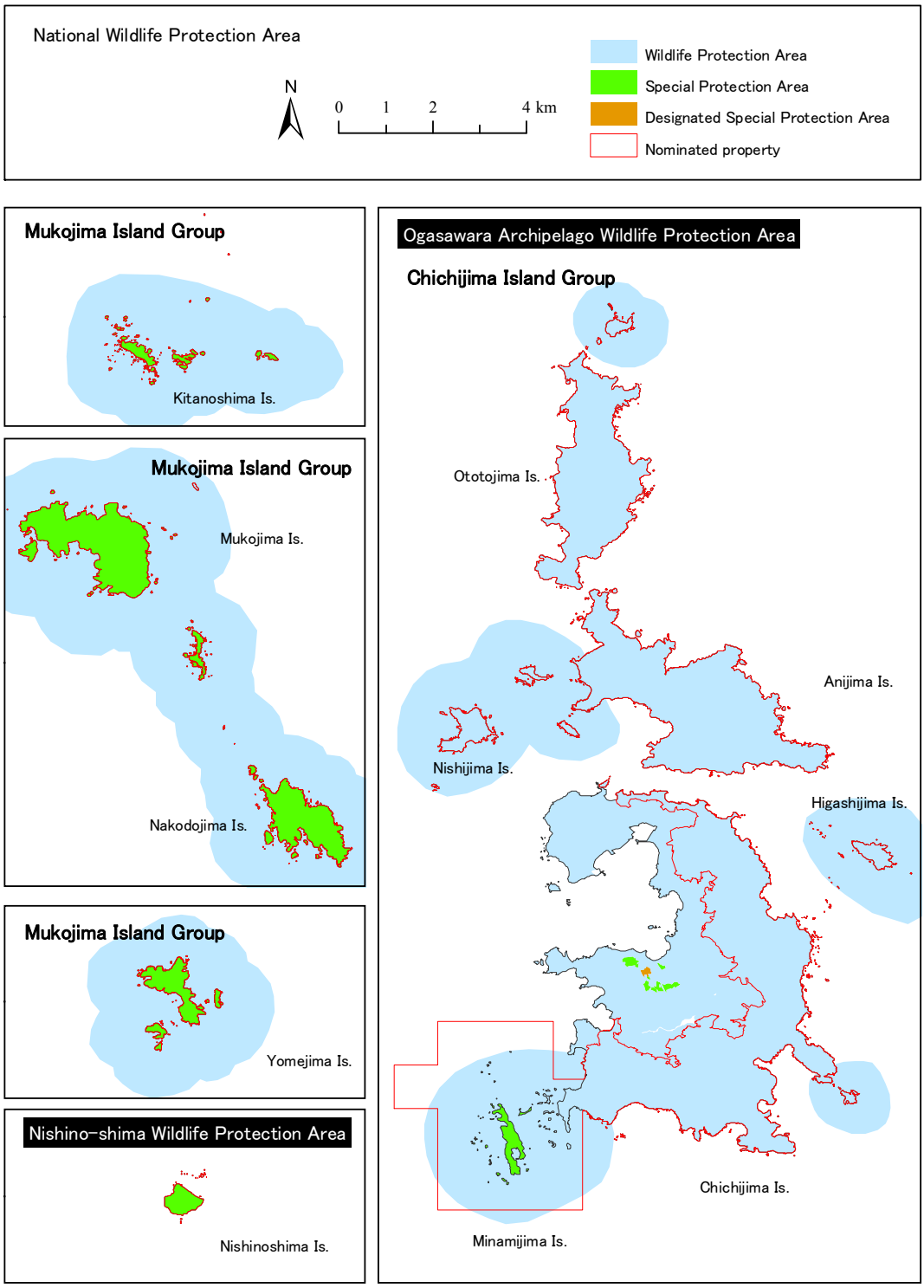


Fig. 5-3-1 National Wildlife Protection Area
(Ogasawara Archipelago, Nishinoshima)

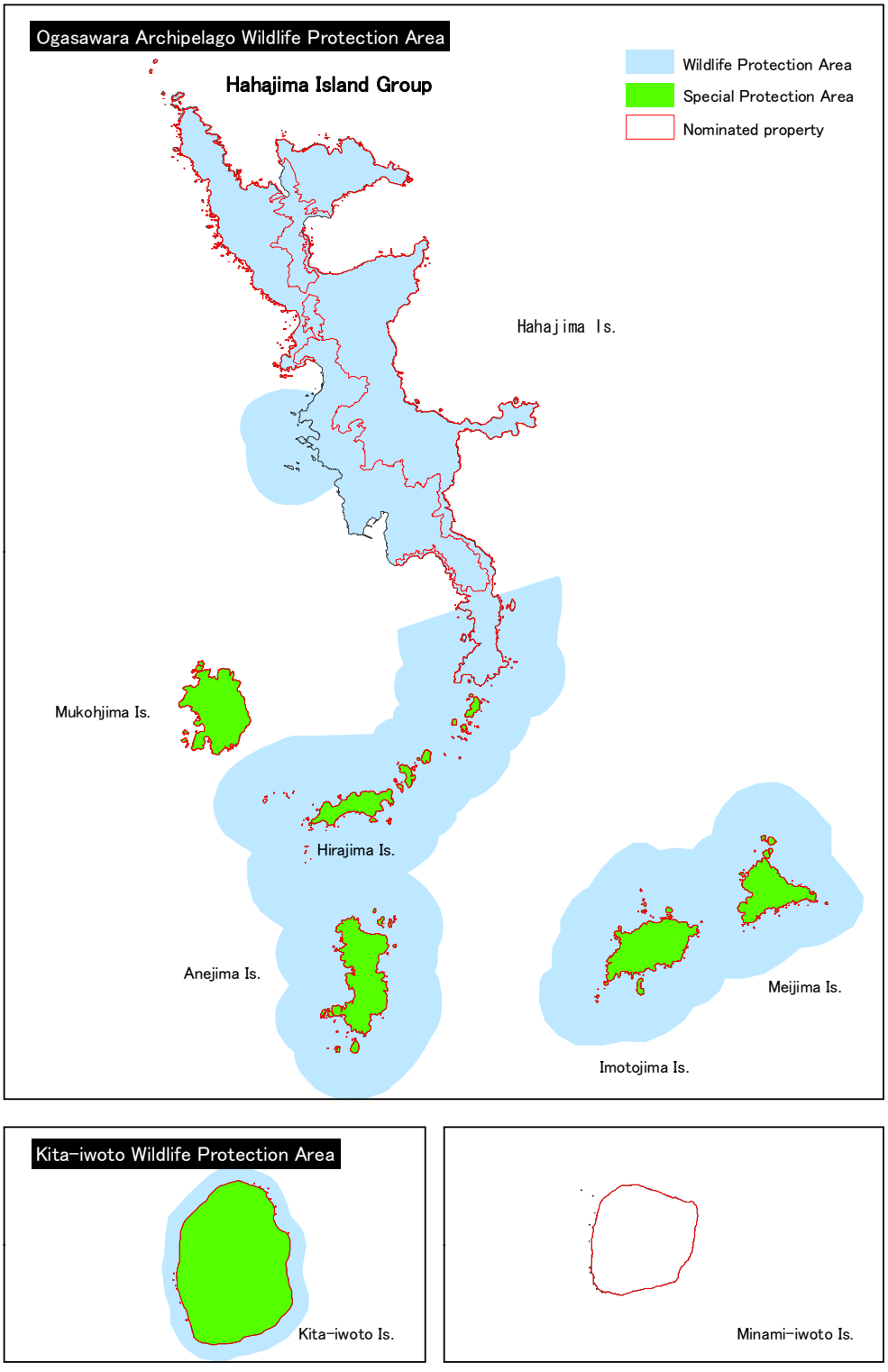


Fig. 5-3-1 National Wildlife Protection Area
(Ogasawara Archipelago, Kita-iwoto)

5.c Means of implementing protective measures

The nominated property is protected by domestic laws conferring the designations shown in Table 5-1. Many of the protected areas overlap and complement each other, which raises the level of protection in the property.

Many endemic wildlife species live or grow within the nominated property. Some of these species are designated and protected as National Endangered Species of Wild Fauna and Flora under the Law for the Conservation of Endangered Species of Wild Fauna and Flora or as Natural Monuments under the Law for the Protection of Cultural Properties.

The following is an outline of the protective measures.

5.c.1 Minami-iwoto Wilderness Area

Wilderness Areas are designated and administered by the Minister of the Environment based on the Nature Conservation Law. Its purpose is to provide necessary protection for virgin natural environments of a significant scale without being influenced by human activities.

Based on this law, the whole area of Minami-iwoto was designated as the Minami-iwoto Wilderness Area in 1975. The entire Wilderness Area is included in the nominated property.

In this Wilderness Area, acts that may affect the conservation of the natural environment are prohibited, except for special reasons such as scientific research. Examples of prohibited acts are shown in the table below. In addition, the entire area has been designated as a Restricted Entry Zone under the law, which prohibits the entry into the area except for special reasons ssuch as academic study.

Prohibited acts in Wilderness Areas (except in cases deemed necessary by the Minister of the Environment for scientific research and so on)	
1. Constructing, reconstructing, or expanding buildings or other structures. 2. Making housing lots, clearing land, or changing the feature of the land. 3. Mining minerals or extracting soil and stones. 4. Reclaiming the surface of water or reclaiming by drainage. 5. Causing increase or decrease in the water-level or quantity of water of rivers, lakes, marshes, swamps and wetlands etc.	9. Capturing, killing or wounding animals, or collecting or damaging their eggs. 10. Pasturing livestock. 11. Setting or making fire. 12. Accumulating or storing things in the open air. 13. Using horses, vehicles or power-driven vessels, or landing airplanes. 14. Releasing animals. 15. Dumping of wastes Entering “Restricted Entry Zones” is prohibited.

Prohibited acts in Wilderness Areas (except in cases deemed necessary by the Minister of the Environment for scientific research and so on)	
6. Felling or damaging trees and bamboos. 7. Collecting or damaging plants, or collecting fallen leaves or branches. 8. Planting and seeding plants.	

5.c.2 Ogasawara National Park

National Park is a designation that protects places of natural scenic beauty and promotes their utilization for the purposes of the health, recreation and education of the people, as well as ensuring the conservation of biodiversity. The Minister of the Environment designates and manages National Parks based on the Natural Parks Law.

National Parks are operated according to established park plans, which divide parks into different classification, including Special Zones for areas of preserving their distinguished state of nature, Special Protection Zones within Special Zones for such areas of most stringent protection for their sate of virgin nature, Marine Park Zones for such areas of characteristic seabed topography and of rich marine fauna and flora, and Ordinary Zones for protection of integrated landscape with above-mentioned zones. Each zone has certain restrictions that apply.

Most of the terrestrial area designated as Ogasawara National Park in 1972 based on the Natural Parks Law is included within the nominated property. A large part of the property is classified into Special Protection Zone, which is the most stringently protected designation. Acts that could impact the natural environment are regulated. For example, there are restrictions on collecting fallen leaves, which serve as in important habitat for land snails. Furthermore, many portions of Chichijima and Hahajima in the nominated property are designated as Class I Special Zones, where quasi protective measures of Special Protection Zones are taken.

There are 51 families and 138 species of vascular plants, including endemic species such as *Rhododendron boninense* and *Callicarpa parvifolia*, which are legally protected from collection or harm as “designated plants” within the Special Zone. In the same way, *Indolestes boninensis* and *Hemicordulia ogasawarensis* are protected as “designated animals” and their capture or harm are restricted. A list of designated species is attached in the Appendix 5-2.

In addition, walkways, recreational sites and such have been built and maintained according to the Visitor Facility Plan of the National Park in order to conserve the natural environment and at the same time encourage visitation in a proper manner.

Regulation contents for each area

Acts that require the permission of the Minister of the Environment in Special Zone	Acts that require the permission of the Minister of the Environment in Special Protection Zone, in addition to the acts listed on the left	Acts that require notification to the Minister of the Environment in Ordinary Zone
1. Constructing, reconstructing or extending structures. 2. Felling trees and bamboos. 3. Mining minerals or extracting soil and stones. 4. Causing increase or decrease in the water level or quantity of water of rivers, lakes, marshes, swamps and wetlands etc. 5. Discharging polluted or waste water into designated lakes etc. 6. Putting up or setting up advertisements etc. 7. Accumulating or storing soil and stones or other designated items in the open air. 8. Reclaiming the surface of water or reclaiming by drainage. 9. Clearing land or changing the feature of land. 10. Collecting or damaging the designated plants etc. 11. Capturing the designated animals etc. 12. Changing the colors of roofs and walls etc. 13. Entering into designated wetlands etc. 14. Using horses, vehicles or power-driven vessels, or landing airplanes. .	1. Damaging trees and bamboos. 2. Planting and seeding plants.. 3. Pasturing livestock. 4. Accumulating or storing things in the open air. 5. Setting or making fire. 6. Collecting or damaging plants, or collecting fallen leaves or branches. 7. Capturing, killing or wounding animals, or collecting or damaging their eggs. 8. Using horses, vehicles or power-driven vessels, or landing airplanes off of roads and public open spaces.. 9. Releasing animals. in addition to 1 through 6, 8, 9, 12, 13 to the left	1. Constructing, reconstructing or extending large-scale structures. 2. Causing increase or decrease in the water-level or quantity of water of rivers, lakes, marshes, swamps and wetlands etc. of the Special Zone 3. Putting up or setting up advertisements etc. 4. Reclaiming the surface of water or reclaiming by drainage. 5. Mining minerals or extracting soil and stones.* 6. Changing the feature of the land. 7. Changing the feature of the seabed.

5.c.3 Ogasawara Islands Forest Ecosystem Reserve

Forest Ecosystem Reserve is a designation for areas of primitive natural forests

representative of forest zones in Japan that exist in a reasonably large scale. Its purpose is to maintain the natural environment of the forest ecosystem, protect plants and animals, preserve genetic resources, develop forest operation and management technique, and promote scientific research etc. In its planned administration and management program of the national forests based on the Law on the Administration and Management of National Forests, the Forestry Agency designates and administers the reserve as stated in National Forest Operation Plan, created in accordance with the National Forests Administration and Management Bylaw which stipulates details on plan creation for the actual administration and management activities of each region. , and.

In 1994, the eastern coast of Hahajima was designated forest ecosystem reserve. Then, in 2007, after a review of the areas covered by the system, the area was expanded to cover national forests on nearly all of the main and subsidiary islands of the Ogasawara Islands (aside from areas being used for public works projects), in order to conserve the unique forest ecosystems of the Ogasawara Islands for future generations. Forest Ecosystem Reserve now covers more than 80% of the nominated property.

The Preservation Zone subcategory in Forest Ecosystem Reserve includes the area where the typical biota as well as endemic and threatened species is found. Its purpose is to maintain, restore, and properly preserve forest ecosystems in their original form. This designation allows for acts deemed necessary based on established scientific evidence to preserve or restore endemic diversity or forest ecosystems, but in principle dictates that the area is left to follow its course of nature, without human interference. Beginning in 2008, utilization is limited as a rule to predetermined designated routes, so as not to diminish the value of vulnerable ecosystems in the Preservation Zone. Furthermore, persons entering these designated routes need to be accompanied by a guide who has been issued a permit to enter the area upon completion of the training courses on the conservation and utilization of threatened wildlife and their habitats.

The Conservation and Utilization Zone subcategory is designed as a buffer zone that prevents the direct influence of external environmental changes that might affect the forest ecosystem of the Preservation Zone. As a general rule, the Conservation and Utilization Zone aims to conserve and restore forest ecosystems of the same quality as the Preservation Zone and is thus treated in a similar manner. Additionally, the use of forests is permitted for educational and other purposes to the extent that such use does not adversely affect its function. In order to ensure proper utilization and protection, persons wishing to enter parts of Zone that are not along the designated routes must likewise obtain a permit to enter the area and complete a course on conservation andutilization.

5.c.4 National Wildlife Protection Areas

National Wildlife Protection Areas are designated by the Minister of the Environment based on the Wildlife Protection and Appropriate Hunting Law. The purpose is to provide protection to wildlife and enforce appropriate requirements on hunting, thereby ensuring the conservation of biodiversity that in turn enables people to enjoy the blessings and benefits of nature. Hunting is prohibited in Wildlife Protection Areas. In addition, the areas where the protection of wildlife and their habitats is deemed especially necessary are designated as Special Protection Areas to restrict certain development acts. Furthermore, areas in need of particular protection within Special Protection Areas are designated as Designated Special Protection Areas where acts like mere observation of fauna and flora by photographing are restricted, as acts that may adversely affect wildlife protection.

- Ogasawara Archipelago National Wildlife Protection Area:

  The Ogasawara Islands National Wildlife Protection Area was designated based on the above law in 1980 because of the islands' status as habitats for threatened wildlife, such as *Buteo buteo toyoshimai*, *Apalopteron familiare hahasima* (a subspecies of the Ogasawara Islands honeyeater), *Columba janthina nitens*, *Carduelis sinica kittlitzi*, and short-tailed albatrosses (*Phoebastria albatrus*). In 2009, the area expanded as Ogasawara Archipelago National Wildlife Protection Area to include surrounding ocean area. The nominated property includes most of the terrestrial parts of this Wildlife Protection Area.

- Nishinoshima National Wildlife Protection Area:

  Nishinoshima was designated as a National Wildlife Protection Area in 2008 because it is a breeding ground for the colonies of the masked booby (*Sula dactylatra*), Tristram's storm-petrel (*Oceanodroma tristrami*), the swift tern (*Thalasseus bergii*), and others. All of this National Wildlife Protection Area is included in the nominated property.

- Kita-iwoto National Wildlife Protection Area (in process of designation);

  Kita-iwoto and its surrounding ocean area were designated as a National Wildlife Protection Area in 2009, because of its importanceas habitats or a breeding site for seabirds including red-tailed tropicbird (*Phaethon rubricauda*), red-footed booby (*Sula sula*), Matsudaira's storm-petrel (*Oceanodroma matsudairae*), brown booby (*Sula leucogaster*), white-tailed tropicbird (*Phaethon lepturus*), bridled tern (*Sterna lunata*), and brown noddy (*Anous stolidus*). The site also provides habitats for such threatened species as *Columba janthina nitens, Carduelis sinica kittlitzi*, and Bonin

flying fox (*Pteropus pselaphon*). The nominated property includes all of the terrestrial parts of this Wildlife Protection Area.

Regulation contents for each area

National Wildlife Protection Area	Acts that require the permission of the Minister of the Environment within a Special Protection Area:	Acts requiring permission from the Minister of the Environment in a Designated Special Protection Area designated based on the act No. 4 in the left column
capture of wildlife is prohibited.	1. Construction, reconstruction and extension of structure 2. Reclamation of surface of water or land reclamation by drainage 3. Felling of trees or bamboo 4. Acts that may adversely affect wildlife protection as designated in the government ordinance	1. Gathering plants, capturing animals, etc. 2. Clearing by fire, other types of open fires 3. Use of horses or vehicles 4. Use of motor-powered boats 5. Entering with dogs or other animals that may be threatening to the wildlife 6. Wildlife observation activities by photographing etc. 7. Outdoor sports and other recreational activity

5.c.5 National Endangered Species of Wild Fauna and Flora

National Endangered Species of Wild Fauna and Flora refer to species of wild fauna and flora that are in danger of extinction. These species are designated by government ordinance based on the Law for the Conservation of Endangered Species of Wild Fauna and Flora (hereinafter called the Species Conservation Law).

Of the wildlife in the nominated property, one species of mammals (*Pteropus pselaphon*), five species of birds including *Columba janthina nitens*, five species of insects including tiger beetle (*Cicindela bonina*), and 12 species of plants including *Hymenasplenium cardiophyllum*, have been designated as National Endangered Species of Wild Fauna and Flora. It is therefore illegal to capture, harm, kill, collect, damage, transfer, etc. these species.

Based on the Species Conservation Law, Species Conservation Programs have been drawn up for 19 of these National Endangered Species of Wild Fauna and Flora, including *Columba janthina nitens* and *Rhododendron boninense*. These programs are for due and

effective implementation of projects to promote the propagation of individuals and maintenance of their habitat. Under these programs, population studies, habitat maintenance and improvement, artificial reproduction, etc. are currently conducted, aiming for the stable and natural continuation of these species (see also Appendix 5-5).

