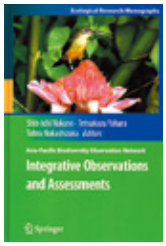
DIWPA News Letter

Office: Center for Ecological Research, Kyoto University, Otsu, Japan No.31

Message *from the Chairperson*



AP-BON Book2

A new biodiversity book "The Biodiversity Observation Network in Asia-Pacific Region: Integrative Observations and Assessments", Nakano, S., T. Yahara and T. Nakashizuka (Eds), Springer, Tokyo, has been released. We DIWPA provided significant contributions to the edition of the book. We hope the book would be useful and informative for you.

In addition, there was the call-for-application to Belmont Forum (BF) Funding "Scenarios of Biodiversity and Ecosystem Services", from May 2 to July 2 in 2014 (http://igfagcr.org/cra-2014-scenarios-of-biodiversity-and-ecosystem-services). We DIWPA examined our application to it, and we finally decided not to do that. The main reason for our resignation was the limitation written in the call-for-application as "This call for proposals encourages the formation of new international networks". However, we will consider our application to BF in future, because BF thinks "The Belmont Forum will consider opening a second call for international research projects on the same topic in 2017". According to the BF website above, it is interested in biodiversity and ecosystem services for decision making.

Shin-ichi Nakano

Also, we are very much pleased to inform all of you that one of our DIWPA Secretary members, Dr. Yachi, has been assigned as a member of the IPBES expert group (see the article about Dr. Yachi below). So, I hope we DIWPA would provide greater contributions to biodiversity research in future.

Dr. Yachi as an IPBES expert group member

We are pleased to let you know that Dr. Shigeo Yachi, one of the DIWPA Secretary members, has been assigned as a member of the IPBES expert group on Deliverable 3(c): Policy support tools and methodologies for scenario analysis and modelling of biodiversity and ecosystem services. He is going to attend the meeting organized the Technical Support Unit (TSU) for this Deliverable, and TSU will be hosted by PBL Netherlands Environmental Assessment Agency which can be considered as a workforce on behalf of the IPBES Secretariat. The meeting is held to facilitate communication between all participants and to write the Deliverable, and will provide strong collaborative oppotunity for the two co-chairs, Dr. Simon Ferrier and Dr. Karachepone Ninan.

Message *from the Secretary General*

Atsushi Ishida

In August 2014, DIWPA will conduct International Field Biology Course (IFBC) at a research station in the middle stream of Kiso River in Japan, to learn stream ecology including basic limnology in streams, fundamental ecological and biodiversity studies on sessile algae, benthic invertebrates, freshwater fish, data analysis and database preparation (Application closed). Unfortunately, we could not make enough funds to invite foreign students or researchers to Japan in this fiscal year. However, 1 foreign student and 2 foreign researchers will participate in 2014 IFBC.

Meanwhile, at the bigining of July, 2014, DIWPA set up an opportunity for Japanese students to report the results of their master theses at the Ogasawara (Bonin) islands for local people and visitors. The students have conducted research in the islands and capitalized Master in Kyoto University in March, 2014. One of students reports his experience at the presentation in this volume (pp 7-8). The islands have been listed in World Natural Heritage since 2011. Ecotourism in the islands has been more promoted, and the number of foreigner visitors is also increasing.

DIWPA will make more efforts for capacity building of young students and researchers through various activities. DIWPA Newsletters always call your papers related to biodiversity and conservation in your countries. We hope to send your papers to DIWPA Office (diwpa@ecology.kyoto-u.ac.jp).

