Column World of Mutualism between Corals and Crabs

A variety of living organisms, including crabs, shrimps, univalve shells and small fish, use the space between coral branches as their habitats. Based on research on the relationship between Pocillopora damicornis and Trapezia cymodoce, we introduce the mutualism (the relationship of harmonious coexistence that brings mutual benefits) between them in this column.

Trapezia cymodoce feeds on mucus made by corals. This is the advantage of living with corals. Corals, on the other hand, are protected by Trapezia cymodoce from acanthasters, their natural enemy. Scenes of Trapezia cymodoce beating off acanthasters that approached to eat corals by cutting off their ambulacral feet and grabbing and cutting their needles are observed. All of more than 10 types of Trapezia cymodoce confirmed to live in coral reefs in Okinawa behave like this.

On the other hand, what remains less well understood is cases where congeneric multiple species of Trapezia cymodoce live in the same coral colony, which is contrary to the principle that "species with the similar mode of life do not live in the same habitat." One tentative theory under study is: "The coexistence relationship between corals and Trapezia cymodoce is related to the existence of acanthasters. When acanthasters are around, many species of Trapezia cymodoce gather to protect corals. If acanthasters are not around, Trapezia cymodoce do not have to exert efforts to beat off acanthasters, so species of Trapezia cymodoce start fighting among them and only strong species survive. Then, individuals in the surviving species start fighting and a pair of a large-size male and female occupy the coral colony."

If the above phenomenon is unraveled, clues to the protection of corals from acanthasters may be obtained. Besides this example, there are a lot of unknowns about the mechanism of ecosystems. Destroying biodiversity that brings immeasurable benefits to us without elucidating these unknowns would be a great loss to all living organisms on the earth, including humans.

Multiple species of Trapezia cymodoce confirmed to live in the same coral colony

Photo: Professor Makoto Tsuchiya, Faculty of Science, University of the Ryukyus

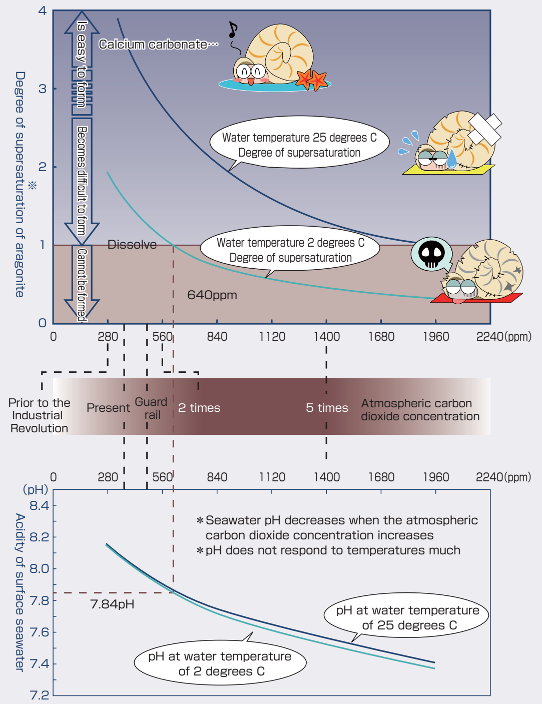
Section 2 Biodiversity and Global Warming

According to the IPCC Fourth Assessment Report, the risk of species extinction is projected to increase with increase in global average temperature. Droughts and wildfire associated with climate change are also threatening food production and ecosystems, while the degradation on biodiversity such as decreasing forest area is accelerating global warming. Therefore, it is necessary to implement measures to conserve biodiversity and measures against global warming by linking them.

1 Impact of global warming on biodiversity

The IPCC Fourth Assessment Report states that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3] % per decade, with larger decreases in summer of 7.4 [5.0 to 9.8] % per decade (Numbers in square brackets indicate a 90% uncertainty interval around a best estimate). The U.S. Fish and Wildlife Service (FWS) estimates that sea ice changes as projected, two-thirds of the global population of polar bears will be lost by around the mid-21st century. The IPCC Fourth Assessment Report states that increases in sea surface temperature of about 1 to 3℃ are projected to result in more frequent coral bleaching events and

Figure3-2-1 Linkages between Acidity of Surface Seawater and Formation of Calcium Carbonate



※Aragonite: Calcite and aragonite are two types of calcium carbonate with different crystal forms. Living organisms that form shells with aragonite more significantly affected by ocean acidification include sea butterflies (planktonic conches) and corals.

Source: Center for Global Environmental Research, National Institute for Environmental Studies, "What We Should Know about Global Warming"
http://www.cger.nies.go.jp/ja/library/qa_index-j.html

widespread mortality, unless there is thermal adaptation or acclimatization by corals.