Table 5-2 List of National Endangered Species of Wild Fauna and Flora in the nominated property

Classification	Species name	Designated date	Conservation program
Plant	*Piper postelsianum Maxim.*	Government ordinance No. 222 (July 2, 2004) (Enforcement : July 15, 2004)	●
	Pittosporum parvifolium Hayata	Same as above	●
	Melastoma tetramerum Hayata	Same as above	●
	Rhododendron boninense Nakai	Same as above	●
	Callicarpa parvifolia Hook. et Arn.	Same as above	●
	Calanthe hattorii Schltr.	Same as above	●
	Calanthe hoshii S.Kobayashi	Same as above	●
	Malaxis boninensis (Koidz.) Nackej.	Same as above	●
	Hymenasplenium cardiophyllum (Hance) Nakaike	Government ordinance No. 238 (July 25, 2008) (Enforcement : August, 15, 2008)	●
	Symplocos kawakamii Hayata	Same as above	●
	Ajuga boninsimae Maxim.	Same as above	●
	Crepidiastrum grandicollum (Koidz.) Nakai	Same as above	●
Mammal	*Pteropus pselaphon*	To be designated on November 18, 2009	
Bird*	*Phoebastria albatrus*	Government ordinance No. 17 (February 10, 1993) (Enforcement : April, 1, 1993)	●
	Buteo buteo	Same as above	
	Columba janthina nitens	Same as above	●
	Apalopteron familiare hahasima	Same as above	
	Carduelis sinica kittlitzi	Same as above	
Insect	*Indolestes boninensis*	Government ordinance No. 238 (July25, 2008) (Enforcement : August, 15,	●

Classification	Species name	Designated date	Conservation program
		2008)	
	Rhinocypha ogasawarensis	Same as above	●
	Hemicordulia ogasawarensis	Same as above	●
	Cicindela bonina	Same as above	●
	Celastrina ogasawaraensis	Same as above	●

* In regard to birds, uncertain records and accidental migrations are excluded from the list.

5.c.6 Natural Monuments

Natural Monuments are designated by the Minister of Education, Culture, Sports, Science and Technology based on the Law for the Protection of Cultural Properties. Its purpose is to protect animals or plants (including their habitats, breeding sites, stopover points for migratory birds and native habitats) and geological minerals (including areas of unique natural phenomenon) which have significant scientific value for the country.

Of the animals that occur in the nominated property, short-tailed albatross and the Bonin honeyeater are designated as Special Natural Monument. In addition, two bird species including *Columba janthina nitens*, one mammal species of the Bonin flying fox, 10 insect species including *Celastrina ogasawaraensis* and a land snail group of Ogasawara Islands including 12 families such as Helicinidae family, as well as two other species have been designated as National Natural Monuments. The submerged karst at Minamijima has also been designated as a National Natural Monument because of its typical and distinctive submerged karst formations.

Acts which change the current state of Natural Monuments or affect their preservation require permission from the Commissioner of the Agency for Cultural Affairs.

Table 5-3 Designation of Natural Monuments

Designation type	Classification	Name of Natural Monument	Designation date	Designation date for Special natural monument
Regional designation (Ogasawara Village)	Natural Monument (NM)	Minami-iwoto	November 24, 1972	
Regional designation (Minamijima Ogasawara Village)	NM	Submerged Karst at Minamijima, Ogasawara Islands	March 28, 2008	

Designation type	Classification	Name of Natural Monument	Designation date	Designation date for Special natural monument
Species designation (area not limited)	Special Natural Monument (SNM)	Short-tailed albatross (*Phoebastria albatrus)*	April 25, 1958	April 19, 1962
Same as above	NM	*Columba janthina nitens*	April 12, 1969	
Same as above	NM	Bonin flying fox (*Pteropus pselaphon)*	Same as above	
Same as above	SNM	Bonin honeyeater (*Apalopteron familiar)*	Same as above	March 15, 1977
Same as above	NM	lycaenid butterfly (*Celastrina ogasawaraensis*)	Same as above	
Same as above	NM	*Boninthemis insularis*	Same as above	
Same as above	NM	*Hemicordulia ogasawarensis*	Same as above	
Same as above	NM	*Boninagrion ezoin*	Same as above	
Same as above	NM	*Rhinocypha ogasawarensis*	Same as above	
Same as above	NM	*Chrysochroa holstii*	Same as above	
Same as above	NM	land snails（12 families such as Helicinidae etc.）	November 12, 1970	
Same as above	NM	*Copelatus ogasawarensis*	Same as above	
Same as above	NM	*Neogerris boninensis*	Same as above	
Same as above	NM	*Xylocopa ogasawarensis*	Same as above	
Same as above	NM	*Meimuna boninensis*	Same as above	
Same as above	NM	*Cellana mazatlandica*	Same as above	
Same as above	NM	*Genus Coenobita*	Same as above	
Same as above	NM	*Buteo buteo toyoshimai*	May 19, 1971	

5.c.7 Systems for the control of alien species

According to the Invasive Alien Species Act, animals and plants introduced into Japan from overseas that harm or may harm ecosystems are designated as “Invasive Alien Species”.

Among alien species that are found in the nominated property, the green anole (*Anolis carolinensis*), the cane toad (*Bufo marinus*), the American bullfrog (*Rana catesbeiana*), and the New Guinea flatworm (*Platydemus manokwari*) have been designated as Invasive Alien Species, and pursuant to the above Act the importation, rearing, growing, storage, transport, etc. of these species are restricted.

5.d Existing plans

Plans involving the conservation and use of the nominated property include the Park Plan for Ogasawara National Park, which stipulates protective regulations and visitor facility plans, and the Regional Administration and Management Plan, which outlines the management policies of the Ogasawara Islands Forest Ecosystem Reserve. The related plans are listed in Table 5-4.

Table 5-4 Plans related to the nominated property

Plan	Legal foundation	Responsible body	Purpose	Outline
Conservation Plan for the Minami-iwoto Wilderness Area	Nature Conservation Law, Article 15	MOE	Plans relating to regulations or facilities for the preservation of natural environments in Wilderness Area	Presents an overview of Minami-iwoto. designates restricted entry areas, etc. and clarifies basic aspects of the conservation of the natural environment.
Park Plan for Ogasawara National Park	National Parks Law, Article 7	MOE	Basic guidelines for the proper administration of parks by clarifying policies for maintaining scenic beauty in National Park for constructing and maintaining facilities thereof.	Outlines restrictions necessary for properly protecting the unique ecosystems, fauna, flora, and landscapes of Ogasawara National Park as well as plans for promoting the utilization of the Park.
Management Plan for Ogasawara National Park	Director General, Nature Conservation Bureau, MOE, Japan, Notification No. 051003001, October 3, 2005	MOE	Promoting the proper protection and utilization of National Park in order to enhance the National Park management based on the characteristics of the area.	Outlines park management policies to promote balance between nature conservation and human activities, and to create comfortable utilization opportunities of the park, taking into consideration the topographical, geographical, and ecosystem features of the Ogasawara National Park. Furthermore, promotes proper use of the natural environments of the park, in accordance with the actual situations of the area.
Basic Plan for the Conservation and Restoration of the Natural Environment of Ogasawara		MOE	Outlines the fundamental policies as well as the discrete technical methods and measures in dealing with alien species in particular, in the conservation and restoration of the natural environment of Ogasawara.	・Outlines basic policies towards the conservation and restoration of the natural environment of Ogasawara. ・Presents objectives and overall strategies for each island. ・Clarifies principles, technical methods and issues for each invasive alien species. ・Suggests future directions

Plan	Legal foundation	Responsible body	Purpose	Outline
				for the development of the islands and mechanisms therefore.
Regional Administration and Management Plan (Izu Islands Forest Planning Area)	Law on the Administration and Management of National Forests, Article 6 Paragraph 1	Forestry Agency	A five-year plan stipulating the basics for the administration and management of the Izu Islands Forest Planning Zone based on the principles of the administration and management plan for national forests. Based on this plan, the administration and management of national forests in the Ogasawara Islands is to be properly implemented.	To restructure existing protected forests, incorporate those changes into the Ogasawara Islands Forest Ecosystem Reserve, and institute the proper protections so that the extended area of unique ecosystems of the Ogasawara Islands can be preserved in an integrated manner. In addition, take proper measures against invasive species such as Bischofia in order to protect the invaluable endemic fauna and flora of the Ogasawara Islands.
Conservation Management Plan for the Ogasawara Islands Forest Ecosystem Reserve		Forestry Agency	Clarifies directions of national forest conservation and management on the Ogasawara Islands, taking into consideration the unique characteristics of the area. The Plan aims to prevent further degradation of the natural environments for future generations as well as to gradually restore the islands' primitive nature.	・Promotes systematic measures against alien species to protect endemic ecosystems of the Ogasawara Islands. ・Achieves a good balance between use and protection, in order to mitigate impact on endemic ecosystem caused by use.
Ogasawara Archipelago National Wildlife Protection Area Plan, Ogasawara Archipelago Special Protection Zone Plan; same for Nishinoshima and Kita-iwoto	Wildlife Protection and Appropriate Hunting Law	MOE	Protection of wildlife and their habitats that are important from international and domestic perspectives.	List the designated areas, their size in area, wildlife that inhabit there, protection guidelines and else
Species Conservation Program based on the Species Conservation	Law for the Conservation of Endangered Species of Wild Fauna and Flora	MOE, Ministry of Agriculture, Forestry and Fisheries	To contribute to the appropriate and effective implementation of Programmes for Rehabilitation of Natural	Indicates the objectives, areas, program content, and related matters to effectively implement the Programme.

Plan	Legal foundation	Responsible body	Purpose	Outline
Law (*Rhododendron boninense*, *Melastoma tetramerum*, short-tailed albatrosses, etc.)		(Forestry Agency)	Habitats and Maintenance of Viable Populations	
Ogasawara Islands Promotion and Development Plan	Act on Special Measures for the Ogasawara Islands Promotion and Development	TMG	Clarifies directions of promotion and development of Ogasawara Islands based on national guidelines	

5.e Property Management Plans or other management systems

5.e.1 Management plans for the nominated property

The “Ogasawara Islands Management Plan” (hereinafter the “Management Plan”) has been drafted in order to properly conserve and manage well into the future the natural environment of the nominated property, which is characterized by outstanding diversity and unique value.

The Management Plan clarifies basic polices related to the implementation of the systems and promotion of projects to facilitate the smooth and proper management of the nominated property. It requires close cooperation between the relevant administrative bodies that have authority over the islands (the MOE, the Forestry Agency, the Agency for Cultural Affairs, the TMG, and Ogasawara Village), and between other related administrative bodies and groups such as local residents, bodies engaged in tourism, agriculture, or fisheries, as well as researchers and NPOs (hereinafter referred to collectively as “concerned bodies”).

The outline of the Management Plan is as follows. The full text of the Management Plan is included in the Appendix 1.

a. Scope of the Management Plan

In order to conserve the natural environment in the nominated property it is necessary to take steps to prevent the invasion of new alien species, but such steps cannot be properly effective if taken only in the nominated property. For this reason, the scope of the Management Plan includes not only the nominated property but its surrounding areas. Main scope of the Management Plan is shown in Fig. 1-6-.

b. Management framework and systems

In addition to properly implementing the protective measures in Section 5.c above and conserving the outstanding value of the natural environment of the nominated property, conservation and management steps such as measures against alien species shall be taken according to the Management Plan through collaboration between relevant organizations and concerned parties. Systems to achieve that objective are outlined in 5.e (3) through 5.e (5).

c. Basic concept of the management and measures

● Conservation of natural environments

Outstanding value pursuant to Criterion (viii) for geological and topographic features and outstanding value pursuant to Criteria (ix) and (x) for ecosystem and biodiversity shall be protected through the proper application of existing protective systems described in 5.c. As for outstanding value relevant to Criteria (ix) and (x), islands shall be treated as individual units. The individual goals and measures of each island's ecosystem conservation shall be indicated with special attention paid, in implementing steps for eradicating alien species, to not being limited to specific species, so that steps for the conservation and management shall be taken in a strategic manner with due consideration of the interaction of different species among different islands while accumulating related findings and technique.

● Steps to prevent the invasion by and spread of new alien species

In order to prevent the introduction of new alien species and the spread of such species to previously uninfluenced areas, strategies will be developed and clarified for specific types of activities that pose the threat of introduction, including ecosystem conservation and management activities, greening/construction and other public works, utilization by customers of ecotourism, the keeping of pets, agricultural activities, the movement of people and transport of supplies via ferry liners, etc, thereby encouraging concerned bodies including local residents to avoid or mitigate impacts of these activities recognizing the risks caused by alien species.

●Adaptive implementation of conservation and management

Conservation and management shall be conducted in an adaptive manner. For this purpose, monitoring shall be carried out in order to properly identify changes to the natural environment caused by the steps for the conservation and management. The result shall be reflected in future steps after scientific assessment.

5.e.2 The Ogasawara Islands Ecosystem Conservation Action Plan

A short-term action plan shall be followed in order to conserve and manage ecosystems in collaboration with relevant organizations in a strategic manner that gives due consideration to the interaction of different species on the different islands.

Through this action plan, data will be gathered per island on predatory and competitive relationships among different species from a scientific perspective. Based on this data, short-term goals and areas of priority shall be determined for each approach that relevant organizations implement to rectify the effects of human intervention, including alien species management strategies.

5.e.3 Ogasawara Islands Natural World Heritage Nominated Property Scientific Council

The nominated property comprises a complex oceanic island ecosystem characterized by a disharmonic species composition in which diverse species, including alien ones, exert influences upon each other. In managing the nominated property, it is necessary to monitor the site, assess the data gathered, and provide feedback based on the latest scientific knowledge. For this reason, the Ogasawara Islands Natural World Heritage Nominated Property Scientific Council, consisting of experts with extensive knowledge of the nature of Ogasawara, has been established. Its mission is to support the development of management and action plans, review them, and present expert advice regarding the implementation of the various programs.

5.e.4 Ogasawara Islands Natural World Heritage Nominated Property Liaison Committee (the Regional Liaison Committee)

There are 1,882 residents on Chichijima and 438 residents on Hahajima (as of June 1, 2009). Most of the residents live outside the nominated property, making their living in the tourism, agricultural and similar industries. The understanding and cooperation of island residents is absolutely essential for the proper management of the nominated property since it must be coordinated with their daily lives and industries. To this end, the Ogasawara Islands Natural World Heritage Nominated Property Liaison Committee has been established. Its membership consists of government and administrative bodies, tourism associations, NPO's, and other concerned bodies. The Liaison Committee coordinates the sharing of duties among the various constituents and encourages their cooperation in order to facilitate the management of the nominated property.

5.e.5 Efforts by individual organizations

The MOE, the Forestry Agency, the Agency for Cultural Affairs, the Tokyo Metropolitan

Government, administrative organs of Ogasawara Village, and the Regional Liaison Committee, shall act, based on an appropriate division of duties, in accordance with the plans mentioned above and the decisions made by the committees.

5.f Sources and levels of finance

The management of the nominated property is undertaken by the administrative authorities that oversee the various systems, facilities, etc. Sources and levels of funding by each in fiscal 2009 are as listed below.

5.f.1 The Ministry of the Environment

The management of the Wilderness Area, National Park, and National Wildlife Protection Area is carried out by the MOE, for which it has an annual budget of about 375,000,000 yen (about 4.17 million dollars). As for National Park, the Ministry of Environment shares the management with the TMG.

The following items are included in the budget above:

- The development of adaptive conservation management systems
- Scientific research and habitat improvements for *Columba janthina nitens* and threatened insects
- Protection and population increase of *Pittosporum parvifolium*, *Rhododendron boninense*, and other threatened plant species
- Prevention and eradication of green anoles, cane toads, and other alien species
- Installation of fences to keep out feral cats and feral goats
- Management of black rats
- Studies for countermeasures against Bischofia, feral cats, and invasion by other alien species, etc.
- Management and maintenance of the Ogasawara Ranger Office for Nature Conservation
- Expenses necessary for patrolling the areas

The budget above is wholly funded by the national government and the necessary budget will continue to be provided.

5.f.2 The Forestry Agency

The Forest Ecosystem Reserve, which occupies about 80% of the nominated property, and the surrounding national forests are under the jurisdiction of the Forestry Agency. The Agency has an annual budget of about 157,000,000 yen (about 1.74 million dollars).

The following items are included in the budget above:

- Scientific research and habitat improvements for *Columba janthina nitens*
- Patrolling for the purpose of protecting and conserving threatened wild plants and animals
- Scientific studies of *Buteo buteo toyoshimai* and *Carduelis sinica kittlitzi*
- Eradication and monitoring of alien plants such as Bischofia, Casuarina (*Casuarina equisetifolia*) etc.
- Analysis of alien plants distribution using aerial photographs Expenses necessary for patrolling the areas

In addition, studies are conducted (30,000,000 yen annually; about 330 thousand dollars) into effective measures against alien species that involve the interactions between invasive alien species and native species in the forest ecosystem of the nominated property.

The budget above is wholly funded by the national government and the necessary budget will continue to be provided.

5.f.3 The Tokyo Metropolitan Government

The management and maintenance of the National Park are carried out by the TMG in conjunction with the MOE, for which there is an annual budget of about 503,638,000 yen (about 5.6 million dollars).

The following items are included in the budget above:

- Management of natural park facilities
- Maintenance of natural park facilities
- Patrolling, guiding visitors
- Promoting ecotourism (training of nature guides licensed by the TMG)
- Alien species countermeasures (elimination of feral goats from Anijima and Ototojima)
- Vegetation restoration (Mukojima, Nakodojima, and Minamijima)
- Natural environment monitoring studies (Mukojima Island Group, Minamijima, Hahajima Sekimon area, and Anijima)
- Conservation and population increase of threatened plants
- Natural environment surveys of peripheral islands
- Awareness promotion for nomination as a World Natural Heritage Site
- Research on short-tailed albatross

The budget above is supplied through the Ogasawara Islands Development Project (half of the project funds comes from the national government, and the other half from the TMG) as well as through funds independently provided by the TMG. The necessary budget will

continue to be provided.

5.f.4 Ogasawara Village

The local administrative government of Ogasawara Village undertakes campaigns to help local residents understand the importance and value of the natural environment of Ogasawara and to raise awareness of the need for individuals to take steps to conserve their precious natural environment and live in harmony with it. For this purpose, the village has an annual budget of about 6,285,000 yen (about 70 thousand dollars).

The following items are included in the budget:

- World Natural Heritage Site nomination promotion projects
- Expenses for resident volunteers to eradicate alien species
- Public relations expenses

The budget above is wholly funded by the Village funds and the necessary budget will continue to be provided.

5.g Sources of expertise and training

5.g.1 The Ministry of the Environment

The Ogasawara Ranger Office for Nature Conservation, under the MOE's Kanto Regional Environment Office, is staffed with employees well-versed in the nature protection systems and conservation management techniques necessary for the conservation and management of the nominated property. The staff provide expert advice to contractors and project administrators concerning approval procedures required by the relevant laws and regulations (such as the Natural Parks Law) and to implement nature restoration projects or programs for the protection and breeding of endemic fauna and flora.

The Office also conducts awareness-raising activities such as nature tours and training volunteer rangers.

The Office staffs seek advice from outside specialists and universities as necessary, thereby securing higher levels of expertise.

◆ Study groups to facilitate duties

Names of study groups	Topics
Wildlife Conservation Study Group, *Columba janthina nitens* Working Group	Studies concerning how to protect and breed for *Columba janthina nitens* (protection of habitats and breeding sites, etc.).

Wildlife Conservation Study Group, Albatross Working Group	Studies concerning how to protect and breed for albatrosses (building of new nesting areas, etc.)
Threatened Wild Flora and Fauna Preservation and Repopulation Study Group	Studies concerning how to protect and breed for threatened flora (commissioned).

5.g.2 The Forestry Agency

The Kanto Regional Forest Office and National Forest Division, Ogasawara General Office of Ministry of Land, Infrastructure, Transport and Tourism are staffed with employees well-versed in the systems and techniques necessary for the conservation and management of forests and wildlife. These staff provide the expert advice needed in the proper management of national forests in accordance with the Forest Law and other laws and regulations pertinent to the administration and management of national forests.

Over the course of their work in managing the Ogasawara Islands Forest Ecosystem Reserve, implementing measures to protect threatened wildlife species (such as *Columba janthina nitens*), and eradicating alien plants, the staff seek advice from outside specialists and universities as necessary, in order to secure higher levels of expertise.

◆ Study groups to facilitate duties

Names of study groups	Topics
The Ogasawara Islands Forest Ecosystem Reserve Preservation and Management Committee	Studies on how to conserve and manage the unique and primitive nature of the Ogasawara Islands for future generations in a healthy state (preservation and management plans, management and use).
Threatened Wildlife Protection and Management Review Committee	Studies to examine the current status of threatened wildlife species such as *Columba janthina nitens* (concrete methods including banding survey, habitat surveys, etc.)
Committee for Increasing Plants for *Columba janthina nitens* and others	Studies on how to compile breeding techniques of the native plants that *Columba janthina nitens* and other animals feed on in a manual.
Endemic Forest Ecosystem Restoration Review Committee	Studies on eradication of Bischofia and Casuarina etc. to restore endemic ecosystems (monitoring methods, basic concepts for eradication, etc.

5.g.3 The Tokyo Metropolitan Government

The Natural Environment Division and Ogasawara Islands Branch Office, TMG are staffed with employees well-versed in the nature protection systems and conservation management techniques necessary for the conservation and management of the nominated property. These employees manage and maintain natural park facilities, carry out nature restoration

projects, programs for the protection and breeding of threatened fauna and flora: they handle permission and approval procedures based on the Natural Parks Law.