Report 1

A report on the forth training workshop of information management for long-term ecological research

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(Japan)

Photo 1. Participants of the workshop (by courtesy of Mr. Enrique Frio of University of the Philippines Diliman)

Information management system is inevitable to preserve and share research data especially for ITLER (International Long-Term Ecological Research network), a network of research sites focusing on long-term ecological and socio-economic research. Currently ILTER serves “Metacat” server (containing various site-based ecological data and its metadata) in at least six member networks (the USA, Japan, Malaysia, Taiwan, Spain, and Brazil). ILTER-EAP (East Asia Pacific region) had largely contributed to the promotion of information managements in the region through organizing three training workshop in 2005, 2006, and 2007. The fourth workshop was held on June 2-4, 2014, at University of the Philippines Diliman in Quezon City, Philippines as a pre-event of ILTER-EAP 10th biennial meeting. Eighty seven students and researchers from the Philippines and other EAP countries attended the three-day workshop.

One of the uniqueness of the fourth workshop was that various specialists from different national LTER networks gathered as trainers under the call of “Many hands make light work” by Dr. Chau Chin Lin from TERN (Taiwan long term Ecological Research Network), chair of ILTER-EAP information management (IM) committee. We attended the workshop as the trainers from JaLTER (Japan Long Term Ecological Research Network), together with Mr. David Blackman, the chair of the ILTER IM Committee, Dr. John Porter from US-LTER, Dr. Sheng-Shan Lu from TERN, Dr. Abdul Rahman Kassim and Dr. Omarali Abdul Rahim from FRIM (Forest Research Institute Malaysia), and Dr. Xuibo Yu from CERN (Chinese Ecosystem Research Network). Taiwan LTER developed their IM system since 2004 and played the central role in the past three workshops. Eiichi Maita (co-author of this report) attended the third workshop held in Korea as a participant and now became an information manager of JaLTER and a trainer of this fourth workshop. The diversity of trainers in the fourth workshop suggests how the IM techniques have prevailed in the East Asian countries during the past

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Photo 2. Training for installing and using Morpho, the standard format and editing software for ecological metadata (by courtesy of Mr. Enrique Frio of University of the Philippines Diliman)

years. We trainers worked together from the preparation to the end of the workshop even though some of us met for the first time just the day before the workshop. At the end, we were able to know each other and shared lots of latest information and techniques.

On the first day, Dr. Porter, through video, referred to big data in relation to the ecological research, and emphasized the need of research collaborations, training to analyze such large and complex data, and sharing of data. Next, Mr. Blackman, Dr. Lin, Dr. Lu and Maita introduced EML (Ecological Metadata Language) and Morpho, the standard format and editing software for ecological metadata. Participants trained how to install and use Morpho with their own laptop PC.

On the second day, Mr. Blackman introduced DataONE (Data Observation Network for Earth) aiming to enable preservation and the use of long-term data. He also introduced DEIMS (Drupal Ecological Information Management System), a web-based online management system for research

Photo 3. Discussion about bilingual database (by courtesy of Mr. Enrique Frio of University of the Philippines Diliman)

information running on Drupal web framework. Masae Ishihara (co-author of this report) explained the state of data paper, one type of peer-reviewed scientific paper about data itself. Data papers are published by journals such as Ecology and Ecological Research and work as a method to give data owners the incentives for data sharing. Tips for writing data paper was also shown. Maita introduced JaLTER Data Center, which is a new web application to create EML metadata and to support researchers to write data paper. State of information managements in FRIM and CERN was presented by Dr. Rahim and Dr. Yu. FRIM in Malaysia established obligatory data sharing mechanism for their data. Dr. Yu explained Centralized Information Management System of CERN (CERN-CIMS), the nation-wide comprehensive system for ecological and environmental monitoring activities in China.

On the third day, Dr. Kassim introduced R, a data analysis and graphical free software. Some participants experienced computer programing for the first time. Ishihara showed how to use RStudio, also free software for editing and running R script, for data quality control, for saving time from repeated data analysis, and for drawing graphs and creating tables. Dr. Kassim further showed the R package googleVis which creates interactive charts based on R data frames using the Google Chart Tools. It provides a new way to visualize data. Finally, Dr. Lin introduced data analysis tool Kepler enabling management and sharing of scientific workflows. Kepler can search and get data from Meacat servers, and run R to analyze data and present the results.