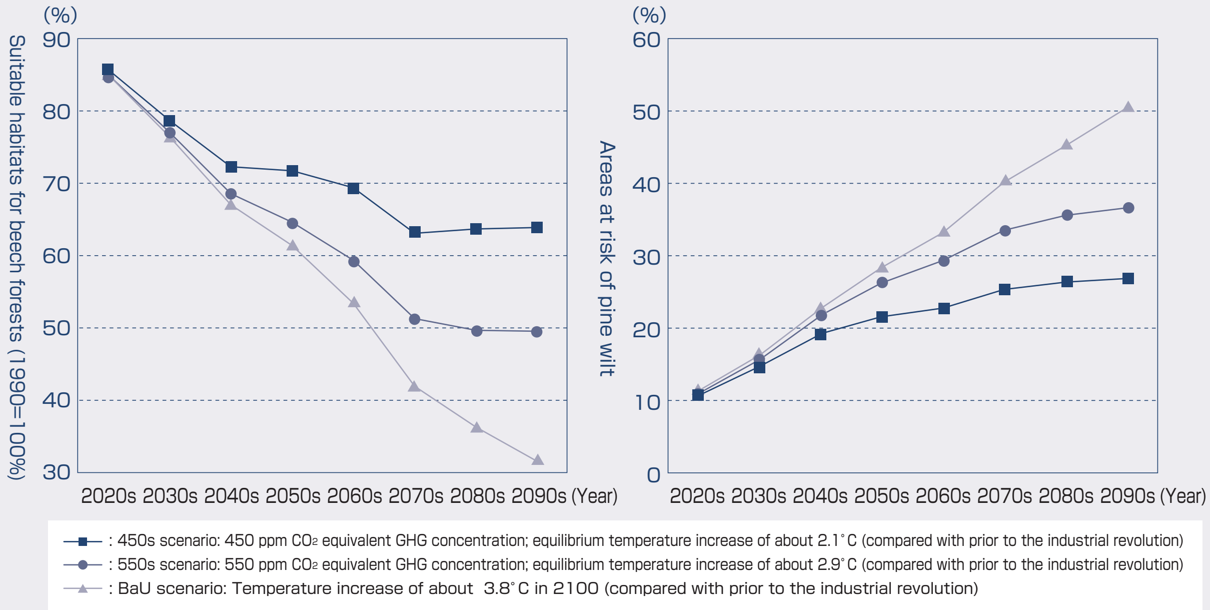
Further, there have been changes in oceans and forests, which are the vital foundations for the living organisms. Before the Industrial Revolution, when the atmospheric concentration of carbon dioxide was around 280ppm, the sea surface had a pH of 8.17. At present, when the carbon dioxide concentration has reached around 380ppm, the sea surface pH has already declined to around 8.06 (Figure 3-2-1). In oceans, there are many living organisms that have calcareous shells and skeletons. For examples, shellfish form shells for self-protection, while fish use calcium carbonate for ear stones that maintain their physical balance. Corals leave calcareous skeletons to nurture the next generation. However, when the carbon dioxide concentration in seawater rises with atmospheric carbon dioxide dissolving into seawater, acid (H^+) generated from carbon dioxide neutralizes carbonate ion (CO_3^{2-}), the material for calcium carbonate, reducing the carbonate ion concentration and making the production of calcium carbonate difficult. According to German Council of Science and Humanities, in order to avoid a critical impact on marine organisms that form calcareous shells, the decline in pH since the Industrial Revolution should not exceed 0.2. Meanwhile, in order to keep atmospheric temperature increases within two degrees C, the carbon dioxide concentration must be kept from exceeding 450ppm. If the carbon dioxide concentration is 450ppm, the decline in seawater pH would be around 0.17, barely below the 0.2 target to avoid a critical impact on marine organisms. Incidentally, both the atmospheric temperature rise target of 2 degrees C, above which climate change is likely to cause a major impact, and the pH decline target to avoid a critical impact on marine organisms have the same carbon dioxide concentration target of 450ppm.

A study on wildfires by the University of California, et al, and referenced by the IPCC Fourth Assessment Report found that since the 1970s, wildfire in the western United States increased in years when temperatures from spring to summer increased by about 2 degrees Celsius. Thus, large wildfires increased suddenly since the mid-1980s, and it has been reported that the frequency of wildfires is about four times and the forested area burned from 1987 to 2003 is 6.7 times the area from 1970 to 1986. In terms of the impact on ecosystems, the IPCC Fourth Assessment Report states that approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5℃ .