The Office staffs seek advice from outside specialists as necessary, thereby securing higher levels of expertise.

◆ Study groups to facilitate duties

Names of study groups	Topics
Study Committee for feral goat eradication in Ogasawara National Park Anijima /Ototojima	Eliminate feral goats efficiently from Anijima and Ototojima. and minimize the project's environmental impact.
Ogasawara National Park Hahajima Sekimon Environment Monitoring Group (specialist consultants)	Monitors vegetation and soil around travel routes and the status of use, studies the current rules, impact caused by use, and other matters necessary to realize proper use and protection of the natural environment.
Minamijima Monitoring Review Committee	Studies the natural environment of Minamijima, the impact of visitation, and vegetation restoration and alien species countermeasure projects. Also considers research items and monitoring system.
Ogasawara National Park Mukojima Island Group Vegetation Restoration Study Committee	Evaluates the restoration of vegetation after feral goats have been cleared from Mukojima and Nakodojima, identifies issues and reviews them.
Ogasawara National Park Nakodojima Vegetation Restoration Measurement and Design Committee	Vegetation destruction and soil erosion advanced even after feral goats were eradicated from Nakodojima For this reason, in order to establish the basement for natural vegetation restoration, the Committee reviews the issues related to the establishment of the vegetation restoration facility and monitoring needed.

5.g.4 Ogasawara Village

The Ogasawara Village Office is staffed with specialists who provide local residents with accurate information on the conservation and management of the nominated property, coordinate with other administrative agencies, and promote conservation activities that can only be carried out in the community.

◆ Study groups and organizations

Names of study groups	Topics
Ogasawara Ecotourism Association	Discusses ways of creating and promoting forms of ecotourism unique to Ogasawara based on consensus by the entire community
Ogasawara Cat Liaison Committee	Studies and coordinates with relevant organizations concerning protective measures in

	the breeding period of *Columba janthina nitens.*

5.h Visitor facilities and statistics

The number of visitors to the Ogasawara Islands (including tourists and returning residents) is shown in table 5-5. A survey conducted in 2004 indicates, as one of the characteristics of tourists to Ogasawara, that many are relatively young, mainly in their 20's or 30's. Tourists 24 to 40 years of age account for over half of all visitors. In addition, 30% of tourists to Ogasawara have been there at least once before, a phenomenon particularly prominent in people in their 30's and 40's.

More than half of the tourists to Ogasawara list the beauty of the natural environment as the reason for visiting. A large proportion of tourists list marine activities such as diving and whale watching, and "on-land" activities like guided tours, trekking, night tours, and historic battle site tours as their reasons for visiting. This demonstrates that many tourists come hoping not only to enjoy the natural scenery, but to do things actively in natural surroundings (Japan Travel Bureau Foundation, 2006).

Table 5-5 Number of Visitors to Ogasawara (fiscal year (FY) base)

	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008
Overall Visitors using Ogasawara Maru (regular liner) (Tokyo - Chichijima)	22,856	21,211	21,680	22,539	24,755	22,906
(Of them, visitors for sightseeing purpose)	(15,012)	(13,361)	(13,986)	(14,367)	(15,981)	(14,619)
Visitors using Sightseeing ship	2,152	2,683	2,399	2,422	1,991	2,554
Grand Total	25,008	23,894	24,079	24,961	26,746	25,460
(Of them, visitors for sightseeing purposes)	(17,164)	(16,044)	(16,385)	(16,789)	(17,972)	(17,173)
Over all visitors using Hahajima Maru (regular liner) (Chichijima - Hahajima)	9,048	8,550	8,706	8,509	8,951	8,783
(Of them, visitors excluding the residents)	(7,145)	(6,595)	(6,698)	(6,095)	(5,596)	(5,388)

(Industries Division, Ogasawara Village)

5.h.1. Local museums and visitor centers

Chichijima has the Ogasawara Visitor Center, the Ogasawara Subtropical Branch of Tokyo Metropolitan Agricultural Experiment Station, the Ogasawara Fisheries Research Center, and the Ogasawara Marine Center, all of which tourists can visit freely.

5.h.1.1 The Ogasawara Visitor Center (Tokyo Metropolitan Government)

The Visitor Center exhibits the history of the Ogasawara Islands since their initial formation, as well as examples of beautiful seascapes, rare plants and animals. It provides information on marine life, and information of conservation efforts, using models, preserved specimens, visual images, panels, and explanations by Center employees. The Center also hosts a variety of exhibits, lectures, hands-on workshops, and nature tours. The displays and events of the center not only promote a deeper appreciation and understanding of Ogasawara's natural environment, they can also be enjoyed by children and adults alike. Displays are open for viewing at no charge.

◆ Overview of the facility:

Address:	Ogasawara-mura, Aza Nishi-machi, Tokyo
Year of opening:	1988
Structure and size:	Single floor, reinforced concrete; 924.12 m^2 (floor area)
Items on display:	Guide to the islands (entrance zone), representative displays (Exhibit Room 1), historical and cultural displays (Exhibit Room 2), natural science, conservation, ecotourism displays (Exhibit Room 3), and planned exhibit room
Other:	Multipurpose room, reading room, study room, storage space
Staff:	2-6 people

Visitors to the Center have been on a slight decline in recent years, but for about 60% of the visitors to Ogasawara it is still a central source of information (Table 5-6).

Table 5-6 Visitors to the Islands and visitors to the Center

	2003	2004	2005	2006	2007	2008
Island visitors	25,008	23,894	24,079	24,961	26,746	25,460
Center visitors	17,783	16,233	15,345	14,289	15,585	14,498
Ratios	71.1%	67.9%	63.7%	57.2%	58.3%	57.3%

(TMG)

5.h.1.2 Other facilities

1. The Ogasawara Subtropical Branch of Tokyo Metropolitan Agricultural Experiment Station

The Ogasawara Subtropical Agriculture Center is run by the TMG. Since its inception in 1970, it has been a center for promoting agriculture in Ogasawara, undertaking various experimental researches related to advancements in the production technologies of brand-name agricultural products, stable in-house cultivation technologies, the selection and introduction of superior seedlings, and the prevention of pests such as the East African land snail. These technologies in effect give something back to farm producers and Tokyo residents. The Center also places examples of cultivation methods on display and holds training courses for farmers to help them achieve more stability in the management of their farms as well as higher levels of productivity. In addition, the Center stores specimens of endemic species that grow on the Ogasawara Islands, introduces and grows garden crops suited to the area, and introduces, grows, and displays tropical plants useful as genetic resources. The greenhouses, gardens and palm grove on display are open to public at no charge.

◆ Overview of the facility:

Address	Ogasawara Subtropical Agriculture Center: Chichijima Komagari, Ogasawara-mura, Tokyo Livestock Guidance Center: Hahajima Aza Motochi, Ogasawara-mura (main facility), Aza Hyougidaira (No. 2 Grounds) Farm Management Training Center: Hahajima Aza Hyougidaira, Ogasawara-mura, Tokyo
Grounds	Ogasawara Subtropical Agriculture Center: 189,000m^2 (20,000 m^2 of which is garden space on display) Livestock Guidance Center: 42,343 m^2 (15,000 m^2 of which is grazing area) Farm Management Training Center: 14,326 m^2 Total: 245,670 m^2
Facilities	Ogasawara Subtropical Agriculture Center: 3,885 m^2 Greenhouses (RC): 10; 2,778 m^2 (418 m^2 of which are on display) Greenhouses (plastic): 16; 1,107 m^2 Farm Management Training Center: 1,354 m^2 Greenhouses (RC): 4; 477 m^2 Greenhouses (plastic): 11; 877 m^2 Livestock Guidance Center (Manure processing plant, etc.): 638 m^2
No. of staff	Ogasawara Subtropical Agriculture Center: 1 director, 7 regular employees Livestock Guidance Center: 3 employees; Farm Management Training Center: 2 employees; Total: 13 employees
No. of facility visitors	12,000

2. The Ogasawara Fisheries Research Center

Since its establishment in 1973, the Ogasawara Fisheries Center has been a base center for promoting the fisheries industries in the Ogasawara Islands marine area. It has served in the development of fishing grounds and the improvement and promotion of fishing equipment and methods, and as a research and teaching facility that places an emphasis on the conservation and management of marine resources and the development of artificial culture technologies. Furthermore, it is responsible for operating a land-based radio station designed to help keep the professional fisheries operations stable. The Center responds to requests and inquiries from fishermen, ordinary citizens, and students concerning specific technical questions and general guidance. The Center also has programs to raise knowledge and awareness about fish and fisheries, to protect natural environments and promote the fisheries industry. The Center makes its cultivation wing available to the general public as a kind of aquarium.

◆ Overview of the facility:

Address	Chichijima Aza Kiyose, Ogasawara-mura
Grounds	6,427 m^2
Facilities	Control wing/radio station: 323 m^2 Work wing: 111 m^2 Diving storehouse: 24 m^2 Cultivation wing (aquarium): 314 m^2 Chlorella wing: 240 m^2 Pump room/elevated tank wing: 46 m^2 Feed processing wing: 126 m^2 Temporary power generator room: 49 m^2
No. of staff	Fishery researchers: 5 employees; land radio operators: 3 employees; fishery research and teaching crew: 9 employees Total: 17 employees
No. of facility visitors	6,099

3. The Ogasawara Marine Center

The Ogasawara Marine Center was established in April of 1982 by the Tokyo Marine Environment Conservation Society, and was handed over to Ogasawara Village in April of 2001. At present, it is operated and managed by the NPO Everlasting Nature of Asia. Since its founding, the Center has focused on research into green turtles, humpback whales, and other marine life. Since April of 2006 it has focused on research, museum display work, educational/awareness campaigns, and museum installation/maintenance. The Center accepts many volunteers, trainees, and interns, whose number now exceeds 500 annually.

◆ Overview of the facility:

Address	Chichijima Aza Byoubutani, Ogasawara-mura
Grounds	1913.43 m^2
Facilities	Display area: 522 m^2 Cultivation tank: 221.43 m^2 Pump room: 32 m^2
No. of staff	1 director, 1 regular employee, 2 part-time employees Total: 4 employees
No. of facility visitors	About 3,500 annually

5.h.2 Trails, guides, signs, and explanatory printed matter

Because ferry liners serving the nominated property only allow direct access to the inhabited Chichijima and Hahajima, visitation is chiefly limited to these two islands. Based on park plans for Ogasawara National Park, walkways and roads are designed and constructed on Chichijima and Hahajima as appropriate.

5.h.2.1. Trails

Use of the facilities in the Natural Park:

The following trails and recreational areas are established and managed appropriately in the nominated property.

Main trails	
・ Chichijima Shore trail	This is the most popular path on Chichijima. Beginning and ending at Kopepe Beach, it traverses the Kominato recreation area and Nakayama-toge mountain pass, and leads to John Beach. Scenic sights along the way include Nakayama-toge mountain pass and Takayama (elevation 228.5 meters). Limestone formations, which are rare on Chichijima can be seen in the John Beach area.
・Denshinyama trail	Beginning and ending at the Miyanohama recreation area, this path leads to Anijima Seto along the sclerophyllous scrub-filled ridge, and reaches the Nagasaki overlook area. There are trenches and searchlights used during World War II and many other war relics. The views of Anijima., Anijima Seto, and Higashijima from Nagasaki are spectacular.
・Mt. Asahi trail	This route starts from Yoake Road at the east side of Mt. Asahi, cuts through a *Schima mertensiana* forest, then forks into two paths, one leading up Mt. Asahi proper (267 m) and the other up Mt. Asahi's southern ridge (272 m). Trekkers can see threatened endemic plant species like *Santalum boninense* and *Juniperus taxifolia* along the way. The view of Futami Port from the overlook at the tip of the island is

	stunning.
・Hatsuneura trail	This path begins halfway along Yoake Road leads through sclerophyllous scrub, and down to Hatsuneura Beach, which is the main breeding ground for green sea turtles on Chichijima. Hatsuneura Beach has a well-developed seaside forest made up of *Calophyllum inophyllum*, *Terminalia Catappa L.* and *Hernandia nymphaeifolia* trees.
・Minamizaki trail	This path takes visitors to the coastwise areas of Miyukinohama and Nankinhama as well as from Omoto Bridge to Minamizaki, the southernmost point on Hahajima. There are several side paths along the way. The side paths lead to Omoto Beach, Horaine Coast, Wai Beach, and other private beaches, in addition to Kofuji, a hill (86.3 m) with a view of the southern part of Hahajima. and adjacent islands.
・ Hahajima. ridge trail	This is a round route that begins from Motomachi Okimura Community area, and leads up Mt. Chibusa (462.6 m), the tallest mountain on the Ogasawara Archepelago. Many endangered endemic plant species grow along the paths, such as *Melastoma tetramerum* var. *pentapetalum* and *Dendrocacalia crepidifolia*.
Recreation areas	
・Mt. Mikazuki recreation area	This recreation area is located at Mt. Mikazuki (204 m) on the northwest side of Chichijima, close to the community area. There are toilets, and rest house. It is an excellent spot to view Futami Port and Anijima, as well as the sunset, which attract many visitors.
・Sakaiura recreation area	This recreation area is located at the east corner of Futami Port and noted for its beautiful seaside forest of Alexandrian laurel and tropical almond trees. The remains of the *Hinko Maru*, a ship bombed and run aground by Allied forces during the World War II, are slightly rising out of the water.
・Mt. Chuosan recreation area	This recreation area is at Mt. Chuosan (317.9 m), which literally means “central mountain”, is almost at the center of Chichijima. All of Chichijima can be viewed from its peak. Near the summit there is a rusted radar mount and a pillbox. The endangered bird *Columba janthina nitens* occurs in this area.
・Kominato recreation area	This area is in Kominato, which has the largest beach on Chichijima. There is a well-developed seaside forest of Alexandrian laurel and tropical almond trees. Pillow lava can be seen along the seashore, which makes the area a center for geological and topographical observation. Many tourists visit this site during the national holiday and summer vacation.
・ Miyanohama Beach recreation area	This recreation area is on Miyanohama, a beach on the north side of Chichijima facing Anijima Seto. It is also the starting point for the Denshinyama trail. Because the beach is an inlet and close to the community area, it is popular with families. The inlet is rich in coral and tropical fish, making it a popular spot for snorkeling as well.
・ Miyukinohama Beach recreation area	Located in the center of Hahajima, the whole of Miyukinohama Beach has been made into a recreation area. It is a spot for visiting the Marine Park, gazing at adjacent islands in the Hahajima Island Group, and whale watching. Nummulites can be seen on the beach.
・ Samegasaki recreation	This recreation area is located in Samegasaki on the tip of Oki

area	Harbor nearby the local community of Okimura. It is a good look out point for sunset, whale watching, or viewing adjacent islands of Hahajima.

5.h.2.2. Explanations from guides, signs, and printed matter

Many private companies have begun to offer guided tours since whale watching tours began in Ogasawara in 1988. There are tours for whale watching off the waters of Chichijima and trekking on Hahajima.

There are about 25,000 visitors to Chichijima annually, 6,000 - 9,000 of which go on to visit Hahajima. Most of the tourists who visit Ogasawara join eco-tours offered by Ogasawara's tourism businesses.

There are 54 tourism business operators that offer guided tours on land and sea. Almost all businesses are individual operators. Aside from diving companies, there are few major businesses that employ multiple guides.

A number of guidebooks and pamphlets related to the nominated property have been published by public organizations. The main ones are as follows:

Table 5-7 Publications and other sources of information related to the nominated property

Title	Publisher
What we can do for Ogasawara's natural environment	MOE
Nature Conservation Projects for Ogasawara Islands Working plans in the past and now on: For the inscription of Ogasawara Islands as World Natural Heritage	MOE
The illegal kayaker: Green anoles	MOE
Animals introduced into the Ogasawara Islands: Green anoles	MOE
Animals introduced into the Ogasawara Islands: Cane toads and bullfrogs	MOE
Nature we must leave for future generations: The Ogasawara Islands Forest Ecosystem Reserve	Kanto Regional Forest Office, Forestry Agency (MAFF)
Ogasawara's national forests: The protection of threatened wild fauna and flora	Kanto Regional Forest Office, MAFF
Natural Monuments of Japan	Monuments and Sites Division, Cultural Properties Department, Agency for Cultural Affairs
Ogasawara Nature Guide: The beauty and mystery of the oceanic Ogasawara Islands	TMG

Ogasawara National Park leaflet	TMG
Nature of the Ogasawara Islands "Footprints of Evolution through Immeasurable Time": Towards Inscription on the World Heritage List	TMG
Ogasawara 2008: 40 years of history	TMG Ogasawara Village
Towards the listing of Ogasawara as a World Natural Heritage Site	Ogasawara Village
Eco-tourism Ogasawara	Ogasawara Village
Ogasawara Rulebook (2005 Edition)	Ogasawara Ecotourism Association
Newsletter of the Ogasawara Nature Information Center	Ogasawara Islands Natural World Heritage Nominated Property Regional Liaison Committee
Ogasawara ecosystem management manual for restoring the ecosystem of Ogasawara	Forestry and Forest Products Research Institute
The culture and nature of Ogasawara	Tokyo Metropolitan University
Ogasawara Nature Information Center http://ogasawara-info.jp/isan.html	MOE
Ogasawara Ecotourism http://www.eco-ogasawara.com/	Ogasawara Village

5.h.3. Lodging facilities

The main centers for lodging are on Chichijima and Hahajima. Camping is prohibited by the Natural Parks Law and by Ogasawara Village ordinances, so visitors to Ogasawara must stay in a lodging facility within the islands. As of August of 2008, there were 54 lodging facilities on Chichijima and 15 on Hahajima (Ogasawara Islands Branch Office, TMG, 2008).

While these lodging facilities are ideally capable of accommodating 1,100 persons per day, this capacity is sufficient due to the fact that the only way to get to the islands is by ferry, and there are a mere 25,000 people who visit the islands per year.

Table 5-8 Number of lodging facilities and capacities

location	No. of lodging facility	occupancy
Chichijima	54	1,008
Hahajima	15	181

(Ogasawara Islands Branch Office, TMG, 2008)

Table 5-9 Number of lodgers

year	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007

No. of Lodging user	78,334	78,696	71,933	76,397	85,472	86,610
Overnight stay in ship*	1,104	1,113	491	487	529	373

*: The regular liner *Ogasawara Maru*

(Ogasawara Islands Branch Office, TMG, 2008)

5.h.4. Restaurants or refreshment facilities.

Outside the nominated property, there are 54 eating and drinking establishments on Chichijima and eight on Hahajima (Ogasawara Islands Branch Office, TMG, 2008).

5.i Presentation and promotion of the property

Ecotourism and other ventures that benefit both nature and the community development shall be proactively pursued so as to ensure that the value of the nominated property is properly managed while sustaining people's social, productive, and economic activities in the future. In order to achieve this, awareness programs directed at visitors and service providers regarding the concept of ecotourism and its rules shall be improved further, and nature guides to facilitate these eco-tours shall continue to be trained.

In addition, information is provided to users of the nominated property about the value of nature, etc. of the Ogasawara Islands through exhibits in the visitor facilities, explanations by guides, and signs posted at major pathways and recreation areas used by visitors as listed in 5.h. above.

In Ogasawara, there are many rules that guides voluntarily abide by (i.e. "autonomous rules") when conducting eco-tours. In the Ogasawara Islands Tourism Promotion Plan (2000), Ogasawara Village places ecotourism as its center policy for encouraging tourism. Based on this plan, in 2002 the Ogasawara Ecotourism Association was founded with a membership made up of tourism-related organizations. The association created the *Ogasawara Rulebook*, which lists various self-imposed codes of conduct, as well as the "Master Plan for Ecotourism". Through these activities, the Commission explores unique modes of ecotourism for Ogasawara and asks that island residents, guides, etc. strictly follow established rules.

5.j Staffing levels

Numbers of staff for professional, technical, and maintenance work are as follows:

(1) Ministry of Environment

Kanto Regional Environment Office of Japan

National park and park facilities division 2 persons

Wildlife division 2 persons

Ogasawara Ranger Office for Nature Conservation 5 persons

(2) Forestry Agency

Kanto Regional Forest Office

Policy department 4 persons

Office of Ogasawara Islands forest ecosystem conservation 1 person

Policy division 3 persons

Extension division 3 persons

Ministry of Land, Infrastructure, Transport and Tourism

National Forests Division, Ogasawara Integrated Office 4 persons

(3) Tokyo Metropolitan Government

Natural Environment Division, Bureau of Environment 5 persons

Civil Section, Ogasawara Islands Branch Office 13 persons

Office of Education 2 persons

(4) Ogasawara Village

General Affairs Division, Policy Office 4 persons

Board of Education 4 persons

6. Monitoring

6.a Key indicators for measuring the state of conservation

6.b Administrative arrangements for monitoring property

6.c Results of previous reporting exercises

6.a Key indicators for measuring the state of conservation

In order to measure the state of conservation of the nominated property, scientific studies, research and long-term monitoring is conducted to collect the basic data necessary for proper management.