Overall, participants were really active in learning despite some technical problems in software installation

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and connecting to FTP server to download workshop materials. Working together and helping each other fostered communication among participants from different universities and organizations.

The workshop was very successful and resulted in preparation of the PhiLTERnet (Philippine Long Term Ecological Research Network) database. If accomplished, the database surely enhances the biodiversity and ecological studies in the country as well as in the East Pacific Region.

Photo 4. Lecture by Eichi Maita about JaLTER Data Center

Photo 5. Trainers of the workshop with

Report 2

Report on the 7th GEOSS Asia-Pacific Symposium in Tokyo focusing on the AP-BON session

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(Japan)

The 7th GEOSS Asia-Pacific Symposium "Benefits for Society from GEOSS Evolution toward Addressing Sustainable Development Goals" was held in Tokyo at Kokusai Fashion Center (KFC) Hall during 26-28 May, 2014[1]. "GEOSS" is for the Global Observation System of Systems, an international project aiming to provide decision makers with scientific information by integrating contact and remote observations of the globe for the nine societal benefit areas including disasters, health, energy, climate, agriculture, **ecosystems**, **biodiversity**, water and weather. AP-BON is an Asia-Pacific network of GEOSS specified for ecosystems and biodiversity areas. GEOSS has been promoted by "GEO (Group of Earth Observations) " for 10 years since 2004 and this symposium was held to seek for cross-sectoral linkages and add trans-disciplinary activities of the above nine areas in Asia-Pacific region for the GEOSS next 10 years (2015-2025). The symposium was closed with the adoption of Tokyo Statement[2] which stresses the importance of the Asia-Pacific region and the strengthening of networking in this region. Here, I'd like to focus and report on the Day 2 Parallel Session WG2 for AP-BON[3] (Co-chairs: T. Yahara, T. Nakashizuka & S. Vergara; Co-Organizers: R. Ishii & H. Yamano).

In the opening address of WG2, Dr, YAHARA (Japan) summarized the AP-BON progress since 2009, discussion in the 5th AP-BON workshop in Philippine, and the concept and implementation of AP-BON. Session 1: "what we could know about current observation technique" was designed to share the recent progress in the observation techniques. Dr. Ishii (Japan) nicely presented the outline of 6 invited speakers of session 1 in a picture (Fig. 2), which expresses the complementary roles of different observation methods (satellite remote sensing, in situ observations and chemical/isotope analysis) to integrate information from watershed (natural forest, agricultural field, rivers and lakes) to coastal areas (mangrove, coral reefs, marine). The presentations in this session elucidated the current reality of anthropogenic damage on coastal and lake ecosystems in various spatial scales and causalities in Asia-Pacific region. Then, in session 2, the AP-BON country/regional progress reports were presented from Korea (Dr. Eun-Shik Kim), Indonesia (Dr. Dedy Darnaedi), Philippine (Dr. Vergara), Taiwan (Dr. Yu-Huang Wang), China (Dr. Keping Ma), and Nepal (Mr. Mangal Man Shakya).

Fig. 1. Presentation in Session 1 by Dr. Takanori NAKANO (Japan, RIHN)

Based on these session reports, discussion session was prepared for the integrated case study to promote data sharing in AP-BON. Since 2009, AP-BON activities have been strongly activated in a relatively short time period, however, limitations in data sharing seem to be a barrier for the future AP-BON development. To overcome this barrier, case study on specific sites in a particular country shared by AP-BON members with different backgrounds and observation methods would be helpful for mutual understanding and communication for data sharing. In all parallel sessions including WG2, Cambodia was proposed as a shared field candidate for the promotion of cross-sectoral activities of GEOSS in the Asia-Pacific region. The conclusion seems to have been postponed, however, in the framework of **Future Earth**, cooperation of research between different areas would be required in

the GEOSS next stage. Likewise, for the advancement of ecosystems and biodiversity area, integration of variety of observation techniques by focusing on ecosystem services in a shared field site seems desirable. Sharing a research site, which is not to be limited to Cambodia, will be an important step toward the AP-BON next stage.