Turning to the impact on ecosystems in Japan, "Comprehensive Assessment of Climate Change Impacts to Determine the Dangerous Level of Global Warming and Appropriate Stabilization Target of Atmospheric GHG (greenhouse gas) Concentration" (hereafter referred to as "Project for Comprehensive Projection of Climate Change Impacts"), a strategic research and development area project financed by the Global Environment Research Fund of the Ministry of the Environment, projects a decrease in suitable habitats for beech forest an expansion of pine distribution areas at risk of pine wilt. It also projects that the impact and damage will likely decrease considerably if the greenhouse gas concentration is contained at the stringent stabilization target of 450ppm, but occurrence of a measure of damage cannot be avoided (Figure 3-2-2).

The degradation on biodiversity also affects global warming. The annual amount of carbon dioxide naturally absorbed by the earth is about 3.1 billion tons-C, of which terrestrial ecosystems (forests, grasslands and farmland, etc.) are estimated to absorb about 1.8 billion tons-C. As discussed in Section 1, the decline in forest area has not halted, with the capacity to absorb carbon dioxide decreasing gradually. Thus, the decline and degradation of forest ecosystems are likely to accelerate global warming. And if the atmospheric carbon dioxide concentration increases, the acidification of oceans that absorb 25% of global carbon dioxide emissions progresses further, threatening a serious impact on marine ecosystems.

Figure3-2-2 Ratio of Changes in Suitable Habitats for Beech Forests and Pine Distribution Areas at Risk of Pine Wilt Due to Global Warming



Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

2　Conservation of biodiversity and global warming measures are inseparable

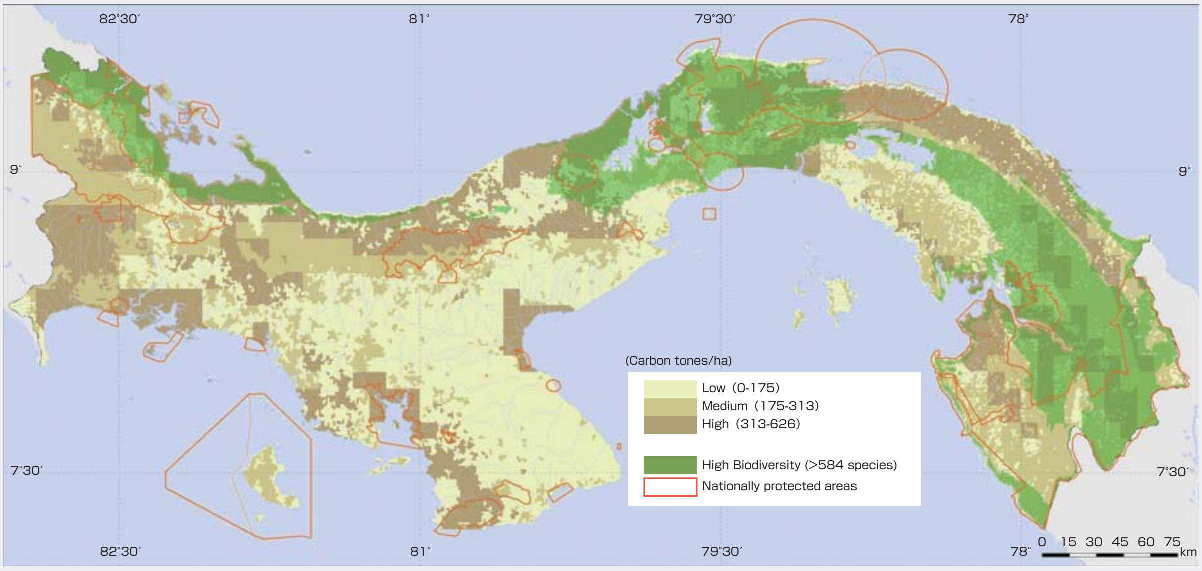
As seen above, biodiversity and global warming are closely connected and thus measures to deal with them should be more effective if they are mutually contributory. The "Stern Review: The Economics of Climate Change," which analyzes the economic impact of climate change, notes that "Curbing deforestation is a highly cost-effective way of reducing greenhouse gas emissions," and also leads to the conservation of biodiversity, etc.

About 20% of global greenhouse gas emissions are said to stem from the decrease and degradation of forests in developing countries. Under these circumstances, a mechanism to provide incentives to efforts to halt the decrease and degradation of forests in developing countries, called "REDD (reducing emissions from deforestation and forest degradation in developing countries)" is being considered under the Framework Convention on Climate Change (FCCC). Further, in recent years, the "REDD-plus" mechanism, which adds to REDD the ideas of forest conservation and sustainable forest management contributory to the conservation of biodiversity, is also being discussed. The Copenhagen Accord, adopted at the 15th session of the Conference of the Parties to the FCCC, held in Copenhagen, Denmark, in December 2009, incorporates the establishment of a mechanism for securing necessary financial resources for these efforts, including REDD Plus. In order to promote REDD effectively from both aspects of biodiversity conservation and global warming countermeasures, the World Conservation Monitoring Centre of the U.N. Environment Program (UNEP) has developed national maps for six tropical countries showing where areas of high carbon storage coincide with areas of biodiversity importance. Figure 3-2-3 illustrates the national map for Panama, where it is estimated that 20% of Panama's carbon emissions is stored in high carbon, high biodiversity areas. These efforts are believed to contribute to the objective identification of prioritized areas for REDD.