The Ministry of the Environment (MOE) has set up about 1,000 monitoring sites throughout Japan to gather fundamental environmental data over the long term for the purpose of detecting and understanding adverse qualitative or quantitative changes in the country's natural environment as quickly as possible. From the standpoint of promoting sustainable management of forests, the Forestry Agency has been studying the status of trees and understory vegetation over the long term to detect any changes in biodiversity, forest ecosystem productivity, and function of forests relating to carbon cycle, by setting up about 15,700 sampling plots systematically within the country. As the Ogasawara Islands are home to six of these stations for these surveys, the islands already have in place a foundation for long-term ecosystem observation.

Table 6-1 lists the major indicators thought to be effective in evaluating the state of conservation

6.b Administrative arrangements for monitoring property

For organizations in charge of monitoring, please refer to the contact information for managing authorities listed in Section 8.

6.c Results of previous reporting exercises

Many surveys and studies of the nominated property have already been conducted. Table 6-2 presents an overview of comprehensive papers and reports from surveys and studies with regard to the state of conservation of the nominated property.

Table 6-1 Major indicators for measuring the state of conservation

Category	Contents/Indicator	Frequency	Location of Records
Climate	Weather conditions for Chichijima and Hahajima（atmospheric pressure, precipitation, temperature, humidity, wind direction / velocity, daylight hours）	Daily	Japan Meteorological Agency (JMA)

Category	Contents/Indicator	Frequency	Location of Records
	Weather conditions at Mt. Hastune, Chichijima（temperature, humidity, wind direction /velocity, amount of solar radiation, precipitation, ground temperature, amount of soil moisture）	Irregular （from Aug. 1999）	Yokohama National University
	Weather conditions at Anijima（atmospheric pressure, precipitation, temperature, humidity, wind direction / velocity）	Irregular （from Dec. 2006）	Tokyo Metropolitan Government (TMG)
	Weather conditions at Minamijima（wind direction /velocity, precipitation, ground temperature, amount of soil moisture）	Irregular （from Apr. 2002）	TMG
	Weather conditions at Nakodojima （temperature, precipitation, wind velocity）	Irregular	TMG
Geology and topography	Volcanic activity observation		JMA
Plants	Population/distribution status and rehabilitation of endangered plant species (*Rhododendron boninense*, *Melastoma tetramerum Hayata*, *Calanthe hattorii*, etc.）	Annually	MOE, Kanto Regional Forest Office, Forestry Agency (MAFF) TMG
	Distribution survey of vegetation (National Survey on the Natural Environment)	Every five years	Biodiversity Center of Japan (BIODIC)
	Forests, lower layer vegetation, soil erosion, pest insects, weather damage (Forestry Resources Monitoring Program)	Every five years	MAFF, TMG
	Forest survey in the protected forests (Protected Forest Monitoring Program)	Every five years	MAFF
	Tree census in Sekimon on Hahajima (Monitoring Sites 1000; Forests / Grasslands)	Every five years	BIODIC
Mammals	Distribution survey of mammals (National Survey on the Natural Environment)	Every five - ten years	BIODIC
	Mammal survey in the protected forests (Protected Forest Monitoring Program)	Every five years	MAFF
	Status survey of Bonin flying fox (*Pteropus pselaphon)*	Annually	Board of Education, Ogasawara Village, Institute of Boninology
Birds	Distribution survey of birds (National Survey on the Natural Environment)	Every five to ten years	BIODIC
	Avian survey in the protected forest (Protected Forest Monitoring Program)	Every five years	MAFF

Category	Contents/Indicator	Frequency	Location of Records
	Status survey of short-tailed albatross (*Phoebastria albatrus*)	Annual	MOE, Yamashina Institute for Ornithology
	Status survey of *Columba janthina nitens*	Irregular	TMG
		Annually	Kanto Regional Forest Office, MAFF
		Annually (Monitoring)	MOE
	Status survey of *Buteo buteo toyoshimai*	Irregular	Kanto Regional Forest Office, MAFF
		Until the end of project	TMG
	Status survey of *Apalopteron familiar* and *Carduelis sinica kittlitzi*	Irregular	Kanto Regional Forest Office, MAFF
	Banding survey (*Diomedea nigripes*, *Diomedea immutabilis*, *Sula leucogaster* on Minamijima)	Annually	Ogasawara Islands Branch Office, TMG Institute of Boninology, Yamashina Institute for Ornithology
	Terrestrial birds survey in Sekimon on Hahajima (Monitoring Sites 1000; Forests / Grasslands)	Every five years	BIODIC
	Seabirds survey on Mukojima Island Group (Monitoring Sites 1000; Small Islands)	Every five years	BIODIC
Amphibia / Reptiles	Distribution survey of Amphibia and reptiles (National Survey on the Natural Environment)	Every five to ten years	BIODIC
	Status of egg production of green turtles (*Chelonia mydas*)	Every five to ten years	Industry and tourism division, Ogasawara Village Everlasting Nature
	Green turtles survey in Hastuneura and Kitahastuneura on Chichijima, and on Minamijima （Monitoring Sites 1000;Beaches)	Annually	BIODIC
Freshwater fish	Distribution survey of freshwater fish (National Survey on the Natural Environment)	Every five to ten years	BIODIC
Insects	Distribution survey of insects (National Survey on the Natural Environment)	Every five to ten years	BIODIC
	Insect survey in the protected forest (Protected Forest Monitoring Program)	Every five years	MAFF
	Status survey of endangered insects (*Cicindela bonina*, *Hemicordulia ogasawarensis*, *Indolestes boninensis*, *Rhinocypha ogasawarensis*,*Celastrina*	Annually	MOE

Category	Contents/Indicator	Frequency	Location of Records
	ogasawaraensis)		
	Status survey of *Celastrina ogasawaraensis*	Irregular	MAFF
	Status survey of beetles（endemic longhorn beetles, weevils etc, at Shin-yuhigaoka on Hahajima)	Until end of the project	MOE
	Restoration monitoring for beetles on Ototojima (stag beetles in particular)	Until end of the project	MOE
	Restoration monitoring for insects on Mukojima.	Until end of the project	Ogasawara Islands Branch Office, TMG
Land snail	Distribution survey of land snails (National Survey on the Natural Environment)	Every five to ten years	BIODIC
	Status survey of land snails on each island	Irregular	Tohoku University, Graduate School of Life Sciences
	Status survey of land snails on Anijima and Ototojima	Until end of the project	MOE, Ogasawara Islands Branch Office, TMG
Use	Use of Visitor Center, etc. (Number of visitors to the islands, Visitor Center, the Ogasawara Subtropical Agriculture Center, the Ogasawara Marine Center etc.)	Annually	Ogasawara Islands Branch Office, TMG Ogasawara Village
	Dynamic survey of use of protected forest (Protected Forest Monitoring Program)	Every five years	MAFF

Table 6-2 Results of previous reports

Paper/report title	Summary	Authors/ editors	Publisher
The Nature of Ogasawara (1970)	This volume presents the results of a two year survey (1968-1969) of the Ogasawara Islands Natural Park conducted by a joint team from the TMG and the Ministry of Welfare. The work is in two volumes: one of an explicatory nature, and the other of color photographs. A broad range of topics were surveyed, including climate, topography and geology, plants, land animals, sea animals, and culture.	Takashi Tsuyama & Shigeo Asami	Hirokawa-Shoten

Paper/report title	Summary	Authors/ editors	Publisher
Report on the Current State of the Natural Environment in the Ogasawara Islands, Vols. 1-3 (1980-1982)	This work, which covers a range of topics on the natural environment of the Ogasawara Islands, is an academic and comprehensive report of the contemporary state of the islands. The first year was dedicated to a study of animal status on Chichijima and Hahajima, the second to a study of endemic plant species, microorganisms in the soil, and the topography/geology of those islands, while the third year was dedicated to the plants and topography/geology of Iwoto and Kita-iwoto.	Tokyo Metropolitan University Natural Environment Research Team	Pollution Affairs Bureau, TMG
The Endemic Plants and Vegetation of Ogasawara (1985)	This work is a more detailed study of endemic plant species presented in the report above. It outlines the botanical and geological position of the Ogasawara Islands, and details individual endemic species (and subspecies). It also includes a distribution list of these species for the islands as well as a searchable list for the identification of species.	Mikio Ono & Kiyoshi Okutomi	Aboc Co. (Publishing)
Second Report on the Current State of the Natural Environment in the Ogasawara Islands（1990-1991）	This work reports on the changes to the natural environment that occurred in the decade since the previous survey. It also reports on Anijima and Ototojima, which were not included in the original report.	Ogasawara Research Committee of Tokyo Metropolitan University	Tokyo Metropolitan University
Minami-iwoto Wilderness Area Report (1982)	This was the first report of scientific studies of the natural environment (topography, geology, soil, flora and fauna) of the Minami-iwoto Wilderness Area.		Nature Conservation Bureau, Environment Agency
Report on Natural Environment of Minami-iwoto (2008)	This is a report of natural environment survey, which was conducted on Minami-iwoto for the first time in 25 years. The survey included a wide range of items such as geology, vegetation, flora, mammals, avifauna, insects, land snails, and marine animals.		TMG, Tokyo Metropolitan University (editing)
Report on Natural Environment of Kita-iwoto (2009)	This work reports on animals of Kita-iwoto (forest birds, ecology of small seabirds, impact of rats on breeding behavior of birds, status of land snails, meteorological data, and vegetation).	Institute of Boninology	Natural Park Staff, Civil Section, Ogasawara Islands Branch Office, TMG
Ogasawara Yearly Research Bulletin Nos. 1-31 (1977-2007)	This is a collection of survey and research reports dealing with a variety of natural and social environment-related topics of Ogasawara.		Ogasawara Research Committee of Tokyo Metropolitan University
Ogasawara Research Nos. 1-33 (1977-2007)	Same as above		same as above

Paper/report title	Summary	Authors/ editors	Publisher
An Account of Vegetation in Japan: Okinawa and Ogasawara (1989)	A report of studies on the natural characteristics of Ogasawara, with a focus on vegetation, but also including the climate, topography, geology, soil, etc.	Akira Miyawaki (lead author)	Shibundo Co.

7. Documentatoin

7.a Photographs, Image inventory

7.b Texts relating to protective designation, copies of property management plans and extracts of other plans relevant to the property

7.c Form and date of most recent records or inventory of property

7.d Address where inventory, records and archives are held

7.e Reference list

7.a Photographs, Image inventory

No	Format	Caption	Date	Photographer	Copyright owner	Contact detail of copyright owner	Non exclusive cession of rights
1	jpg	Semifossil of *Mandarina*	2009	H.Mori	H.Mori	Japan Wildlife Research Center	yes
2	jpg	Chichijima Island Group	2009	H.Maruoka	H.Maruoka	same as above	same as above
3	jpg	Mukojima Island Group	2008	T.Hashimoto	T.Hashimoto	same as above	same as above
4	jpg	Boninites in Mukojima Is.	2009	H.Maruoka	H.Maruoka	same as above	same as above
5	jpg	Sclerophyllous scrub	2007	H.Chiba	H.Chiba	same as above	same as above
6	jpg	*Morus boninensis*	2007	H.Chiba	H.Chiba	same as above	same as above
7	jpg	*Juniperus taxifolia*	2009	K.Fukasawa	K.Fukasawa	same as above	same as above
8	jpg	*Callicarpa parvifolia*	2006	E.Nakajima	E.Nakajima	same as above	same as above
9	jpg	*Phoebastria nigripes*	2009	H.Chiba	H.Chiba	same as above	same as above
10	jpg	*Cryptoblepharus nigropunctatus*	2009	H.Mori	H.Mori	same as above	same as above
11	jpg	Green turtle which returns to the sea after laying eggs	2009	H.Chiba	H.Chiba	same as above	same as above
12	jpg	*Stenomelania boninensis*	2009	H.Imai	H.Imai	same as above	same as above
13	jpg	*Boninagrion ezoin*	2009	H.Mori	H.Mori	same as above	same as above
14	jpg	*Chlorophorus kobayashii*	2009	H.Mori	H.Mori	same as above	same as above
15	jpg	*Phoebastria immutabilis*	2007	M.Takiguchi	M.Takiguchi	same as above	same as above
16	jpg	Corals	2008	Y.Takahuji	Y.Takahuji	same as above	same as above
17	jpg	*Mandarina suenoae*	2009	H.Mori	H.Mori	same as above	same as above

7.b Texts relating to protective designation, copies of property management plans and extracts of other plans relevant to the property

Appendix 4: Legal instruments of protection applying to the nominated property

Appendix 1 & 5: Management plan and other plans applying to the nominated property

7.c Form and date of most recent records or inventory of property

Article	Content	Implementing organization	Form	Date
Topography & geology	Geological map（1/50,000）	Geological survey of Japan, AIST	Map	
Climate	**Automated Meteorological Data Acquisition System（AMeDAS）** In order to observe weather conditions such as rain, wind, snow, observations at manned stations cover amonut of precipitation, wind direction/speed, air temperature, sunshine duration. All of these elements are observed automatically.	Japan Meteorological Agency	http://www.data.jma.go.jp/obd/stats/data/mdrr/index.html	every 10 minutes - hours
	AMeDAS Annual Report (Amonut of precipitation, wind direction/speed, air temperature, sunshine duration)	Japan Meteorological Agency	CD－ROM	2008
	Radar-AMeDAS rainfall	Japan Meteorological Agency	DVD	2008
Plant	Vegetation map (satellite islands in Hahajima Is.) （Report on the plan for Promotion for the Nature Restoration in Ogasawara ）	Ministry of the Environment	http://ogasawara-info.jp/pdf/h16_houkoku2/02_h16_2.pdf	2006
	Vegetation map (Chichijima, Hahajima Is. and satellite islands in Chichijima Is.) （Report on the lan for promotion for the nature restoration in Ogasawara ）	Ministry of the Environment	http://ogasawara-info.jp/pdf/h17_houkoku/02_h17.pdf	2007
	National Survey on the Nature Environment - vegetation survey, etc.	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2001
	Revised: Threatened Wildlife of Japan -Red list - Plant I (vascular plant)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2007

Article	Content	Implementing organization	Form	Date
	Revised: Threatened Wildlife of Japan -Red list - Plant II (nonvascular plant)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2007
Mammal	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (mammal)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002
	Threatened Wildlife of Japan - Red list revision. - mammalia	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2007
Aves	Revised: Threatened Wildlife of Japan - Red list - Aves	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2006
	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Aves)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2004
Amphibia / Reptile	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Amphibia / Reptile)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2001
	Revised: Threatened Wildlife of Japan - Red list - Amphibia / Reptile	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2006
Insect	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (beetles)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002
	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Cicadas & Aquatic Hemiptera)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002
	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Butterflies)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002

Article	Content	Implementing organization	Form	Date
	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Dragonflies)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002
	Revised: Threatened Wildlife of Japan - Red list - Insect	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2007
Arachnida / Myriapoda	Revised: Threatened Wildlife of Japan - Red list - Arachnida / Myriapoda	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2006
Land & Fresh Water Mollusks	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Land & Fresh Water Mollusks)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002
	Revised: Threatened Wildlife of Japan - Red list - Land & Fresh Water Mollusks	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2007
Fish	Distribution Map The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (Fresh water fish)	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/kiso/fnd_f.html	2002
	Revised: Threatened Wildlife of Japan - Red list - Brackish /Fresh water Fish	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2007
Crustacean	Revised: Threatened Wildlife of Japan - Red list revision. - Crustacean, etc.	Biodiversity Center of Japan, Ministry of the Environment	http://www.biodic.go.jp/rdb/rdb_f.html	2006

7.d Address where inventory, records and archives are held

- Biodiversity Center of Japan, Nature Conservation Bureau, Ministry of the Environment
  5597-1, Kenmarubi, Kamiyashida, Fujiyashida City, Yamanashi Prefecture 403-0005
  TEL: +81-555-72-6031 FAX: +81-555-72-6035

- Makino Herbarium, Tokyo Metropolitan University
  1-1, Minami Ohsawa, Hachijyo City, Tokyo, 192-0397

TEL: +81-42-677-1111

- Koishikawa Botanical Gardens, Botanical Gardens, Graduate School of Science, The University of Tokyo
  3-7-1 Hakusan, Bunkyo-ku,Tokyo 112-0001
  TEL: +81-3-3814-2625 FAX: +81-3-3814-0139

- Kanagawa Prefectural Museum of Natural History
  499 Iryuda, Odawara City, Kanagawa Prefecture 250-0031
  TEL: +81-465-21-1515 FAX: +81-465-23-8846

- Ogasawara Visitor Center
  Nishi-machi, Chichijima, Ogasawara Village, Tokyo 100-2101
  TEL: +81-4998-2-3001

- Yamashina Institute for Ornithology
  115 Konoyama, Abiko City, Chiba Prefecture 270-1145
  TEL: +81-4-7182-1101 FAX: +81-4-7182-1106

- Institute of Boninology
  Miyanohama, Chichijima, Ogasawara Village, Tokyo 110-2101
  TEL: +81-44998-2-3779 FAX: +81-4998-2-3779

- Ogasawara Wildlife Research Society
  Okumura, Chichijima, Ogasawara Village, Tokyo 110-2101
  TEL: +81-44998-2-2206 FAX: +81-44998-2-2206

7.e Bibliography

(Note: English translations of titles in Japanese are tentative, unauthorized, and only for information purposes)

Description

- **Description of Property**

Geology and topography

Ishizuka, O., J. Kimura, Y. Li, R. Stern, M. Reagan, R. Taylor, Y. Ohara, S. Bloomer, T. Ishii, U. Hargrove and S. Haraguchi. 2006. Early stages in the evolution of Izu–Bonin arc volcanism: New age, chemical, and isotopic constraints. *Earth Planet,* Sci. Lett., 250, 385-401.

Ishizuka, O., R. N. Taylor, M. Yuasa, J. A. Milton, R. W. Nesbitt, K. Uto and I. Sakamoto. 2007. Processes controlling along-arc isotopic variation of the southern Izu-Bonin arc. *Geochem. Geophys. Geosyst.*, 8, Q06008, doi:10.1029/2006GC001475.

Kodaira, S., T. Sato, N. Takahashi, M. Yamashita, T. No and Y. Kaneda. 2008. Seismic imaging of a possible paleoarc in the Izu-Bonin intraoceanic arc and its implications for arc evolution processes. *Geochem. Geophys. Geosyst.*, 9, Q10X01, doi:10.1029/2008GC002073.

Matsumaru, K. 1984. Larger foraminiferal associations useful for the correlation of the Eocene and Oligocene sediments in the Ogasawara Islands, Japan, and an examination of *Nummiltes boniensis* HANZAWA. *Benthos '83 2nd international symposium on benthic foraminifera* (Pau, April 1983), 415-422.

Petersen, J. 1891. Beiträge zur petrographie von Sulphur Island, Peel Island, Hachijo und Mijakeshima. Jahrbuch der Hamburgischen Wissenschaftl. *Anstalten*, 8, 1-59.

Stern, R. J. and S. H. Bloomer. 1992. Subduction zone infancy: examples from the Eocene Izu-Bonin-Mariana and Jurassic California. *Geological Society of America Bulletin*, 104, 1621–1636.

Suyehiro, K., N. Takahashi, Y. Ariie, Y. Yokoi, R. Hino, M. Shinohara, T. Kanazawa, N. Hirata, H. Tokuyama and A. Taira. 1996. Continental crust, crustal underplating, and low-Q upper mantle beneath an oceanic island arc. *Science*, 271, 390-392.

Takahashi, N., S. Kodaira, Y. Tatsumi, M. Yamashita, T. Sato, Y. Kaiho, S. Miura, T. No, T. Takizawa and Y. Kaneda. 2009. Structural variations of arc crusts and rifted margins in the southern Izu-Ogasawara arc-back arc system. *Geochem. Geophys. Geosyst*. (in press).

Tatsumi, Y. and S. Maruyama. 1989. Boninites and high-Mg andesites: tectonics and petrogenesis. *In*: A. J. Crawford (Ed). *Boninites and related rocks*, London:Unwyn Hyman, pp. 50-71.

Tatsumi, Y., Shukuno, K. Tani, N. Takahashi, S. Kodaira and T. Kogiso. 2008. Structure and growth of the Izu-Bonin-Mariana arc crust: 2. Role of crust-mantle transformation and the transparent Moho in arc crust evolution. *J. Geophys. Res.*, 113, B02203, doi: 10.1029/2007JB005121.

Umino, S. 2008. The geology and topography of Ogasawara. *The Map Center*, 430, 6-7 (in Japanese).

Umino, S., K. Kanayama, N. Niitsuma, S. Nakano and O. Ishizuka. 2007. Geology of Ogasawara (Bonin) Island group. *Annual meeting of the Geological Society of Japan*, p. 231 (in

Japanese).

Umino, S. and I. Kushiro. 1989. Experimental studies on boninite petrogenesis. *A. J.* Crawford （Ed.）, *Boninites and Related Rocks*, London: Unwyn Hyman, 89-111.