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1) https://www.restec.or.jp/geoss_ap7/

2) https://www.restec.or.jp/geoss_ap7/public/TokyoStatement.pdf

3) https://www.restec.or.jp/geoss_ap7/program_wg2.html

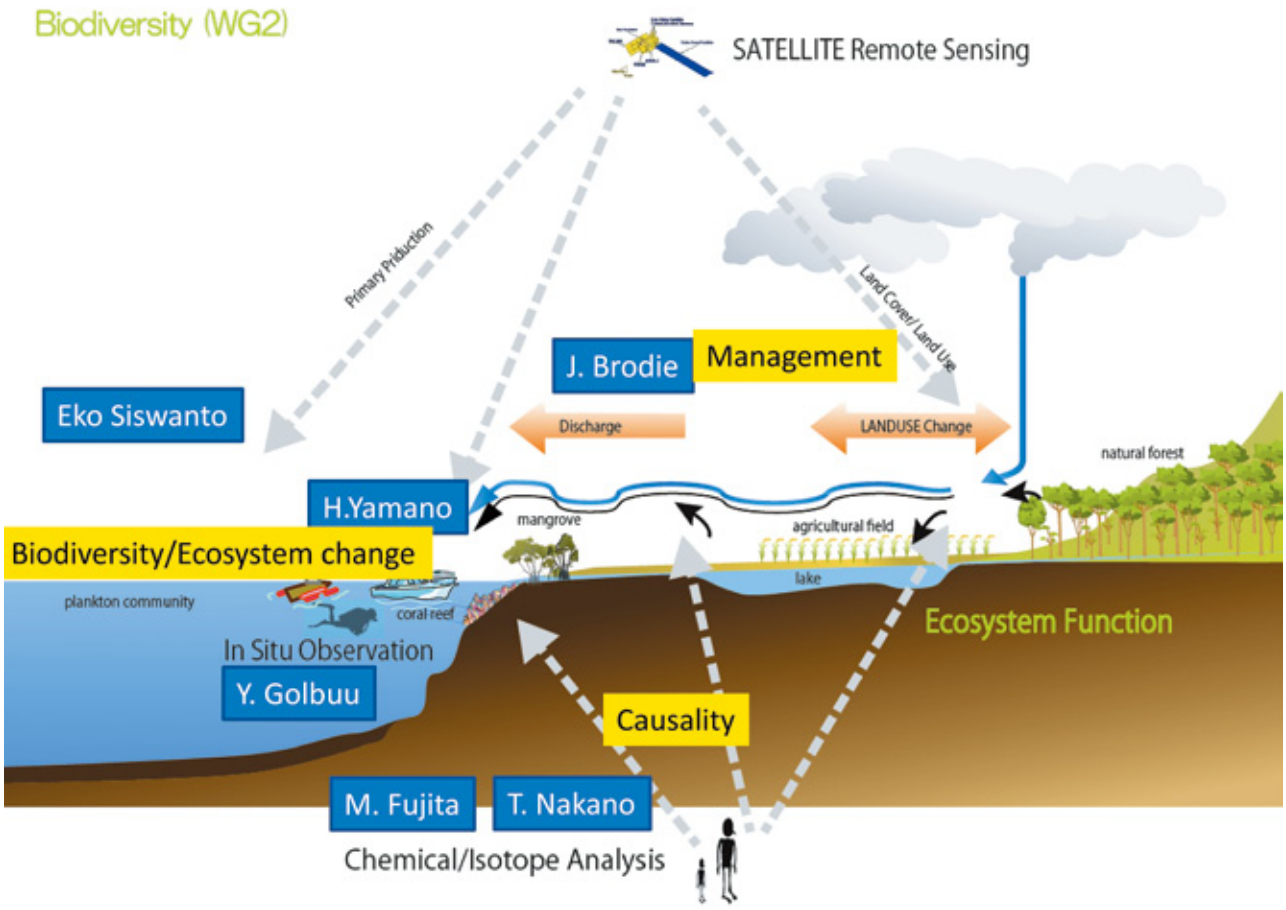

Fig. 2. Outline of Session 1 presentation by Dr. Reiichiro ISHII (Japan, JAMSTEC)