Furthermore, for example, the "Payment for Ecosystem Services (PES)," a method for maintaining ecosystem services, such as the cultivation of water source forests to secure water sources, can be expected to function as carbon sinks, if forests are adequately protected as a consequence. The following maps have been developed for Madagascar as an example. Colored areas in the left panel depicts the overlap between multiple ecosystem services in forest and wetlands, while red areas in the right panel indicates where payments would be suitable, after considering ecosystem services and payment costs (Figure 3-2-4).

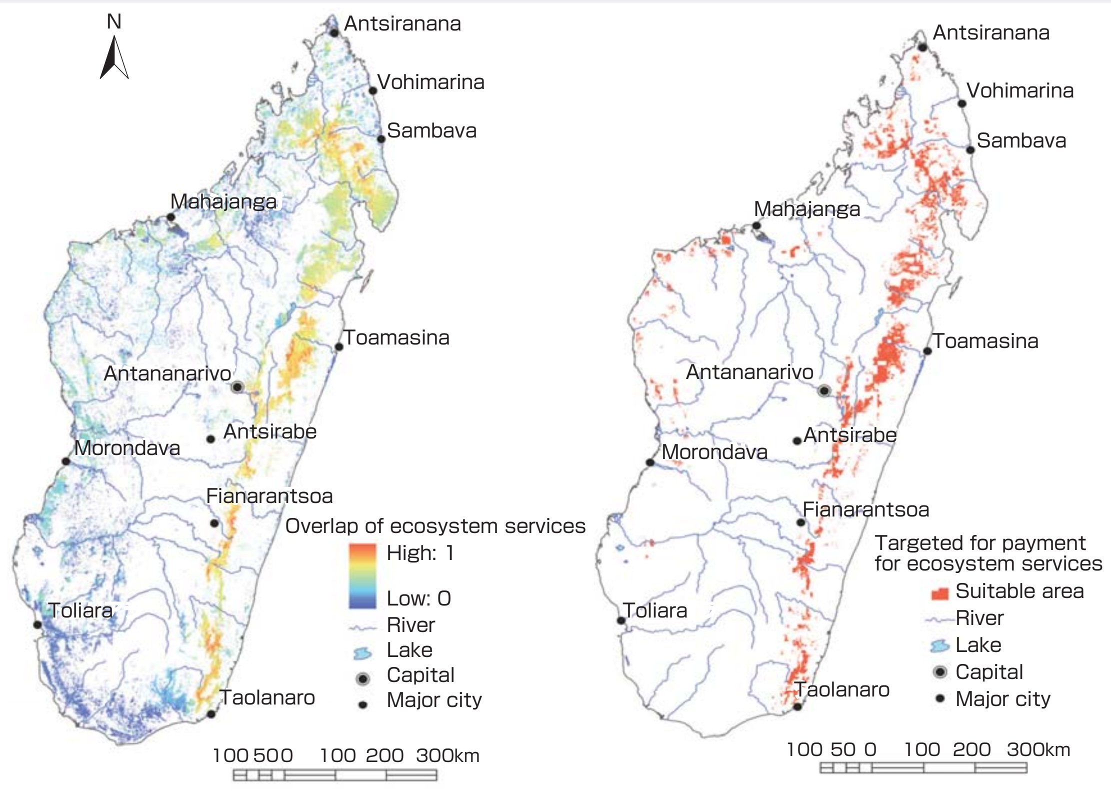
As seen above, since the conservation of biodiversity and global warming countermeasures mutually bring about synergetic effects and added value to the other, it can be considered more effective if efforts are made by linking both measures.

Figure3-2-3 An Example of National Maps Developed by the United Nations Environment Program's World Conservation Monitoring Centre (UNEP-WCMC) (Panama)



Source: Kapos et al. 2008

Figure3-2-4 Targeted Payments for Ecosystem Services in Madagascar



Source: Adapted from Wendland et al. 2009

Section 3 Shift to Biodiversity-Friendly Socio-economy (Mainstreaming of Biodiversity)

In order to realize the coexistence of humans and nature and make a shift to a biodiversity-friendly socio-economy, it is necessary to incorporate the conservation and sustainable use of biodiversity into various social and economic activities on a global scale as well as at the level of civil life (mainstreaming of biodiversity).

Therefore, in this section, we shed light on the relationship between corporate activities and cities and