Umino, S. and S. Nakano. 2007. The geology of the Chichijima Islands area. *Geological Map of Japan (1:50,000) Ogasawara Islands (20) No. 2 NG-54-8-13·14*, Geological Survey of Japan, P.71 (in Japanese).

Yuasa, M. and M. Nohara. 1992, Petrographic and geochemical along-arc raviations of volcanic rocks on the volcanic front of the Izu-Ogasawara (Bonin) Arc. *Bulletin of the Geological Survey of Japan*, 43, 7, 421-456.

Climate

Iijima, Y. 2004. The climatic conditions of Ogasawara/hydroclimatic conditions of Ogasawara. *Human society and nature in Ogasawara: Aiming for coexistence of people and nature*, Tokyo Metropolitan University Ogasawara Project 2003, pp. 53-61 (in Japanese).

Iijima, Y., K. Yoshida, H. Iwashita and S. Oka. 2004. Changes in hydroclimatic conditions on Chichijima Island of the Ogasawara Islands seen in potential evaporation. *Annual Ogasawara Research Journal*, 27, 97-104 (in Japanese).

Kato, Y. and T. Utugawa. 1982. The soil of the Ogasawara Islands. *Annual Ogasawara Research Journal*, 6, 53-64 (in Japanese).

Kondo, J. and J. Xu. 1997. Potential Evaporation and Climatological Wetness Index. *Tenki* (Meteorological Society of Japan), 44, 875-882 (in Japanese).

Nakamura, K. and Komabayashi. 1996. *Regions, 8 Southern Islands. In* : K. Nakamura (Ed.), *Nature of Japan*, Iwanami Shoten, 234p (in Japanese).

Oka, S. 1989. *In* : A. Miyawaki (Ed.), *Vegetation of Japan: Okinawa and Ogasawara*, Tokyo: Shibundo (in Japanese).

Oka, S. 2004. Column 3 cloud belt. *Human society and nature in Ogasawara: Aiming for coexistence of people and nature*, Tokyo Metropolitan University Ogasawara Project 2003, pp. 66-68 (in Japanese).

Oka, S., K. Yosida, H. Iwashita, Y. Iijima and T. Satoh. 2000. Interannual variability of ther hydroclimatic envirionment, based on the water balance at Chichi-jima Island in the Bonin (Ogasawara) Islands. *Ogasawara Research*, 26, 15-33.

TMG Ogasawara Office. 2008. *Overview of jurisdiction, 2007 edition* (in Japanese).

Yoshida, K., H. Iwashita, Y. Iijima and S. Oka. 2006. Changes in hydroclimatic conditions on Chichijima Island of the Ogasawara Islands in the 20th century. *Geographical Review of Japan*, 79-10, 516-526 (in Japanese).

Plant

Abe, T. 2006. Colonization of Nishino-shima Island by Plants and Arthropods 31 Years after Eruption. *Pacific Science*, 60(3), 355-365.

Fujita, T., H. Kato and M. Wakabayashi. 2002. Morphological variation and environmental conditions of Syzygium (Myrtaceae) in the Bonin Islands. *Acta Phytotaxonomica et Geobotanica*, 53, 181-199.

Ishida, A., T. Nakano, H. Harayama, K. Yazaki, Y. Osone, S. Kawarasaki, M. Shimizu, S. Matsuki, K. Yamaji and N. Yamashita. 2008. Ecophysilogical Traits in Leaves and Stems of Plants Growing Dry-ridge Sites on the Bonin Islands. *Ogasawara Research*, 34, 9-31 (in Japanese).

Ishida, A., T. Nakano, K. Yamazaki, S. Matsuki, N. Koike, D. L. Lauenstein, M. Shimizu and N. Yamashita. 2008. Coordination between leaf and stem traits related to leaf carbon gain and hydraulics across 32 drought-tolerant angiosperms. *Oecologia*, 156, 193-202.

Ito, M. 1992. Flora. *In*: *Nature of Ogasawara: the Galapagos of the East*, Tokyo: Kokon Shoin, pp. 52-57 (in Japanese).

Ito, M. 1998. Origin and Evolution of Endemic Plants of the Bonin (Ogasawara) Islands. *Res. Pop. Ecol*, 40, 205-212.

Ito, M. and M. Ono. 1990. Allozyme diversity and the evolution of Crepidiastrum (Compositae) on the Bonin (Ogasawara) Islands. *Bot. Mag*, Tokyo 103, 449-459.

Ito, M., J. H. Pak. 1996. Phylogenetic relationships of Crepidiastrum (Asteraceae) of the Bonin (Ogasawara) Islands based on chloroplast DNA restriction site variation. *J. Plant Res*, 109, 277-280.

Ito, M., A. Soejima and M. Ono. 1997. Allozyme Diversity of Pittosporum (Pittosporaceae) on the Bonin (Ogasawara) Islands. *J. Plant Res*, 110, 455-462.

Kato, H. 2004. Endemic plants of Ogasawara. *In*: H. Karube and M. Takakuwa (Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History, Odawara,pp. 21-27 (in Japanese).

Kato, M. and H. Nagamasu. 1995. Dioecy in the Endemic genus Dendrocacalia (Compositae) on the bonin (Ogasawara) Island. *Journal of Plant Research*, 108, 443-450

Katoh, S., H. Kato and N. Kachi. 1998. An analysis of morphological variations and enzyme polymorphism in plants in the genus *Boninia*. *Annual Ogasawara Research Journal*, 22, 41-50 (in Japanese).

Kawakubo, N. 1990. Dioecism of genus *Callicarpa* (verbenaceae) in the Bonin (Ogasawara) Islands. *The Botanical Magazine,* Tokyo 103, 57-66

Kondo, Y., M. Nishide, K. Watanabe and T. Sugawara. 2007. Floral dimorphism in Psychotria boninensis Nakai (Rubiaceae) endemic to the Bonin (Ogasawara) Islands. *The Journal of Japanese Botany*, 82, 251-258.

Matsumoto, K. 2009. The psyllids of Ogasawara Islands, diversity and islands speciation. *The nature and nsects*, 44(6), 21-24 (in Japanese).

Mishio, M. 1992. Adaptations to drougt in five woody species co-occurring on shallow-soil ridges. *Australian J. Plant Physiology*, 19, 539-553.

Mishio, M., N. Kachi and N. Kawakubo. 1997. Physiological characteristics of *Boninia grisea* and *Boninia glabra* (Rutaceae) of Chichijima. *Annual Ogasawara Research Journal*, 21, 51-55 (in Japanese).

Mishio, M., N. Kawakubo and N. Kachi. 2007. Intra-specific variation of leaf morphology and photosynthetic traits in *Boninia grisea* Planchon (Rutaceae) endemic to the Bonin Islands, Japan. *Plant Species Biology*, 22, 117-124.

Miyawaki, A. 1989. *Vegetation of Japan: Okinawa and Ogasawara*, Shibundo Co., Tokyo, 676p (in Japanese).

MOE. 2007. *Revised: Threatened Wildlife of Japan - Red list –Plant I (vascular plant)*, URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Nature Conservation Bureau, MOE. 2004. *Fiscal 2003 Ogasawara Area Nature Revitalization Plan Survey (1): Activity Report* (in Japanese).

Nishide, M., K. Saito, H. Kato and T. Sugawara. 2009. Functional androdioecy in *Morinda umbellata* L. subsp. *boninensis* (Ohwi) T. Yamaz. (Rubiaceae), endemic to the Bonin (Ogasawara) Islands. *Acta Phytotaxomica et Geobotanica*, 60. (in press)

Okutomi, K. 1982. Vegetation of Minami-Iwoto Island. *Conservation reports of Minami-Iwoto wilderness area, Tokyo, Japan*, Nature Conservation Bureau, Environment Agency, pp. 151-189 (in Japanese).

Okutomi, K., T. Iseki, Y. Hioki, K. Kitayama and H. Sumihiro. 1983. Section II: Vegetation of Ogasawara. *In*: *Ogasawara Islands natural environment status report: endemic species of plants and vegetation of the Ogasawara Islands*, Bureau of Environment, TMG, 97-262 (in Japanese).

Ono, M. 1994. *Creatures of Isolated Islands: The Galapagos and Ogasawara*, Tokyo: Iwanami Shoten, 239 (in Japanese).

Ono, M. and J. Kobayashi. 1983. Section I: Endemic plants of Ogasawara. *In*: *Ogasawara Islands natural environment status report: endemic species of plants and vegetation of the Ogasawara Islands*, Bureau of Environment, TMG, 3-93 (in Japanese).

Pemberton, R. W. 1998. The occurrence and abundance of plants with extrafloral nectaries, the basis for antiherbivore defensive mutualisms, along a latitudinal gradient in East Asia. *Journal of Biogeography*, 25, 661–668.

Shimizu, Y. 1984. Comparison of the woody species between the Bonin (oceanic) and the Ryukyu (continental) islands concerning the ecological release of plants in islands. *Ogasawara research*, 11, 25-49.

Shimizu, Y. 1989. The ecological characteristics of oceanic island vegetation as seen on the

Ogasawara Islands. *In*: A. Miyawaki (Ed.), *Vegetation of Japan: Okinawa and Ogasawara*, Tokyo: Shibundo Co., 159-291 (in Japanese).

Shimizu, Y. 1998. *Chronicles of Nature in Ogasawara*, Tokyo: Iwanami Shoten, 162 (in Japanese).

Shimizu, Y. 1999. A 21-year population dynamics in a dry forest at Chichijima in the Bonin Islands. *Japanese Journal of Conservation Ecology*, 4, 175-197 (in Japanese).

Shimizu, Y. 2007. The Galapagos and Ogasawara, the Galapagos of the East: What "Galapagos" means when we say the "Galapagos of the East". *Komazawa University Journal of the Faculty of Arts and Sciences*, 1 (Fascicle I) (in Japanese).

Shimizu, Y. 2008. What constitutes "xeric scrub" in Ogasawara. Tokyo Metropolitan University, *Annual Ogasawara Research Journal*, 31, 1-17 (in Japanese).

Soejima, A. 1995. Speciation of plantlife on islands. *Science of Life: Genetics*, 49(6), 34-40 (in Japanese).

Soejima, A., H. Nagamasu, M. Ito and M. Ono. 1994. Allozyme diversity and the evolution of Symplocos (Symplocaceae) on the Bonin (Ogasawara) Islands. *J. Plant Res*, 107, 245-251.

Sugawara, T., K. Watanabe, H. Kato and K. Yasuda. 2004. Dioecy in Wikstroemia pseudoretusa (Thymelaeaceae) Endemic to thaBonin (Ogasawara) Islands. *Acta Phytotax. Geobot*, 55(1), 55-61

Sugiura, S. 2007. Are anti-herbivore defences of island plants significant? : loss of extrafloral nectaries of oceanic island plants and impacts of introduced ants. *Biological science*, 58(2), 111-114 (in Japanese).

Sugiura, S., T. Abe and S. Makino. 2006. Loss of extrafloral nectary on an oceanic island plant and its consequences for herbivory. *American Journal of Botany*, 93, 491-495.

Takayama, K., T. Ohi-Toma, H. Kudoh and H. Kato. 2005. Origin and diversification of Hibiscus glaber, species endemic to the oceanic Bonin Island, revealed by chloroplast DNA polymorphism. *Molecular Ecology*, 14, 1059-1071.

TMG. 1997. *Fiscal 1997 Ogasawara Airport Environmental Survey* (in Japanese).

Bureau of Environment, TMG. 2007. *Subcontract report for drafting a management plan of world natural heritagethe in the Ogasawara Islands* (in Japanese).

Toyoda, T. 2003. *Flora of the Bonin Islands (Enlarged & Revised)*, Aboc (in Japanese).

Uchiyama, M. and N. Kachi. 1996. The composition of *Lobelia boninensis* communities on Higashijima in the Chichijima Islands. *Annual Ogasawara Research Journal*, 20, 1-31 (in Japanese).

Uchiyama, M., H. Kudoh and N. Kchi. 1996. Demography and life history of a moncarpic prerennial, *Lobelia boninensis*, endemic to Bonin Islands. *Ogasawara Research*, 22, 1-31.

Uchiyama, M. and N. Kachi. 1998. Statistics for *Lobelia boninensis* communities on

Higashijima in the Chichijima Islands. *Annual Ogasawara Research Journal*, 22, 29-40 (in Japanese).

Wright, S. D., G. G. Yong, J. W. Dawson, D. J. Whittaker and R. C. Gardner. 2000. Riding the ice age El Nino? Pacific biogeography and evolution of Metrosideros subg. Meterosideros (Myrtaceae) inferred from nuclear ribosomal DNA. *Proc. Natl. Acad. Sci. USA*, 97(8), 4118-4123.

Yokoyama, J. 2003. Cospeciation of figs and fig-wasps: a case study of endemic species pairs in the Ogasawara Islands. *Population Ecology*, 45, 249-256.

Mammals

Hasuo, Y. 1970. Land animals. *In* : T. Tsuyama and S. Asami (Eds.), *Nature in the Bonin Islands: Commentary*, Tokyo: Hirokawa-Shoten (in Japanese).

Takakuwa, M. 2004. Conditions for the formation of flora and fauna on oceanic islands: The example of Ogasawara. *In*: H. Karube and M. Takakuwa (Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History, Odawara (in Japanese).

Land mammals:

Abe, M., K. Maeda, N. Ishii and H. Sano. 1994. Distribution, feeding habits, and home range of the Bonin flying fox (*Pteropus pselaphon*). *Annual Ogasawara Research Journal*, Ogasawara Research Committee, Tokyo Metropolitan University,18 (in Japanese).

Inaba, M., 2004. *Current status of the Bonin flying fox, Pteropus pselaphon, on Kita-iwoto Island*, Ogasawara Islands Branch Office,TMG (in Japanese).

Inaba, M. 2004. The Bonin flying fox (*Pteropus pselaphon*). *In*: H. Karube and M. Takakuwa (Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History (in Japanese).

Institute of Boninology. 2008. *Fiscal 2007 Bonin flying fox (*Pteropus pselaphon*) Population Monitoring Survey Report* (in Japanese).

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

McConkey, K. R. and D. R. Drake. 2006. Flying foxes cease to function as seed dispersers long before they become rare. *Ecology*, 87(2), 271-276.

MOE. 2007. *Threatened Wildlife of Japan - Red list – mammalian*, URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Suzuki, H., K. Kawakami and T. Fujita. 2008. Flying fox of Minamiiwoto Island,. *Minami-iwoto Natural Environment Survey Report*, pp. 102-117. TMGand Tokyo Metropolitan University (in Japanese).

Marine mammals:

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins and N. Maloney. 2008. SPLASH: Structure of populations, levels of abundance and status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078. *Cascadia Research*, 57.

Darling, J. D. and K. Mori. 1993. Recent observations of humpback whales (*Megaptera novaeangliae*) in Japanese waters off Ogasawara and Okinawa. *Canadian Journal of Zoology*, 71, 322-333.

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

Jefferson, T. A., M. A. Webber and R. L. Pitman. 2008. *Marine mammals of the world. A comprehensive guide to their identification*. Academic Press, p. 573.

Mori, K. 2009. *Stenella longirostris* (Gray, 1828). *The Wild Mammals of Japan*.

Mori, K., H. Abe, M. Suzuki and T. Kubodera. 1999. School structure, distibution and food habits of sperm whales near the Ogasawara Islands, Japan. *Abstracts of 13th Biennial Conference on the Biology of Marine Mammals*, 130.

Mori, K. and M. Yoshioka. 2009. *Tursiops aduncus* (Ehrenberg, 1833). *The Wild Mammals of Japan*.

Mori, K. 2004. Mammals of the sea. In : D. Long and M. Inaba (Eds.), *Ogasawara Handbook*, Nanpoushinsha, 62-64 (in Japanese).

Birds

BirdLife International website. Birdlife EBA Factsheet 147 Ogasawara Islands. URL: http://www.birdlife.org/datazone/ebas/index.html?action= EbaHTMDetails.asp&sid=147&m=0

Chiba H. 1977. Birds of Chichijima in winter. *In*: *Survey report on natural environment of Chichijima, Ogasawara Islands for the road construction plan* (in Japanese).

Chiba, H. 1990. First breeding record of the Bull-headed shrike from the Ogasawara Islands. *Japanese Journal of Ornithlogy*, 38(3). 150-151 (in Japanese).

Chiba, H., K. Kawakami, H. Suzuki and K. Horikoshi. 2007. The Distribution of Seabirds in the Bonin Islands, Southern Japan. *Journal of the Yamashina Institute for Ornithology*, 39, 1-17.

Clements, J. F. 2007. *The Clements checklist of birds of the world Sixth edition*.

Committee for Check-List of Japanese Birds. 2000. *Check-List of Japanese Birds Sixth Revised Edition*.

del Hoyo, J., A. Elliott and J. Sargatal eds. 1992. *Handbook of the Birds of the World Vol.1 Ostrich to Ducks*, Barcelona: Lynx Edicions.

del Hoyo, J., A. Elliott and J. Sargatal eds. 1994. *Handbook of the Birds of the World. Vol.2 New World Vultures to Guineafoul*, Barcelona: Lynx Edicions.

del Hoyo, J., A. Elliott and D. A. Christie eds. 2008. *Handbook of the Birds of the World. Vol.13 Penduline-tits to Shrikes*, Barcelona: Lynx Edicions.

Eda, M., K. Kawakami, H. Chiba, H. Suzuki, K. Horikoshi and H. Koike. 2008. Genetic characteristics of the Black-footed Albatross *Diomedea nigripes* on the Bonin Islands and their implications for the species' demographic history and population structure. *Ornithol Sci*, 7, 109-116.

Hasuo, Y. 1970. Land animals. *In*: T. Tsuyama and S. Asami (Eds.), *Nature in the Bonin Islands: Commentary*, Tokyo: Hirokawa-Shoten (in Japanese).

Higuchi, Y. 1984. List of Birds in Ogasawara Islands, including Iwo Islands and Minamitorishima. *Strix*, 3,73-87 (in Japanese).

Hiraoka T. and Chiba H. 1997. The first record of *Puffinus assimilis* in Japan at the Hahajima island in the Ogasawara Islands. *The Summary of presentation at 1997 annual meeting of the Ornithological Society of Japan*.

Institute of Boninology. 2005. *Research on Albatrosses in Ogasawara: 2005* (in Japanese).

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

Kawakami, K., S. Harada, T. Suzuki and H. Higuchi. 2008. Genetic and morphological differences among populations of the Bonin Islands White-eye in Japan. *Zoological science*, 25, 882-887.

Kawakami, K. and H. Higuchi. 2002. The first record of cavity nesting in the Ogasawara Islands Honeyeater *Apalopteron familiare* on Hahajima, Bonin Islands, Japan. *Ornithol. Sci.*, 1, 153-154.

Kawakami, K. and Higuchi, H. 2003. Interspecific interactions between the native and introduced White-eyes in the Bonin Islands. *Ibis*, 145(4), 583-592

Kawakami, K., H. Suzuki, H. Chiba and K. Horikoshi. 2008. Avifauna of Minamiiwoto Island, the Bonin Islands. *Ogasawara Research*, 33, 111-127 (in Japanese).

Kawakami, K., Y. Yamamoto and K. Horikoshi. 2005. The seabird fauna of Nishinoshima Island, the Bonin Islands, Southern Japan. *Strix*, 23, 159-166 (in Japanese).

MOE. 2006. *Revised: Threatened Wildlife of Japan - Red list – Aves*, URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Nakano, A. 2006. An observation of a Common Starling on Chichijima, Bonin Islands. *Japanese Journal of Ornithology*, 55(2), 112-113 (in Japanese).

Ono, M. 1991. The flora of the Bonin (Ogasawara) Islands: Endemism and dispersal modes. *Aliso*, 13, 95-105.

Springer, M., S. Higuchi, H. Ueda, K. Minton, J. and C. G. Sibley. 1995. Molecular evidence that

the Bonin Islands “Honeyeater” is a White-eye. *Journal of the Yamashina Institute for Ornithology*, 27, 66-77.

Suzuki, H. and H. Chiba. 2004. Seabirds. *Fiscal 2003 Ogasawara Area Nature Revitalization Plan Survey (1): Activity Report*, Nature Conservation Bureau, MOE (in Japanese).

TMG. 2001. *Summary result of environmental survey for the Ogasawara airport plan*.

Reptiles

Asami,S. 1970a. Climate and ocean. *In*: T. Tsuyama and S. Asami (Eds.), *The Nature in the Bonin Islands* , Tokyo: Hirokawa Publishing, pp. 87–90 (in Japanese).

Asami,S. 1970b. Climate and ocean. *In*: T. Tsuyama and S. Asami (Eds.), *The Nature in the Bonin Islands*, Tokyo: Hirokawa Publishing, 91-108 (in Japanese).

Bowen, B. W., A. B. Meylan, J. P. Ross, C. J. Limpus, G. H. Balazs and J. C. Avise. 1992. Global population structure and natural history of the green turtle (*Chelonia mydas*) in terms of matriarchal phylogeny. *Evolution*, 46, 865-881.