Report 3

Presentation of Master Theses at the Ogasawara (Bonin) Islands

Shin-Taro Saiki
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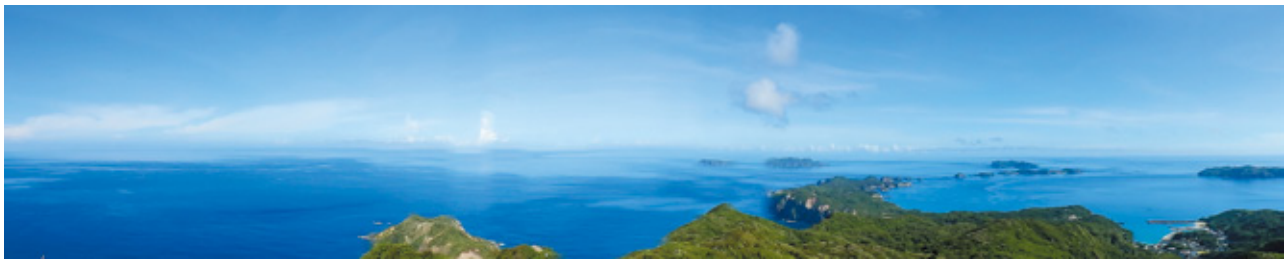

Photo 1. A panorama photograph from the southern tip at Haha-jima Island

DIWPA set up an opportunity for Japanese students who have studied at the Ogasawara (Bonin) Islands for exhibiting the results of master theses for local people and visitors. I reported my research topic at Chichi-jima and Haha-jima Islands on 2nd and 4th in July, 2014, respectively. Chichi-jima and Haha-jima Islands are member islands of the Ogasawara Islands in Japan. My research presentation was conducted at Visitor Center in Chichi-jima Island and at Village Hall in Haha-jima Island. The Ogasawara islands are a National Park in Japan and one of World Natural Heritage sites. The Visitor Center usually displays the specific attraction or interest, such as landmark, specific animals and plants, ecosystems in forests and sea, and the history of islands, and provides information for tourists or visitors. There are many rules that they have to do or not to do at the islands for conservation of natural ecosystems. In especially, care against invasion species is the most important issue in the islands. Presentation by researchers in natural and cultural history has been also periodically conducted for in-depth educational exhibition at the Visitor Center. The Visitor Center is thus an important place, where local people, NPOs, visitors, and researchers are coordinated in the islands. The populations in Chichi-jima and Haha-jima islands are approximately 2,000 and 400 people, respectively. Although the population is not so large, many local people have high interests in the nature of islands.

I got a degree in the Master of Science in Kyoto University in March, 2014. Now I succeed my research at the islands as a student of doctor course. In July 2014, I reported the research topic in my master thesis for local people and visitors at the islands. The main topic of my research is how tree heights are decided or why tree heights are limited. This question has been given the central position in forest research (e.g., Ryan and Yoder, 1997), yet there is no common explanation for the limitation of tree heights. Many possible hypotheses have been proposed to explain the limits of tree heights. Ryan and Yoder (1997) have argued that the most likely explanation depends on the increasing hydraulic resistance to transfer in the xylem as trees grow, called “hydraulic limitation hypothesis”. According to this hypothesis, the increasing hydraulic resistance from soil to top-canopy leaves as trees grow is proposed to lead falling shoot water potential with consequent stomatal closure and reduced photosynthesis. Many factors, such as nutrients deficit, an increase in respiration, and damage due to wind velocity, would be included in the determinant of tree heights. However, increasing hydraulic limitation would play the major role in the limitation of tree heights. Therefore, I have examined hydraulics and water use among individual trees with contrasting top-canopy heights within a tree species at the islands.

The Ogasawara Islands are small oceanic islands that have never been connected to any continental landmass. Approximately 70% of tree species are indigenous in the islands. The top-canopy heights of woody plants gradually decrease from 20 m to less than 1 m high from humid valleys to dry ridges. At the dry ridges, the vegetation is thus predominated by dwarf woody plants on the rude, shallow soil originated by volcanic origin. On the other hand, in the humid

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valleys, the vegetation is predominated by tall trees on deep soil. Some trees grow at only the ridges or the valleys, but the other trees can grow from the dry ridge to the wet valley sites with contrasting tree heights. Such forest structure is very unique and gives us the most suitable study sites, to examine how tree heights are decided.

I challenged this question in my master thesis, using *Hibiscus glaber* Matsum., an endemic woody plant species. They grow from the ridge to valley sites, varying from 16 m to 0.9 m high above the ground in the top-canopies(Photo 3). Here, we hypothesized that *H. glaber* can select alternative strategies of soil desiccation tolerance and height competition, resulting in a generalist that can grow from dry ridges to wet valleys with contrasting tree heights at the islands. At the soil depth was 2 m, their tree heights reached 10 m above the ground. With decreasing soil depth from 2 m toward the ridges, tree heights drastically decreased. Leaf water potential at predawn (ψ_{pre}) during the dry season extremely decreased in short individuals at the ridges, and ψ_{pre} slightly decreased in tall individuals at the valleys. In contrast, ψ_{pre} in individuals at the middle slopes was kept at relatively high values even in the dry season. Furthermore, leaf mass per area and leaf thickness decreased with tree heights and individual leaf area increased with tree heights. Carbon isotope ratio ($\delta^{13}C$) in the top-canopy leaves was less negative in short individuals at the dry ridge and tall individuals at the wet valleys than in intermediate tree heights at the middle slopes. The less negative values of $\delta^{13}C$ mean a long-term trend of low internal CO_2 concentrations within lamina, resulting from stomatal closure. These facts indicate that the top-canopy leaves of short individuals at the dry ridges and tall individuals at the wet valleys suffered from drought stress originated by different causes. At the dry ridges, drought stress was due to soil desiccation because of thin soil. In contrast, at the wet valleys, drought stress was due to both the high gravity potential and the long hydraulic path length from soil to leaves. Approximately 10 m of tree height and 2 m of soil depth seem to be the sift point of alternative strategies, from soil desiccation tolerance at the dry ridges to height competition at the wet valleys.

Photo 2. My presentation at Village Hall in Haha-jima Island

After my presentation, many listeners gave me questions and suggestions. They have high interests and much knowledge of plants and vegetation at the islands. The questions from them were sure nice, because the discussion with them was enough for me to wake up to the importance of science again. I can boost my motivation for research at the islands. I would like to produce good papers in international journals that clearly explain scientific topics. I express my appreciation to DIWPA for giving me a chance to present the results of my theses at the islands. I also thank my supervisor (Professor Atsushi Ishida) and colleagues for obtaining data and continuing my research at the islands. I hope that the beautiful nature in the islands is maintained for eternity, and my research can be helpful for such social contribution.

Photo 3. The photographs of *Hibiscus glaber* individuals from a wet valley to a dry ridge (from left to right panels) in Chichi-jima Island. The top-canopy heights are 16 m, 10 m, 5 m, and 0.9 m above the grounds from the left to the right panels, respectively. Yellow arrows show a body length (approximately 1.7 m).