Hayashi, F., A. Shima, K. Horikoshi, K. Kawakami, R. D. Segawa, T. Aotsuka and T. Suzuki. 2009. Limited overwater dispersal and genetic differentiation of the snake-eyed skink *Cryptoblepharus nigropunctatus* in the oceanic Ogasawara Islands, *Japan. Zoological Science*, 26, 543-549.

Hikida, T. 2007. On the taxonomic position of the Ogasawara snake-eyed skink (*Cryptoblepharus nigropunctatus*). *Bulletin of the Herpetological Society of Japan*, 2007, 83 (in Japanese).

Horikoshi, K., H. Suganuma, H. Tachikawa, F. Sato and M. Yamaguchi. 1984. Decline of Ogasawara green turtle population in Japan. *In*: Bjorndal, K.A., A. B. Bolten, D. A. Johnson, P. J. Eliazar (comps.) *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*, NOAA Technical Memorandum NMFS-SEFSC-351, National Marine Fisheries Service, Miami, 235-236.

Horner, P. 2007. Systematics of the snake-eyed skinks, *Cryptoblepharus* Wiegmann (Reptilia: Squamata: Scincidae) - an Australian-based review. *The Beagle, Records of the museum and art galleries of the Northern Territory* Supplement 3, 21-198.

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

Karl, S. A., B. W. Bowen and J. C. Avise. 1992. Global population genetic structure and male-mediated gene flow in the green turtle *(Chelonia mydas)*: RFLP analyses of anonymous nuclear loci. *Genetics*, 131, 163-173.

MOE. 2006. *Revised: Threatened Wildlife of Japan - Red list – Amphibia / Reptile,* URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Green sea turtle (*Chelonia mydas*), 5-year review: summary and evaluation.

Roberts, M. A., T. S. Schwartz and S. A. Karl. 2004. Global population genetic structure and male-mediated gene flow in the green sea turtle (*Chelonia mydas*): analysis of

microsatellite loci. *Genetics*, 166, 1854-1870.

Sengoku. S., T. Hikita, M. Matsui, K. Nakatani. 1996. *The encyclopedia of animals in Japan Vol.5: Amphibians, Reptiles and Selatii*, Tokyo: Heibonsha Ltd.

Suzuki, A. and M. Nagoshi. 1999. Habitat utilizations of the native lizard, *Cryptoblepharus boutonii nigropunctatus*, in areas with and without the introduced lizard, *Anolis carolinensis*, on Hahajima, the Ogasawara Islands, Japan. *In*: H. Ota (Ed.), *Tropical Island Herpetofauna: Origin, Current Diversity, and Conservation*, Amsterdam: Elsevier.

Yamashita, H. 2004. The geological history of the Ogasawara Islands. *In*: Kanagawa Prefectural Museum of Natural History (Ed.), *The Oriental Galapagos, the Ogasawara Islands*, Kanagawa, 16–20 (in Japanese).

Aquatic animals (except mammals and reptiles)

Freshwater animals

[Fish]

MOE. 2007. *Revised: Threatened Wildlife of Japan - Red list – Brackish /Fresh water Fish,* URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Yokoi, K. 2006. Study on the protection for the endangered freshwater goby, Rhinogobius sp. BI from the Bonin Islands. Doctoral thesis, Kinki University, 76 (in Japanese).

Yoshigou, H. 2002. Inland water fishes, shrimps and crabs of the Chichi-jima and Haha-jima Islands, Ogasawara (Bonin) Islands, Japan, with notes for inland water fish fauna of some subtropical Islands. *Miscellaneous Reports of the Hiwa Museum for Natural History*, 41, 1-30 (in Japanese).

[Crustaceans]

Asakura, A. Recent topics on taxonomy of hermit crabs from Japanese waters - Family Coenobitidae. *Aquabiology*, 150, 83-39

Cai, Y., P. K. L. Ng., S. Shokita and K. Satake. 2006. On the species of Japanese atyid shrimps (Decapoda: Caridea) described by William Stimpson (1860). *Journal of Crustacean Biology*, 26(3), 392-419.

Imajima, M. 1970. Marine life. *In* : T. Tsuyama and S. Asami (Eds.), *Nature in the Bonin Islands: Commentary*, Tokyo: Hirokawa-Shoten , 179-196 (in Japanese).

Kato, H. and M. Takeda. 1981. A new shrimp of the genus *Palaemon* (Crustacea, Decapoda) from the Ogasawara Islands. *Bulletin of the National Science Museum*, Tokyo, Ser. A. 7(3), 101-109.

Kobayashi, S. 2005. Survey on the enormous mitten crabs in Bonin Islands. *Cancer*, 14, 17-22 (in Japanese).

Komai, T., I. Yamazaki, S. Kobayashi, T. Yamamoto and S. Watanabe. 2006. *Eriocheir ogasawaraensis* Komai, a new species of mitten crab (Crustacea: Decapoda: Brachyura: Varunidae) from the Ogasawara Islands, Japan, with notes on the systematics of *Eriocheir* De Haan, 1835. *Zootaxa*, 1168, 1-20.

Kuwabara, S. 1995. *Coenobita*. *In*: *Natural monuments of Japan*, Kodansha, 710 (in Japanese).

Miya, Y. 1998. *Metabetaeus minutus*. *In*: Fisheries Agency (Ed.), *Databook on Rare Wildlife in Japan*, Japan Fisheries Resource Conservation Association, 364-365 (in Japanese).

MOE. 2006. *Revised: Threatened Wildlife of Japan - Red list – Crustacean, etc.,* URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Nunomura, N. and K. Satake. 2006. A new species of the genus *Gnorimosphaeroma* (Crustacea: Isopoda) from Hahajima, Bonin Islands, southern Japan. *Bulletin of the Toyama Science Museum*, 29, 1-6.

Nunomura, N., K. Satake and R. Ueno. 2008. A new species of the genus *Spherillo* (Crustacea: Isopoda) from Hahajima, Bonin Islands, southern Japan. *Bulletin of the Toyama Science Museum*, 31, 45-50.

Sasaki, T. and K. Horikosi. 2008. Marine animals of Minami-Iwo-To Island. *Ogasawara Research*, 33, 155-171 (in Japanese).

Satake, K. and Y. Cai. 2005. *Paratya boninensis*, a new species of freshwater shrimp (Crustacea: Decapoda: Atyidae) from Ogasawara, Japan. *Proceedings of the Biological Society of Washington*, 118(2), 306-311.

Satake, K. and R. Ueno. 2001. Bottom fauna on small subtropical islands, especially freshwater shrimp. *Research Report from the National Institute for Environmental Studies, Japan*, R-158, 52-56 (in Japanese).

Satake, K. and R. Ueno. 2004. Shrimp in the rivers of Ogasawara. *In*: H. Karube and M. Takakuwa (Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History, Odawara, 63-64 (in Japanese).

Stimpson, W. 1858. Prodromus descriptionis animalium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septemtrionalem, a Republica Federata missa, C. Ringgold et J. Rodgers, observavit et descriptist. Pars VII. Crustacea Anomura. *Proceedings of the Academy of Natural Science of Philadelphia*, 10, 63-90, 225-252.

Suzuki, H. 1972. Freshwater and commensal crustacean decapods from the Bonin Islands. Science Reports of the Yokohama National University. Section II, *Biological and Geological Sciences*, 19, 1-26.

TMG Board of Education. 1987. *Report on the habitat status of Coenobita on the Ogasawara Islands*, 108 (in Japanese).

Yoshigou, H. 2002. Inland water fishes, shrimps and crabs of the Chichi-jima and Haha-jima Islands, Ogasawara (Bonin) Islands, Japan, with notes for inland water fish fauna of some subtropical Islands. *Miscellaneous Reports of the Hiwa Museum for Natural History*, 41, 1-30 (in Japanese).

[Gastropods]

Bandel, K., F. Riedel and H. Weikert. 1997. Planctonic Gastropod Larvae from the Red Sea: A Synopsis. *Ophelia*, 47 (3), 151-202.

Fukada, H. 1993. Marine gastropoda (Mollsca) of the Ogasawara (Bonin) Islands Part 1: Archaenogastropoda and Neotaenioglossa. *Ogasawara Research*, 19, 1-86.

Fukada, H. 1995. Marine gastropoda (Mollsca) of the Ogasawara (Bonin) Islands Part 3: Additional records. *Ogasawara Research*, 21, 1-142.

Habe, T. 1969. The shell fauna of Ogasawara. *Science of Life: Genetics*, 23, 19-25 (in Japanese).

Institute of Boninology. 2007. *Fiscal 2006 Report of Tamagawa Dam (Hahajima) Environmental Survey consigned by the TMG Ogasawara Office*, TMG Ogasawara Office, 30 (in Japanese).

Institute of Boninology. 2008. *Fiscal 2007 Report of Tamagawa Dam (Hahajima) Environmental Survey (follow-up) consigned by the Tokyo Metropolitan Government Ogasawara Office*, TMG Ogasawara Office, 48 (in Japanese).

Kanno, T. 1973. A survey mainly on neritic animals. *Biota survey report in the Ogasawara Islands 1970-1972*, Ogasawara Research Committte, Tokyo Metropolitan University, 22-44

Köhler, F. and M. Glaubrecht. 2001. Toward a systematic revision of the Southeast Asian freshwater gastropod *Brotia* H. Adams, 1866 (Cerithioidea: Pachychilidae): an account of species from around the South China Sea. *Journal of Molluscan Studies*, 67, 281-318.

Komatsu, S. 1993. Neritids in Guam Island. *Chiribotan* (bulletin of the Malacological Society of Japan), 23(4), 104-105 (in Japanese).

Miura, M., H. Mori, S. Nakai, K. Satake, T. Sasaki and S. Chiba. 2008. Molecular evidence of the evolutionary origin of a Bonin Islands endemic Stenomelania boninensis. *Journal of Molluscan Studies*, 74, 199-202.

MOE. 2007. *Revised: Threatened Wildlife of Japan - Red list – Land & Fresh Water Mollusks,* URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Sasaki, T., K. Satake and K. Tsuchiya. 2009. Distributions of an alien snail, *Melanoides tuberculata*, and an endemic snail, *Stenomelania boninensis*, in the Ogasawara (Bonin) Islands, with special reference to the effects of stream bank construction on the thiarid snails). *Japanese Journal of Limnology*, 70, 31-38 (in Japanese).

Satake, K., T. Sasaki and K. Tsuchiya. 2006. First record of the parthenogenetic snail *Melanoides tuberculana* (Gastropoda: Thiaridae) from Chichijima Island, Ogasawara Islands. *Chiribotan*, 37 (3), 112-117 (in Japanese).

Marine animals:

[Fish]

Randall, J. E., H. Ida, K. Kato, R. L. Pyle and J. L. Earle. 1997. Annotated checklist of the inshore fishes of the Ogasawara Island. *Nat. Sci. Mus. Monogr*, 11, 1-74, 19 pls.

Senou, H. 2004. The fish of Ogasawara. *In*: H. Karube and M. Takakuwa(Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History, Odawara, 55-62 (in Japanese).

[Gastropods]

Fukuda, H. 1993. Marine Gastropoda (Mollusca) of the Ogasawara (Bonin) Islands. Part 1: Archaeogastropoda and Neotaenioglossa. *Ogasawara Research*, 19, 1-86.

Fukuda, H. 1994. Marine Gastropoda (Mollusca) of the Ogasawara (Bonin) Islands. Part 2: Neogastropoda, Heterobranchia and fossil species, with faunal accounts. *Ogasawara Research*, 20, 1-126.

Fukuda, H. 1995. Marine Gastropoda (Mollusca) of the Ogasawara (Bonin) Islands. Part 3: Additional Records. *Ogasawara Research*, 21, 1-142.

Tachikawa, H. (ed. and auth.). 2009. *Fiscal 2008 Marine Science Gallery: Sea creatures of Ogasawara, the Galapagos of the East Exhibit book* (in Japanese).

[Coral reef]

Inaba, M. 2003. Ecological feature and status of reef-building corals in the Bonin Islands. *Midoriishi*, 14, 20-23 (in Japanese).

Inaba, M. 2004. Ogasawara Islands. Status of coral reefs around the country. *Coral Reefs of Japan*. Ministry of Environment and Japanese Coral Reef Society (in Japanese).

Ministry of Environment and Japanese Coral Reef Society. 2004. *Coral Reefs of Japan*.

Insects

Ball, G. E. 1992. The tribe Licnini (Coleoptera: Carabidae): a review of the genus-groups and of the species of selected genera. *Journal of the New York Entomological society*, 100, 325-380.

Blüthgen, N. and K. Reinfenrath. 2003. Extrafloral nectaries in an Australian rainforest: structure and distribution. *Australian Journal of Botany*, 51, 515–527.

Entomological Laboratory, Faculty of Agriculture, Kyushu University and the Japan Wildlife Research Center. 1989. *A Check List of Japanese Insects*, Vol. I, xiii, pp. 1-540; Vol. II, pp. 541-1088, Vol. III,pp. 1089-1767 (in Japanese).

Gouhara, M. 2002. Bee fauna and its conservation in the Ogasawara Islands. *In*: *Natural history of bees and ants: instinct evolution study*, Hokkaido University Press, 229-245.

Habu, N. 1986. Insects introduced to Ogasawara: The establishment of organisms on oceanic islands. *In*: *Insects of Japan: The Ecology of Strategy and Disruption*, Tokai University Press, pp. 107-114 (in Japanese).

Hasegawa, M. 2004. Discovery of a new Olenecamptus (Coleptera, Cerambycidae) from the Ogasawara Islands, Japan. *Elytra*, Tokyo, 32, 225-228.

Hasegawa, M. 2009. A revisional study of the genus *Boninella* Gressitt (Coleoptera, Cerambycidae, Lamiinae). *Spec. Bull. Jpn. Soc. Coleopterol.*, Tokyo, (7), 357-384.

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

Kato, M. 1991. A list of Insects from the Ogasawara Islands. *Ogasawara Research*, 17/18, 32-59 (in Japanese).

Kato, T., H. Kitajima and H. Makihara. 1998. Beetles caught by Malaise traps set up in various forest environments on Chichijima and Hahajima of the Ogasawara Islands. *Transactions of the 49th Annual Meeting of Kanto Branch, Japanese Forestry Society*, 61-64 (in Japanese).

Kurosawa, Y. 1976a. Beetle fauna of the Bonin Islands, with a consideration on its origin and constitution (1). *Gekkan-mushi*, 68, 21-26 (in Japanese).

Kurosawa, Y. 1976b. Beetle fauna of the Bonin Islands, with a consideration on its origin and constitution (2). *Gekkan-mushi*, 69, 3-8 (in Japanese).

Matsumoto, K. 2009. The psyllids of Ogasawara Islands, diversity and island speciation. *The Nature and Insects*, 44(6), 21-24 (in Japanese).

MOE. 2007. *Revised: Threatened Wildlife of Japan - Red list – Insect,* URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Morimoto, K. 2005. Weevils in Ogasawara. *18th Conferences of the Japanese Society of Coleopterology, Collection of Lecture Abstracts*, 20 (in Japanese).

Nakamura, M. 1994. Earthworms (Anneldae: Oligochaeta) of Ogasawara archipelagoes. *Chuo University Journal of Papers*, 15, 21-32.

Ohbayashi, T., M. Inaba, H. Suzuki and M. Kato. 2004. List of insects in Ogasawara Islands, Japan. *Ogasawara Research*, 29, 17-74 (in Japanese).

Olesen, J. M., L. I. Eskildsen and S. Venkatasamy. 2002. Invasion of pollination networks on oceanic islands: importance of invader complexes and endemic supergeneralists. *Diversity and Distributions*, 8, 181-192.

Oliveira, P. S. and A. V. L. Freitas. 2004. Ant–plant–herbivore interactions in the neotropical cerrado savanna. *Naturwissenschaften*, 91, 557–570.

Pemberton, R. W. 1998. The occurrence and abundance of plants with extrafloral nectaries, the basis for antiherbivore defensive mutualisms, along a latitudinal gradient in East Asia. *Journal of Biogeography*, 25, 661–668.

Sugiura, S. 2007. Are anti-herbivore defences of island plants significant?: Loss of extrafloral nectaries of oceanic island plants and impacts of introduced ants. *Biological Science*, Tokyo: Iwanami Shoten, 58(2), 111-114 (in Japanese).

Sugiura, S., T. Abe and S. Makino. 2006. Loss of extrafloral nectary on an oceanic island plant and its consequences for herbivory. *American Journal of Botany*, 93, 491-495.

Sugiura, S., Y. Yamaura and H. Makihara. 2008. Biological invasion into the nested assemblage of tree-beetle associations on the oceanic Ogasawara Islands. *Biological Invasions*, 9, 1061-1071.

Takakuwa, M. 2004. Conditions for the formation of flora and fauna on oceanic islands: The example of Ogasawara. *In*: H. Karube and M. Takakuwa (Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History, 5-8 (in Japanese).

Yamaki, A., T. Kishimoto, M. Hasegawa and T. Kikuchi. 2008. Species diversity in the suborder Oniscidea and the effects of the predatory cane toad (*Bufo marinus*) on community formation. *The 46th Annual Meeting of the Carcinological Society of Japan, Collection of Lecture Abstracts*, 74 (in Japanese).

Land snail

Chiba, S. 1993. Modern and historical evidences of natural hybridization between sympatric species in Mandarina (Pulmonata, Camaenidae). *Evolution* 47, 1539-1556.

Chiba, S. 1996. Ecological and morphological diversification and character displacement in Mandarina, an endemic land snail of the Bonin Islands. *Journal of Evolutionary Biology*, 9, 277-291.

Chiba, S. 1997. Novel color polymorphisms in a hybrid zone of Mandarina (Pulmonata). *Biological Journal of the Linnean Society*, 61, 369-389

Chiba, S. 1998. Synchronized evolution in lineages of land snails in an oceanic island. *Paleobiology*, 24, 99-108.

Chiba, S. 1999a. Accelerated evolution of land snails *Mandarina* in the oceanic Bonin Islands: evidence from mitochondrial DNA sequences. *Evolution*, 53, 460-471.

Chiba, S. 1999b. Character displacement, frequency-dependent selection, and divergence of shell colour in land snails Mandarina (Pulmonata). *Biological Journal of the Linnean Society*, 66, 465-479.

Chiba, S. 2003. Species diversity and conservation of *Mandarina*, an endemic land snail of the

Ogasawara Islands. *Global Environmental Research*, 7, 29-37.

Chiba, S. 2004. Ecological and morphological patterns in communities of land snails of the genus Mandarina from the Bonin Islands. *Journal of Evolutionary Biology*, 17, 131-143.

Chiba, S. 2005. Appearance of morphological novelty in a hybrid zone between two species of land snail. *Evolution*, 59, 1712-1720.

Chiba, S. 2007. The land molluscan fauna on Minami-Iwo-to Island. *Ogasawara Research*, 33, 145-154 (in Japanese).

Chiba, S. 2009. Paradise on the edge: current status and conservation of endemic land snail fauna on the Ogasawara Islands. *Global Environment Research*, 14(1), 15-24 (in Japanese).

Chiba, S., A. Davison and H. Mori. 2007. The endemic land snail fauna on a remote peninsula in Ogasawara, northwestern Pacific. *Pacific Science*, 61:257-265

Davison, A. and S. Chiba. 2006. Labile ecotypes accompany rapid cladgenesis in a land snail adaptive radiation. *Biological Journal of the Linnean Society*, 88, 269-282.

Davison, A., C. M. Wade, P. B. Mordan and S. Chiba. 2005. Sex and darts in slugs and snails (Mollusca: Gastropoda: Stylommatophora). *Journal of Zoology (London)*, 267, 329-338.

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

MOE. 2007. *Revised: Threatened Wildlife of Japan - Red list – Land & Fresh Water Mollusks,* URL: http://www.biodic.go.jp/rdb/rdb_f.html (in Japanese).

Other invertebrates worthy of note:

Aoki, J. 1992. Soil Organisms. *In* : Ogasawara Natural Environment Research Association (Ed.), *Field Guide to the Nature of Ogasawara: The Galapagos of the East*, Tokyo: Kokon Shoin, 122-123 (in Japanese).

Horiguchi, H., M. Hironaka, V. B. Meyer-Rochow and T. Hariyama. 2007. Water uptake via two pairs of specialized legs in Ligia exotica (Crustacea, Isopoda). *Biol. Bull*, 213, 196-203.

Horiguchi, H., M. Hironaka. and T. Hariyama. 2008. Comparative study between terrestrial (*Ligia boninensis*) and sublittoral (*L. exotica*) isopods. *Proceedings of the 79th Annual Meeting of the Zoological Society of Japan*, 118 (in Japanese).

Nunomura, N. 1991. 4-e-4. Woodlouse fauna on the Ogasawara Islands. *In*: Ogasawara Research Committee, Tokyo Metropolitan University (Ed.)., *Second Ogasawara Islands Natural Environment Status Report*, Tokyo Metropolitan University, 227-230 (in Japanese).

Nunomura, N. 1999. Isopoda. Pictorial keys to soil animals of Japan. Tokai University Press, Tokyo, pp. 569-625 (in Japanese).