New Site

Monitoring development of ecosystem on volcanic Miyake-jima Island

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Fig. 1. Crater of Mt.Oyama on Miyake-jima Island (2001)

Miyake-jima Island erupted in 2000, and extremely large areas were destroyed by volcanic ash and gas containing surfer dioxide. I have continued vegetation monitoring with my co-workers since 2000. We have already reported vegetation decline by volcanic activities and recovery processes in several papers (e.g., Kamijo *et al*. 2008, Kamijo & Higuchi 2011, Kamijo 2014). However, to understand ecosystem development on volcanically devastated sites more information about other biological groups and ecosystem elements, such as birds, insects, microbes and soils are necessary. Therefore, we have conducted a new project in which we don't focus only on plants but also other biological groups and soils on Miyake-jima Island since 2011. In this paper, I would like to introduce this one.

Miyake-jima Island

Miyake-jima Island (N34° 04'37", E139° 31'34") is a one of volcanic Izu islands situated on western rim of the Pacific Ocean. Miyake-jima Island is quite active volcano which has erupted 4 times since 1900. The 2000 year eruption is the most recent and the biggest eruption among them. From July to September in 2000, Mt. Oyama on the island erupted, ejecting large amounts of volcanic ash and forming a collapsed crater over 1 km in diameter and 400 m deep (Fig.1). Wind-borne material covered extensive areas of the island. After the formation of the new crater, a large quantity of volcanic gas containing high concentrations of SO_2 and H_2S were emitted. Because of the continuous volcanic gas emission, all the people had been evacuated from Miyake-jima Island from September, in 2000 to January in 2005.

Purpose of monitoring

Large volcanic eruption does not destroy only aboveground vegetation but also soil systems. However, influences of the eruption, such as deposition of volcanic ash and exposure of SO_2 on ecosystem changes among sites because of distance from the volcanic crater, wind direction and so on. Therefore, disturbance mosaic of ecosystems with different damages occurred after the eruption and ecosystem structure and process quite differs among them. Our focus is to understand ecosystem development on volcano in terms of biodiversity and ecosystem function by comparing ecosystems with different damages.

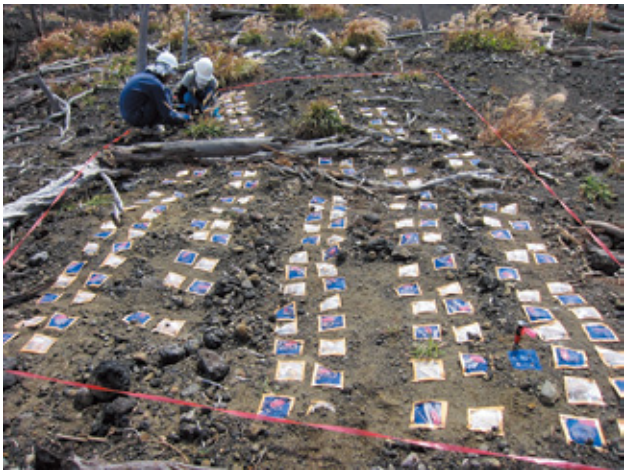

Fig. 2. Litter bags in OY8 (2012)

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Monitoring sites

Eleven monitoring sites including bare lands to climax forests had been set on Miyake-jima Island to monitor ecosystem development since 2011. We monitored climatic conditions, concentration of SO_2 in air which is a feature of the volcanic activities on Miyake-jima Island, vegetation, soil fauna, birds, insects, litter decomposition, soils and soil respirations (Figs. 2, 3).

1) OY8 (N34° 4.692', E139° 30.966'): This site is the most heavily disturbed sites (Figs. 2, 3). The 2000-year volcanic ash depth was about 30 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 20%. Ecosystem is being affected by SO_2 now. Almost all living organisms were ruined by the 2000-year eruption and volcanic gas. Legacies of organisms on the site were only dead stems. Plant succession on this site can be classified to primary succession. Patches of *Miscanths condensatus*, a perennial grass species with very high tolerance to SO_2 were found after 11-13 years.