Sato, H. 1984. Pseudoscopions from the Ogasawara Islands. *The Proceedings of the Japanese Society of Systematic Zoology*, 28, 49-56.

Sato, H. 1991a. Metagoniochernes tomiyamai, a New Pseudosvorpion (Chernetidae) from the Ogasawara Islands, Japan. *Bull. Biogeogr. Soc.*, 46(10), 97-101.

Sato, H. 1991b. 4-e-1. Pseudoscorpions on the Ogasawara Islands. *In*: Ogasawara Research Committee, Tokyo Metropolitan University (Ed.), *Second Ogasawara Islands Natural Environment Status Report 1990-1991*, Tokyo Metropolitan University, 216-219 (in Japanese).

Sato, H. 1992a. Biogeographical characteristics of Ogasawara's pseudoscorpions at the genus level. Ogasawara Research Committee, Tokyo Metropolitan University, *Annual Ogasawara Research Journal*, 15, 52-56 (in Japanese).

Sato, H. 1992b. *Metagoniochernes tomiyama*. *In*: Ogasawara Natural Environment Research Association (Ed.), *Field Guide to the Nature of Ogasawara: The Galapagos of the East*, Tokyo: Kokon Shoin, p. 124 (in Japanese).

Sato, H. 2006. *Metagoniochernes tomiyamai*. *In*: MOE (Ed.), *Threatened Wildlife of Japan -Red Data Book 2nd ed.-.Volume 7, Invertebrata (except Insecta and Mollusca)*, p. 69 (in Japanese).

Taiti, S., M. A. Arnedo, S. E. Lew and G. K. Roderick. 2003. Evolution of terrestriality in Hawaiian species of the genus *Ligia* (Isopoda, Oniscidea). *Crustaceana Monographs*, 2, 85-102.

● History and development

Chaloupka, M., K. A. Bjorndal, G. H. Balazs, A. B. Bolten, L. M. Ehrhart, C. J. Limpus, H. Suganuma, S. Troëng and M. Yamaguchi. 2007. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. ***Global*** *Ecology and Biogeography*, 17, 297-304.

Everlasting Nature of Asia. 2008. *Report of Results of the Fiscal 2007 Ogasawara Village Grant-Aid Resource Management Project (Green Turtles)* (in Japanese).

Horikoshi, K., H. Suganuma, H. Tachikawa, F. Sato and M. Yamaguchi. 1994. Decline of Ogasawara green turtle population in Japan. *In*: K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (Eds.) *Proc. 14th Annual Symposium on Sea Turtle Biology and Conservation*, NOAA Technical Memorandum NMFS-SEFSC-351, 235-237.

Japan Fisheries Resource Conservation Association. 1999. *General Report for the Consigned Survey Project on Measures to Conserve Aquatic Organisms (1994—1998), Fascicle I: Identifying Migratory Routes and Diving Habitats*, 87, and 81 (bibliographical/source appendix) (in Japanese).

Kato, Y. and K. Hamanaka. 1995. *Seven Islands of Izu and the Ogasawara Islands: Tokyo's National Parks in the Ocean*, Municipal Parks Division, Tokyo Metropolitan Office, Tokyo Parks Publishing No. 7, Tokyo Metropolitan Parks Association (in Japanese).

Kurata, Y. 1980. The green turtles of Ogasawara: Past and present. *Annual Ogasawara Research Journal*, 4, 36-46 (in Japanese).

Ogasawara Village. 2005. *Ogasawara Village Guide*, Ogasawara Village Office, Division of General Affairs (Ed.) (in Japanese).

Seminoff, J. A. 2004. *Chelonia mydas*. In: IUCN (Ed.) *2008 IUCN Red List of Threatened Species*, URL: http://www.iucnredlist.org/ www.iucnredlist.org.

Shimizu, Y. 2007. The Galapagos and Ogasawara, the Galapagos of the East: What "Galapagos" means when we say the "Galapagos of the East". *Komazawa University Journal of the Faculty of Arts and Sciences*, 1 (Fascicle I) (in Japanese).

TMG Ogasawara Office. 2008. *Overview of jurisdiction, 2007 edition*, TMG Ogasawara Office, General Affairs Division (in Japanese).

Justification for Inscription

Anthoni, J.F. 2002. Kermadec Islands – geography and geology. URL: http://www.seafriends.org.nz/issues/res/kermadec/kermgeo.htm

Australian Government. 1981. Nomination of the Lord Howe Island Group for inclusion in the World Heritage List.

Australian Government. 2002. Australian National Periodic Report Section II, Report on the State of Conservation of Lord Howe Island.

Bloomer, S. H. and J. W. Hawkins. 1987. Petrology and geochemistry of boninite series volcanic rocks from the Mariana Trench. *Contrib. Mineral. Petrol.*, 97, 361-367.

Brooke, M. de L. et al. 2004. Henderson Island World Heirtage Site: Management Plan 2004-2009. Foreign and Commonwealth Office, London.

Brown, A. V. and G. A. Jenner. 1989. Geological setting, petrology and chemistry of Cambrian boninite and low-Ti tholeiite lavas in western Tasmania. *In*: A. J. Crawford (Ed.), *Boninites and Related Rocks*, London: Unwyn Hyman, 232-263.

Cameron, W. E. 1989. Contrasting boninite-tholeiite associations from New Caledonia. *In*: A. J. Crawford (Ed.), *Boninites*, London: Unwin Hyman, 314-338.

Cameron, R.A.D. and L. M. Cook. 1992. The development of diversity in the land snail fauna of the Madeiran archipelago. *Biological Journal of the Linnean Society*, 46, 105-114.

Cassis G, Meades L, Harris R, Reid C, Carter G, Wilkie L, Jeff reys E. 2003. *Lord Howe Island: terrestrial invertebrate biodiversity and conservation report*, Australian Museum, Centre for Biodiversity and Conservation Research, p. 156.

Chilean Government. 1994. Tentative List of Chile for Juan Fernández Archipelago National Park. URL: http://whc.unesco.org/en/tentativelists/84/.

Churikova, T., F. Dorendorf and G. Worner. 2001. Sources and fluids in the mantle wedge below Kamchatka, evidence from across-arc geochemical variation. *J. Petrol.*, 42, 1567-1593.

Coish, R. A. 1989. Boninitic lavas in Appalachian ophiolites: a review. *In*: A. J. Crawford (Ed.), *Boninites and Related Rocks*, London: Unwyn Hyman, pp. 264-287.

Coote, T., É. Loève. 2003. From 61 species to five: Endemic tree snails of the Society Islands fall prey to an ill-judged biological control programme. *Oryx*, 37, 91-96.

Cowie, R. H. 1995. Variation in species diversity and shell shape in Hawaiian land snails, in situ speciation and ecological relationships. *Evolution*, 49, 1191-1202.

Cowie, R. H. 1996. Pacific island land snails: Relationships, origins, and determinants of diversity. *In*: A. Keast and S. E. Miller (Eds.), *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and Processe*s. Amsterdam: SPB Academic, pp. 347-372.

Cowie, R. H., N. L. Evenhuis and C. C. Christensen. 1995. *Catalog of the Native Land and Freshwater Molluscs of the Hawaiian Islands*. Oegstgeest-Leiden (The Netherlands): Backhuys.

Cowie, R. H. and A. C. Robinson. 2003. The decline of native Pacific island faunas: Changes in status of the land snails of Samoa through the 20th century. B*iological Conservation*, 110, 55-65.

Daczko, N. R., K. L. Wertz, S. Mosher, M. F. Coffin and T. A. Meckel. 2003. Extension along the Australian-Pacific transpressional transform plate boundary near Macquarie Island. *Geochem. Geophys. Geosyst.*, 1080, doi: 10.1029/2003GC000523.

Dallwitz, W. B. 1967. Chemical composition and genesis of clinoenstatite-bearing volcanic rocks from the Cape Vogel, Papua: A discussion. *XXIII International Geological Congress*, 2, 229-242.

Davis, S. D., V. H. Heywood and A. C. Hamilton (Ed.). 1995. *Centres of Plant Diversity. A Guide and Strategy for their Conservation. Volume 2. Asia, Australasia and The Pacific*. WWF & IUCN.

Desender, K. and L. Baert. 1996. The Coleoptera of Easter Island**.** *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Entomologie*, 66, 27-50.

Dietrich, V. R., R. Emmermann, R. Oberhansli and H. Puchelt. 1978. Geochemistry of basaltic and gabbroic rocks from the West Mariana Basin and Mariana trench. *Earth Planet. Sci. Lett.*, 39, 127-144.

Dingwall, P., T. Weighell and T. Badman. 2005. *Geological World Heritage: A Global Framework*. IUCN

Department of Conservation. 2006. *Our World Heritage: A Tentative List of New Zealand Cultural and Natural Heritage Sites*. 79, Downloaded from: http://www.doc.govt.nz/publications/getting-involved/consultations/results/our-world-heritage/

Eda, M., K. Kawakami, H. Chiba, H. Suzuki, K. Horikoshi and H. Koike. 2008. Genetic characteristics of the Black-footed Albatross *Diomedea nigripeson* in the Bonin Islands and their implications for the species' demographic history and population structure.

Ornithological Science, 7, 109-116.

Falloon, T. J., D. H. Green and M. T. McCulloch. 1989. Petrogenesis of high-Mg and associated lavas from the north Tonga Trench. *In*: A. J. Crawford (Ed.), Boninites and Related Rocks, London: Unwyn Hyman, 357-395.

Galapagos Online Tours. Birds of the Galapagos. URL: http://www.galapagosonline.com/nathistory/wildlife/birds/galapagosbirds.htm

Government of Solomon Islands. 1997. *Nomination of East Rennell, Solomon Islands for inclusion in the World Heritage List – Natural Sites*.

Ibanez, M., M.R. Alonso, F. Henriquez and M. J.Valido. 1997. Distribution of land snails (Mollusca, Gastropoda, Pulmonata) on the island of Gran Canaria (Canary Islands) in relation to protected natural areas. *Biodiversity and Conservation* 6, 627-632.

Ishikawa, T., K. Nagaishi and S. Umino. 2002. Boninitic volcanism in the Oman ophiolite: Implications for thermal condition during transition from spreading ridge to arc. *Geology*, 30: 899-902.

Ishiwatari, A., Y. Yanagida, Y. B. Li, T. Ishii, S. Haraguchi, K. Koizumi, Y. Ichiyama and M. Umeka. 2006. Dredge petrology of the boninite- and adakite-bearing Hahajima Seamount of the Ogasawara (Bonin) forearc: An ophiolite or a serpentinite seamount? *Island Arc*, 15: 102-118.

Ishizuka, O., J. Kimura, Y. B. Li, R. J. Stern, M. K. Reagan, R. N. Taylor, Y. Ohara, S. H. Bloomer, T. Ishii, U. S. Hargrove III and S. Haraguchi. 2006. Early stages in the evolution of Izu Bonin arc volcanism: New age, chemical, and isotopic constraints. *Earth Planet. Sci. Lett.*, 250: 385-401.

IUCN. 2008. *2008 IUCN Red List of Threatened Species,* URL: http://www.iucnredlist.org.

Kurozumi, T. 1994. Land molluscs from the Northern Mariana Islands, Micronesia. *Natural History Research*, 1 (special issue), 113-119.

Kuschel, G. 1963. Composition and relationship of the terrestrial faunas of Easter, Juan Fercandz, Desventuradas, and Galapagos Islands. *Occasional Papers of the California Academy of Science*, 44, 79-95.

Loope, L. L., O. Hamann and C. P. Stone. 1988. Comparative Conservation Biology of Oceanic Archipelagoes, Hawaii and the Galapagos. *BioScience*, 38, 272-282.

Loope, L. L. and D. Mueller-Dombois. 1989. Characteristics of Invaded Islands, with Special Reference to Hawaii. *In*: J. A. Drake et al. (Eds.) *Biological Invasions: a Global Perspective*, John Wiley and Sons Ltd.,, pp. 257-280.

Lydeard, C., R. H. Cowie, W. F. Ponder et al. 2004. The global decline of nonmarine mollusks. *Bioscience*, 54, 321-330.

MacArthur, R. H. and E. O. Wilson. 1963. An equibrium theory of insular zoogeography. *Evolution*, 17, 373-387.

MacArthur, R. H. and E. O. Wilson. 1967. *The theory of Island Biogeography*. Princeton:

Princeton Univ. Press , New Jersey.

McCulloch, M. T. and W. E. Cameron. 1983. Nd-Sr isotopic study of primitive lavas from the Troodos Ophiolite, Cyprus: evidence for a subduction-related setting. *Geology*, 11, 727-731.

Meffre, S., J. C. Aitchison and A. J. Crawford. 1996. Geochemical evolution and tectonic significance of boninites and tholeiites from the Koh ophiolite, New Caledonia. *Tectonics*, 15, 67-83.

MOE. 2007. *Revised: Threatened Wildlife of Japan - Red list – Plant I (vascular plant),* URL: http://www.biodic.go.jp/rdb/rdb_f.html

Nature Conservation Bureau, MOE. 2005. *Fiscal 2004 Ogasawara Area Nature Revitalization Plan Survey (1): Activity Report* (in Japanese).

Nishida, G. M. 1997. *Hawaiian terrestrial arthropod checklist. Edition 3*. p. 263

Nishida, G. M. 2008. French Polynesia Beetle Checklist (Preliminary)

URL: http://essigdb.berkeley.edu/checklists/fpColeoptera.doc.

Oikonos. Juan Fernández Conservancy. URL: http://www.oikonos.org/projects/jfic.htm.

Pearce, J. A., T. Alabaster, A. W. Shelton and M. P. Searle. 1981. The Oman ophiolite as a Cretaceous arc-basin complex: evidence and implications. *Phil. Trans. R. Soc.*, London, Ser. A, 300, 299-317.

Peck, S. B. 2006. Chapter 4. Processes I: Origin and Arrival of the Beetle Colonists. *In*: *The Beetles of the Galapagos Islands, Ecuador: Evolution, Ecology, and Diversity (Insecta: Coleoptera)*, NRC Research Press, pp. 29-46.

Pena, L. 1987. Consideraciones sobre la fauna de arthropodos terrestres de las Islas Oceanicas Chilenas. *In*: *Islas Oceanicas Chilenas: conocimiento cientifico y neccesidades de investigaciones*, Ediciones Universidad Catolica de Chile, pp. 217-223.

Ponder, W. F. 1997. Conservation status, threats and habitat requirements of Australian terrestrial and freshwater Mollusca. *Memoirs of the Museum of Victoria*, 56, 421-430.

Preece. R. C. 1998. Impact of early Polynesian occupation on the land snail fauna of Henderson Island, Pitcairn group (South Pacific). *Philosophical Transactions of the Royal Society* B, London, 353, 347-368.

Pyle, R. L. 2002. *Checklist of the Birds of Hawaii – 2002*. Downloaded from the website of Hawaii Audubon Society. URL: http://www.hawaiiaudubon.com/birding/.

Reagan, M. K. and A. Meijer. 1984. Geology and geochemistry of early arc-volcanic rocks from Guam. *Geol. Soc. Amer. Bull.*, 95, 701-713.

Reagan, M. K., B. B. Hanan, M. T. Heizler, B. S. Hartman and R. Hickey-Vargas. 2008. Petrogenesis of volcanic rocks from Saipan and Rota, Mariana Islands, and implications for the evolution of nascent island arcs. *J. Petrol.*, 49, 441 - 461, doi:10.1093/petrology/egm087.

Rogers, N. W. and A. D. Saunders. 1989. Magnesian andesites from Mexico, Chile and the

Aleutian Islands: implications for magmatism associated with ridge - trench collision. *In*: A. J. Crawford (Ed.), *Boninites and Related Rock*s, London: Unwyn Hyman, pp. 416-445.

Rothman, R. Natural Histry of the Galapagos Islands. URL: http://people.rit.edu/rhrsbi/GalapagosPages/Galapagos.html

Sameshima, T., J. P. Paris, P. M. Black and R. F. Heming. 1983. Clinoenstatite-bearing lava from Nepoui, New Caledonia. *Amer. Mineralogist*, 68, 1076-1082.

Solem, A. 1959. Systematics and Zoogeography of the Land and Freshwater Mollusca of the New Hebrides. Chicago: Chicago Natural History Museum. *Fieldiana Zoology*, vol. 43, no. 1.

St. John, H. 1973. *List and summary of the flowering plants in the Hawaiian Islands*. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

State of Hawaii, National Oceanic and Atmospheric Administration, Office of Hawaiian Affairs, and U.S. Fish and Wildlife Service. 2009. *The United States of America's Nomination of Papahänaumokuäkea Marine National Monument for inscription on the World Heritage List*. p. 280. Downloaded from:
http://papahanaumokuakea.gov/management/worldheritage.html.

Stuessy, T. F., D. J. Crawford, C. Marticorena and R. Rodriguez. 1998. Island biogeography of angiosperms of the Juan Fernandez archipelago. *In*: T. Stuessy and M. Ono (Ed), *Evolution and speciation of Island Plants*, Cambridge University Press, pp. 121-138.

Tatsumi, Y. and S. Maruyama. 1989. Boninites and high-Mg andesites: tectonics and petrogenesis. In A. J. Crawford (Ed.), *Boninites and Related Rocks*. London: Unwyn Hyman, pp. 50-71.

Tourismo Yamaichi. Robinson Island. (in Japanese)
URL: http://www.yamaichi.cl/spot/robinson_summary.html

Tye, A., H. L. Snell, S. B. Peck and H. Adsersen. 2002. Chapter 3 – Outstanding Terrestrial Features of The Galapagos Archipelago. *In*: R. Bensted-Smith (Ed.), *A Biodiversity Vison for the Galapagos Islands*, pp. 12-23.

Wagner, W. L., D. R. Herbst and S. H. Sophmer 1990. *Manual of the Flowering Plants of Hawaii*. B. P. Bishop Museum, Honolulu.

Whittaker, R. J. and J. M. Fernández-Palacios. 2007. *Island Biogeography: Ecology, evolution, and conservation*. 2nd ed. Oxford University Press.

Wood, D. A., N. G. Marsh, J. Tarney, J. L. Joron, P. Fryer and M. Treuil. 1981. Geochemistry of igneous rocks recovered from a transect across the Mariana Trough, arc, fore-arc, and trench, Site 453 through 461, DSDP Leg 60. *In*: D. M. Hussong, S. Uyeda, et al. (Eds.) *Init. Repts. DSDP*, 55: Washington (U.S. Govt. Printing Office), 611-645.

Yemeni Government. 2006. *Socotra Archipelago Proposal for inclusion in the World Heritage List/UNESCO.*

State of conservation and factors affecting the Property

● Present state of conservation

Abe, M., K. Maeda, N. Ishii and H. Sano. 1995. Distribution, feeding habits, and home range of the Bonin flying fox (*Pteropus pselaphon*). *Annual Ogasawara Research Journal*, 18, 4-43 (in Japanese).

Abe, T. and Y. Hoshi. 2008. Ecological characteristics of the endangered shrub *Stachyurus macrocarpus* var. *prunifolius* Tuyama revealed by a population discovery in Hahajima Island (Ogasawara). *Japanese journal of conservation ecology,* 13(2), 219-223 (in Japanese).

Abe, T., K. Wada and N. Nakagoshi. 2008, Extinction threats of a narrowly endemic shrub, *Stachyurus macrocarpus* (Stachyuraceae) in the Ogasawara Islands. *Plant Ecology*, 198, 169-183.

Chiba, H., K. Kawakami, H. Suzuki and K. Horikoshi. 2007. The Distribution of Seabirds in the Bonin Islands, Southern Japan. *Journal of the Yamashina Institute for Ornithology*, 39, 1-17.

Chiba, S. 2007. Morphological and ecological shifts in a land snail caused by the impacts of an introduced predator. *Ecological Research,* 22, 884-891.

Deguchi, T. 2009. A step forward to the settlement of Short-tailed Albatorss in the Ogasawara Islands: A successful fledging of 15 chicks transported to Mukojima Island. *Science of Life: Genetics,* 63.

Deguchi, T., F. Sato, N. Nakamura, T. Harada, Y. Wanatabe, J. Jacobs and K. Ozaki. 2008. Translocation of albatross chicks to Mukojima and their artificial rearing. *Proceedings of the 2008 Annual Meeting of the Ornithological Society of Japan, Collection of Lecture Abstracts*, 57 (in Japanese).

Eda, M., K. Kawakami, H. Chiba, H. Suzuki, K. Horikoshi and H. Koike. 2008. Genetic characteristics of the Black-footed Albatross *Diomedea nigripes* on the Bonin Islands and their implications for the species' demographic history and population structure. *Ornithol Sci*, 7, 109-116.

Fujita, T. 2004. Endemic species threatened by extinction. *In* : H. Karube and M. Takakuwa, (Eds.), *Ogasawara, the Galapagos of the East: The Appeal of Endemic Organisms and the Crisis They Face*, Kanagawa Prefectural Museum of Natural History, pp. 5-8 (in Japanese).