2) IG7 (N34° 5.378', E139° 30.832'): The volcanic ash depth was about 40 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 7%. Almost all living organisms were ruined by the 2000-year eruption and volcanic gas. Legacies of organisms on the site were only dead stems. However, SO_2 concentrations were not so high in spite of high altitude, because this site is situated on windward side where frequency of exposures of volcanic gas is relatively low. Plant succession on this site can be classified to primary succession. Patches of *M. condensatus* were found.

3) M1 (N34° 4.760', E139° 33.293'): The 2000-year volcanic ash depth was 0 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 37%. This site is characterized by almost no ash deposition and heavy effect of SO_2. The ecosystem is destroyed by higher concentration of SO_2 soon after the eruption. Therefore, soil condition is good for plants. *M. condensatus* dominated this site.

4) OY2 (N34° 3.894', E139° 30.632'): The 2000-year volcanic ash depth was about 10 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 19%. This site is characterized by relatively heavy effect of SO_2. *Eurya japonica*, an evergreen broadleaved tree species with high tolerance to SO_2 formed opened shrub vegetation. These trees had survived after the eruption by re-sprouting from their stem (Fig. 4).

5) IG8 (N34° 5.474', E139° 30.561'): The 2000-year volcanic ash depth was about 40 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 6%. Although heavy deposition of volcanic ash destroyed ecosystem, some living legacies of organism, such as survived tree stems were found. *Alnus sieboldiana*, a nitrogen fixing pioneer tree species and *M. condensatus* dominated this site.

6) N1 (N34° 4.799', E139° 30.231'): The 2000-year volcanic ash depth was about 20 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 8%. Although heavy deposition of volcanic ash destroyed ecosystem, some living legacies of organism, such as survived tree stems were found. *A. sieboldiana* dominated this site.

7) IG9 (N34° 5.592', E139° 30.361'): The 2000-year volcanic ash depth was about 20 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 5%. Although heavy deposition of volcanic ash destroyed ecosystem, some living legacies of organism, such as survived tree stems were found. *A. sieboldiana* dominated this site.

8) IZ2 (N34° 6.150', E139° 30.745'): The 2000-year volcanic ash depth was about 10 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 2%. Vegetation damage was medium in this site because the ash depth is not so thick and exposure of volcanic ash is not so frequently. *Machilus thunbergii*, an evergreen broadleaved tree species and *E. japonica* formed opened forest vegetation. These trees had survived after the eruption by re-sprouting from their stems and crowns.

Fig. 3. Chambers for measurement of soil respiration in OY8 (2012, photo. by Mitsuru Hiota)

New Site

Fig. 4. OY2 dominated by *Miscanthus condensatus* and *Eurya japonica* (2011)

Fig. 5. IZ1 dominated by *Castanopsis sieboldii* (2011)

9) N4 (N34° 4.243', E139° 29.271'): The 2000-year volcanic ash depth was about 5 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 6%. Vegetation damage was medium in this site because the ash depth is not so thick and exposure of volcanic ash is not so frequently. *M. thunbergii*, an evergreen broadleaved tree species and *E. japonica* formed opened forest vegetation. These trees had survived after the eruption by re-sprouting from their stems and crowns.

10) T1 (N34° 3.120', E139° 31.598'): The 2000-year volcanic ash depth was 0 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 8%. Vegetation damage was little. *Castanopsis sieboldii* an evergreen broadleaved tree species formed closed forest vegetation.

11) IZ1 (N34° 6.710', E139° 30.081'): The 2000-year volcanic ash depth was 0 cm, and frequency of higher concentration of SO_2 than 0.1 ppm was about 2%. Vegetation damage was little. *C. sieboldii* an evergreen broadleaved tree species formed closed forest vegetation (Fig. 5).

Future works

Based on the analysis of ecological parameters obtained in each of these 11 sites, we are going to clarify development of ecosystem processes including interactions among organisms, and organisms and environment on volcanically devastated sites.

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