Hasuo, Y. 1969. Animals of the Ogasawara Islands. *Report of Natural Scenery Survey in the Ogasawara Islands*, Bureau of Construction, TMG, pp. 192-213 (in Japanese).

Inaba, M. 1999. Distribution and population numbers of the Bonin flying fox (*Pteropus*

pselaphon) on Chichijima. *Natural Monument Emergency Survey (Pteropus pselaphon) Report*, TMG Ogasawara Municipal Board of Education, pp. 29-40 (in Japanese).

Inaba, M. 2001. State of the Bonin flying fox (*Pteropus pselaphon*) on Kita-Iwoto. *Kita-Iwoto Biological Survey Report*, TMG Ogasawara Office, pp. 50-57 (in Japanese).

Inaba, M., S. Takatsuki, K. Ueda, M. Izawa, H. Suzuki and K. Horikosi. 2002. An urgent appeal for conservation of the Bonin flying fox, *Pteropus pselaphon* Layard, an endaugered species. *Japanese Journal of Conservatiom Ecology*, 7(1), 51-61 (in Japanese).

Institute of Boninology. 2003. *Fiscal 2002 Bonin flying fox* (Pteropus pselaphon) *Population Monitoring Survey Report Consigned by Ogasawara Village* (in Japanese).

Institute of Boninology. 2004a. *Fiscal 2003 Bonin flying fox (*Pteropus pselaphon*) Population Monitoring Survey Report Consigned by Ogasawara Village* (in Japanese).

Institute of Boninology. 2004b. *Research on Albatrosses in Ogasawara: 2004* (in Japanese).

Institute of Boninology. 2005. *Research on Albatrosses in Ogasawara: 2005* (in Japanese).

Institute of Boninology. 2008. *Fiscal 2007 Bonin flying fox (*Pteropus pselaphon*) Population Monitoring Survey Report Consigned by Ogasawara Village* (in Japanese).

Institute of Boninology. 2009. *Kita-Iwojima Animal Survey Report*. Parks and Public Works Manager, TMG Ogasawara Office, (in Japanese).

Ishii, N. 1982. Mammals of Minami-iwoto Island. *Conservation Reports of the Minami-iwoto Wilderness Area, Tokyo, Japan*. Nature Conservation Bureau, Environment Agency (in Japanese).

Kaneko, H. 1986. The Bonin flying fox (*Pteropus pselaphon*). *Mainichi Graph*, October 19 edition (in Japanese).

Kanto Regional Forest Office. 2006. *Endangered Species of Wild Fauna and Flora (*Columba janthina nitens*) Protection and Management Survey Report* (in Japanese).

Kanto Regional Forest Office. 2007. *Endangered Species of Wild Fauna and Flora (*Columba janthina nitens*) Protection and Management Survey Report* (in Japanese).

Kanto Regional Forest Office. 2009. *Endangered Species of Wild Fauna and Flora (*Columba janthina nitens*) Protection and Management Survey Report* (in Japanese).

Karube, H. 2001. On a critical situation of the endemic dragonflies from the Ogasawara Island. Gekkan-mushi, 369, 22-32 (in Japanese).

Karube, H. 2004. The present situation of the endemic dragonflies in the Ogasawara Islands - When and Why have they declined? -. *Research Report of the Kanagawa Prefectural Museum*, Natural History, 12, 31-45 (in Japanese).

Matsumoto, T. and K. Miyashita. 1980. Survey of mammals. *First Ogasawara Islands Natural Environment Status Report* (in Japanese).

Nakane, T., S. Takano and M. Shigei. 1970. Observations based on animals. *Nature of the Bonin and the Volcano Islands*, Agency for Cultural Affairs, 89-91 (in Japanese).

Nature Conservation Bureau, MOE. 2005. *Fiscal 2004 Ogasawara Area Nature Revitalization*

Plan Survey (1): Activity Report (in Japanese).

Nature Conservation Bureau, MOE and the TMG. 2008. *Fiscal 2008 Endangered Species of Wild Fauna and Flora Conservation and Repopulation Project (Endangered Species of Wild Fauna and Flora in Ogasawara) Report* (in Japanese).

Nobushima, F. 2000. Distribution and ecology of *Metrosideros boninensis Tuyama*, a species endemic to the Ogasawara Islands (cont.). *Annual Ogasawara Research Journal*, 23, 13-28 (in Japanese).

Ohbayashi, T., I. Okochi, H. Sato, T. Ono and S. Chiba. 2007. Rapid decline of the endemic snails in the Ogasawara Islands. *Applied Entomology and Zoology,* 42, 479-485.

Ooi, T., H. Kato and J. Murata. 1999. The present distribution of rare plants in Ogasawara (*Stachyurus praecox* var. macrocarpus, *Stachyurus macrocarpus* var. prunifolius, and *Eurya boninensis*). *Annual Ogasawara Research Journal*, 22, 51-55 (in Japanese).

Ozaki K., F. Sato, T. Deguchi and N. Nakamura. 2008. Satellite tracking of *Diomedea albatrus* chicks. *Proceedings of the 2008 Annual Meeting of the Ornithological Society of Japan, Collection of Lecture Abstracts*, 58 (in Japanese).

Sato, Y. 1991. The Bonin flying fox (*Pteropus pselaphon*) on Chichijima in the Ogasawara Islands. *In* : Ogasawara Research Committee (Ed.), *Second Ogasawara Islands Natural Environment Status Report* (in Japanese).

Shimizu, Y. 1999. A 21-year population dynamics in a dry forest at Chichijima in the Bonin Islands. *Japanese journal of conservation ecology,* 4, 175-197 (in Japanese).

Suzuki, H., K. Kawakami and T. Fujita. 2007. A Status survery of the Bonin Flying Fox. *Ogasawara Research*, 33 (in Japanese).

TMG. 2008. *Fiscal 2007 Report on the Study of Genetic Diversity in* Columba janthina nitens, p. 30 (in Japanese).

TMG Ogasawara Office. 2001. *Report on Habitat Survey of Birds on the Mukojima Island Group, Ogasawara National Park* (in Japanese).

TMG Ogasawara Office. 2002. *Report on Distribution Survey of Birds on the Mukojima Island Group, Ogasawara National Park* (in Japanese)

TMG Ogasawara Office. 2003. *Report on Survey of Brid Reproduction* (in Japanese).

TMG Ogasawara Office, 2008. *Report of the seabird breeding status survey*.

Toyoda, T. 1981. *Flora of Bonin Is.*, Kamakura: Aboc (in Japanese).

Toyoda, T. 2003. *Flora of Bonin Is. (Enlarged & Revised)*, Kamakura: Aboc.

Yoshimura, M. and I. Okochi. 2005. *A decrease in endemic odonates in the Ogasawara* (in Japanese).

Yamashina Institute for Ornithology Website. All 15 albatross chicks, transported to Mukojima Island, fledged successfully. URL: http://www.yamashina.or.jp/hp/wadai/backnumber/2009_07_09.html#03

- **Factors affecting the property**

Development Pressures

Ogasawara Village. 2006. *Ogasawara Village Databook*, 32 (in Japanese).

Environmental Pressures

Hasegawa, M., T. Kusano and K. Miyashita. 1988. Range Expansion of Anolis c.carolinensis on Chichi-jima, the Bonin Islands, Japan. *Japanese Journal of Herpetology*, 12(3), 115-118.

Hashimoto, T. 2009. Eradication and ecosystem impact of rats in the Ogasawara Islands. *Global Enviromental Research*, Association of International Reseach Intiatives for Environmental Studies, 14(1), 93-101, (in Japanese).

Hata, K. and N. Kachi. 2009. Invasion of an alien woody species, *Leucaena leucocephala*, on the Ogasawara Islands after feral goat eradication. *Global Enviromental Research*, , Association of International Reseach Intiatives for Environmental Studies, 14(1), 65-72 (in Japanese).

Horikoshi, K., H. Suzuki, T. Sasaki and H. Chiba. 2009. The impact assessment of invasive alien mammals on sea bird colonies. *Global Enviromental Research*, Association of International Reseach Intiatives for Environmental Studies, 14(1), 103-106, (in Japanese).

Horikoshi, K., H. Suzuki, N. Suzuki, H. Chiba and T. Sasaki. 2006. F-051 Research on the effects of alien species on biological diversity and mitigating those effects using vulnerable oceanic islands as a model: 6. Evaluating the effects of invasive mammals on the reproduction of small birds. *Global Environment Research Fund Fiscal 2005 Interim Reports* (Vol. 3 of 8), Global Environment Bureau, MOE, pp. 301-305 (in Japanese).

Iijima, Y. 2004. The climatic conditions of Ogasawara/hydroclimatic conditions of Ogasawara. *Human society and nature in Ogasawara: Aiming for coexistence of people and nature*, Tokyo Metropolitan University Ogasawara Project 2003, pp. 53-61 (in Japanese)

Iijima, Y., K. Yoshida, H. Iwashita and S. Oka. 2005. Hydroclimatic status of Chichijima as seen from long-term meteorological data analysis for small islands in the North Pacific. *Annual Ogasawara Research Journal*, 28, 63-71 (in Japanese).

Japan Wildlife Research Center. 2008a. *Survery report of alien mamal control for Fiscal 2007 Ogasawara Area Nature Revitalization Program* (in Japanese).

Japan Wildlife Research Center. 2008b. Bullfrogs (*Rana catesbeiana*). *In* : Y. Taki (Ed.), *Photographic Guide to Invasive Alien Species in Japan, Definitive Edition*, Tokyo: Heibonsha Publishers, pp. 117-118 (in Japanese).

Japan Wildlife Research Center. 2009. *Survery report of alien mamal control for Fiscal 2008 Ogasawara Area Nature Revitalization Program* (in Japanese).

Kato, H. 2004. Genetic diversity, uniqueness, and the problem of alien species regarding flora and fauna in Ogasawara. *Human society and nature in Ogasawara: Aiming for coexistence of people and nature*, Tokyo Metropolitan University Ogasawara Project 2003, pp. 53-61 (in Japanese).

Kawahara, T. and H. Yoshimaru. 2002. *Morus boninensis*. *Journal of the Japanese Forestry Society*, 34, 14-18 (in Japanese).

Kawakami, K. 2002. Feral cats and rodents in the Bonin Islands. *In* : The Ecological Society of Japan, ed., *Handbook of Alien Species in Japan,* Tokyo: Chijin-Shokan, pp. 236-237 (in Japanese).

Makino, S. 2009. A study on eradication of invasive species and effects on the ecosystem of the Ogasawara Islands. Global Enviromental Research, Association of International Reseach Intiatives for Environmental Studies, 14(1), 9-13 (in Japanese).

Matsumoto, Y., T. Matsumoto, and K. Miyashita. 1984. Feeding habits of the marine toad, *Bufo marinus,* in the Bonin Islands, Japan. *Japanese journal of ecology*, 34, 289-297.

Miyashita, K. 1980. Denizens in the Ogasawara Islands. *Annual Ogasawara Research Journal*, 4, 47-54 (in Japanese).

MOE. 2007a. *Basic Plan for the Preservation and Revitalization of the Natural Environment in Ogasawara* (in Japanese).

MOE. 2007b. *Pamphlet: What we are doing for the natural environment of Ogasawara* (in Japanese).

Kanto Regional Environment Office, MOE. 2007. *Alien species contrl report for fiscal 2006 Ogasawara Area Nature Revitalization Program* (in Japanese).

Kanto Regional Environment Office, MOE. 2008. *Survery report of Tricladida control and land snail conservation for Fiscal 2007 Ogasawara Area Nature Revitalization Program* (in Japanese).

Nature Conservation Bureau, MOE. 2005. *Fiscal 2004 Ogasawara Area Nature Revitalization Plan Survey (1): Activity Report* (in Japanese).

Nature Conservation Bureau, MOE and the TMG. 2006. *Fiscal 2006 Endangered Species of Wild Fauna and Flora Conservation and Repopulation Project (Endangered Species of Wild Fauna and Flora in Ogasawara) Report* (in Japanese).

Nakayama, R. 2009. Collaboration of government, local residents and scientists against invasive alien species in Ogasawara. *Global Enviromental Research*, Association of International Reseach Intiatives for Environmental Studies, 14(1), 107-114 (in Japanese).

Ogasawara Ecotourism Promotion Commission. 2005. *Ogasawara Rulebook (2005 Edition),* p. 28 (in Japanese).

Ogasawara Village. 2008. *Ogasawara Villagers' News*, August, 2008 (No.541) (in Japanese). URL: http://www.vill.ogasawara.tokyo.jp/sonmin/tayori/pdf/no_541.pdf.

Shimizu, Y. 1982. The effects on Chichijima's vegetation of the 1980 summer drought. *In* :

Tokyo Metropolitan University Natural Environment Research Team (Eds.), *Ogasawara Islands Natural Environment Status Report (II)*, Bureau of Environment, TMG, pp. 31-37 (in Japanese).

Suzuki, A. 2000. *The relationship in the Ogasawara Islands between two lizard species: one introduced and one native.* Nara Women's University Graduate School of Humanities and Sciences, academic dissertation for the 1999 Academic Year, Nara Women's University, p. 76 (in Japanese).

Tanaka, N., K. Fukazawa, K. Otsu, E. Noguchi and F. Koike. 2009. Eradication of invasive tree species, *Bischofia javanica* and restoration of native forests in the Ogasawara Islands. *Global Enviromental Research*, Association of International Reseach Intiatives for Environmental Studies,14(1), 73-84 (in Japanese).

Toda, M., N. Nakagawa and N. Sukigara. 2009. Ecology and control of green anole *Anolis carolinensis*, invasive alien in the Ogasawara Islands. *Global Enviromental Research*, Association of International Reseach Intiatives for Environmental Studies, 14(1), 3 9-46, (in Japanese).

Toyoda, T. 2003. III-5 Damages caused by feral animals. *Flora of the Bonin Islands (Enlarged & Revised)*. Aboc, 437-444 (in Japanese).

Toyoda, T and Y. Kawaoka. 2005. The decline of native species with the rise of the composite ratio of bishop wood (*Bischofia javanica*). *Annual Ogasawara Research Journal*, Tokyo Metropolitan University, 28, 73-85 (in Japanese).

TMG. 2005. *Fiscal 2004 Tsunami Flooding Projection Report (Ogasawara Islands)* (in Japanese),

URL: http://www.metro.tokyo.jp/INET/CHOUSA/2005/02/60f2g200.htm.

TMG. Agreement concerning Proper Use Rules (in Japanese), URL: http://www2.kankyo.metro.tokyo.jp/sizen/eco/o_eco/syousai-rule.htm.

Tokyo Metropolitan University. 2004. *Human society and nature in Ogasawara: Aiming for coexistence of people and nature* (in Japanese).

Yamamura, Y., K. Fujita, S. Sudo, W. Kimura, A. Honma, S. Takahashi, A. Ishida, T. Nakano, M. Funakoshi and M. Kimura. 1999. The renewal of *Leucaena* forests in Ogasawara. *Japanese Journal of Conservation Ecology*, 4, 152-166 (in Japanese).

Yoshida, K. and S. Oka. 2000. The effects of biological invasions of *Leucaena* on secondary transition and species diversity on Hahajima of the Ogasawara Islands. *Japanese Journal of Ecology*, 50, 111-119 (in Japanese).

Natural disasters and Risk Preparedness

Iijima, Y., K. Yoshida, H. Iwashita and S. Oka. 2005. Hydroclimatic status of Chichijima as seen from long-term meteorological data analysis for small islands in the North Pacific. *Annual Ogasawara Research Journal*, 28, 63-71 (in Japanese).

Kanto Regional Forest Office. 2008. *Ogasawara Islands Forest Ecosystem Protection and Conservation Management Plan*, 22p (in Japanese).

Nature Conservation Bureau, MOE and the TMG. 2006. *Fiscal 2006 Endangered Species of Wild Fauna and Flora Conservation and Repopulation Project (Endangered Species of Wild Fauna and Flora in Ogasawara) Report* (in Japanese).

Ogasawara Ecotourism Promotion Commission. 2005. *Ogasawara Rulebook (2005 Edition),* p. 28 (in Japanese).

Oka, S., K. Yoshida, H. Iwashita, Y. Iijima and T. Satoh. 2001. Interannual Variability of the Hydroclimatic Environment, based on the Water Balance at Chichi-jima Island in the Ogasawara (Bonin) Islands.*Ogasawara research*, 26.

Oka, S. 2004. III. The natural background of Ogasawara. *Human society and nature in Ogasawara: Aiming for coexistence of people and nature*, Tokyo Metropolitan University Ogasawara Project 2003, pp. 45-61 (in Japanese).

Shimizu, Y. 1982. The effects on Chichijima's vegetation of the 1980 summer drought. *In* : Tokyo Metropolitan University Natural Environment Research Team (Ed.), *Ogasawara Islands Natural Environment Status Report (II)*, Bureau of Environment, TMG, pp. 31-37 (in Japanese).

Shimizu, Y. 1988. The vegetation of Mt. Kuwanoki, Hahajima and the invasion of bishop wood (*Bischofia javanica*), *Studies in Regional Science*, 1, 31-46 (in Japanese).

Takakuwa, M. 2004. An outline of the formation and Characteristics of biota especially of insect founa of Ogasawara Islands, and the change of biota influenced by human activities and alien species. Reseach Report of the Kanagawa Prefect. Museum *Natural History*, 12, 5-12 (in Japanese).

Tanaka, N., K. Fukazawa, K. Otsu, E. Noguchi and F. Koike. 2009. Eradication of invasive tree species, *Bischofia javanica* and restoration of native forests in the Ogasawara Islands. *Global Enviromental Research*, Association of International Reseach Intiatives for Environmental Studies, 14(1), 73-84 (in Japanese).

TMG. 2005. *Fiscal 2004 Tsunami Flooding Projection Report (Ogasawara Islands)* (in Japanese),

URL: http://www.metro.tokyo.jp/INET/CHOUSA/2005/02/60f2g200.htm.

Yoshida, K., Y. Iijima and S. Oka. 2006a. Studies in meteorological observations on the Ogasawara Islands. Tokyo Metropolitan University, *Annual Ogasawara Research Journal,* 29 (in Japanese).

Yoshida, K., H. Iwashita, Y. Iijima and S. Oka. 2006b. Long-term Change in the Hydroclimatic Environment during the 20th Century on Chichi-jima in the Ogasawara (Bonin) Islands. *Geographical Review of Japan*, 79-10 (in Japanese).

Vistor / Tourism Pressures

General Affairs Divison, Ogasawara Village Office. 2009. *Ogasawara Villagers' News*, 552, 14 (in Japanese).

Ogasawara Ecotourism Promotion Commission. 2005. *Ogasawara Rulebook (2005 Edition),* p. 28 (in Japanese).

Ogasawara Nature Conservation Office, MOE. 2007. *Pamphlet: What we are doing for the natural environment of Ogasawara* (in Japanese).

TMG Ogasawara Office. 2008. *Overview of jurisdiction, 2007 edition*, TMG Ogasawara Office, General Affairs Division (in Japanese).

TMG website. *Agreement concerning Proper Use Rules* (in Japanese), URL: http://www2.kankyo.metro.tokyo.jp/sizen/eco/o_eco/syousai-rule.htm.

Protection and Management of the Property

Japan Travel Bureau Foundation. 2006. *Fiscal 2005 Ogasawara Area Ecotourism Promotion Model Project Report.* MOE (in Japanese).

TMG Ogasawara Office. 2008. *Overview of jurisdiction, 2008 edition*, TMG Ogasawara Office, General Affairs Division (in Japanese).

Monitoring

Nature Conservation Bureau, Environment Agency. 1982. *Minami-iwoto Wilderness Area Report* (in Japanese).

Akira Miyawaki. 1989. A*n Account of Vegetation in Japan: Okinawa and Ogasawara*. Tokyo: Shibundo, p. 676 (in Japanese).

Mikio Ono and Kiyoshi Okutomi. 1985. *The Endemic Plants and Vegetation of Ogasawara*. Aboc (in Japanese).

Tusyama, T. and S. Asami. 1970. *The Nature of Ogasawara*. Tokyo: Hirokawa-Shoten (in Japanese).

Ogasawara Research Committee of Tokyo Metropolitan University. 1977-2007. *Annual Ogasawara Research Journal* (in Japanese).

Ogasawara Research Committee of Tokyo Metropolitan University. 1977-2007. *Ogasawara Research* (in Japanese).

Institute of Boninology. 2009. Report on Natural Environment of Kita-iwoto (in Japanese).

Tokyo Metropolitan University Natural Enviroment Research Team (Ed.). 1980-1982. *Report on the Current State of the Natural Environment in the Ogasawara Islands*. Pollution Affairs Bureau, TMG, Vols. 1-3 (in Japanese).

Ogasawara Research Committee of Tokyo Metropolitan University. 1991. *Second Report on the Current State of the Natural Environment in the Ogasawara Islands* (in Japanese).

TMG and Tokyo Metropolitan University. 2008. *Report on Natural Environment of Minami-iwoto* (in Japanese).

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9. Signature on behalf of the State Party