Conservation of Biodiversity by Making Use of ICT

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Our lives, including our economic activities, depend on the blessings of ecosystems based on biodiversity. However, expansion of human activities has reduced the habitats of creatures, and the number of species constituting ecosystems is decreasing at an accelerating pace. These activities are destroying the foundation of our lives. Global Biodiversity Outlook 3 published by the Secretariat of the Convention on Biological Diversity in 2010 says that, while efforts are being made in some fields, loss of global biodiversity is still continuing and it is essential to act in the coming 10 to 20 years. In order to stop this biodiversity loss on a global scale, the national and local governments, NPOs, research institutions and enterprises are required to cooperate in conserving biodiversity. The Fujitsu Group, which formulated the Fujitsu Group Biodiversity Action Principles in 2009, is carrying out activities based on the priority measures of making use of information and communications technology (ICT) to contribute to the conservation of biodiversity together with various stakeholders, in addition to striving to reduce the impact of its own business activities. This paper presents examples of utilizing ICT as Fujitsu's activities for biodiversity conservation: the Mobile Phone Photo System cloud service that has allowed biological research with the participation of citizens, and the birdcall recognition system for research on a habitat of Blakiston's fish owls, which is an endangered species.

1. Introduction

There are various ecosystems on the Earth such as forests, marshes, rivers and oceans. An enormous number of creatures living on the Earth including humans is supported by these ecosystems. Thinking only of the known ones, there are about 1.75 million species of creatures in the world. Including those that are yet to be found, it is estimated that there are more than 30 million species. However according to the Red List reported by the International Union for Conservation of Nature and Natural Resources (IUCN) in 2012, about 20% of the vertebrates and about 60% of the plants, in total about 30% of all organisms are in danger of going extinct.

To arrest this loss of biodiversity, Aichi Biodiversity Targets adopted in the tenth meeting of the Conference of the Parties (COP10) of the Convention on Biological Diversity, held in 2010 in Nagoya, act as a series of strategic initiatives including: Mainstreaming biodiversity across government and society; promoting sustainable use; and enhancing implementation through participatory planning, knowledge management and capacity building. To realize "the Life in Harmony, into the Future" by 2050, it is imperative to have policies and actions based on more scientific knowledge and technologies.

In this report, we will introduce the Fujitsu Group's two cases where preservation of biodiversity is addressed by making positive use of information and communications technology (ICT).

2. Possibility of biodiversity preservation using ICT

By using ICT, it is possible to collect, analyze and evaluate a large amount of information efficiently, and it is also possible to optimize human behaviors, working processes and social systems by making positive use of the data obtained from the aforementioned

information. In recent years, these data have come to be used in a wide range of applications to make our life more rational by carrying out composite analysis of diverse information as big data based on the combined knowledge of people, with the aim of creating new values. Also in the field of biodiversity, efficient collection and appropriate use of the complex and diverse information may contribute to the avoidance and decrease of biodiversity loss, promotion of sustainable use and maintenance/extension of biodiversity (**Figure 1**).

Scenes of using ICT for biodiversity preservation include:

1) Information collection

Remote sensing of organisms, temperature and humidity; identification of species by image analysis of organisms, collection of organism information and environment information by using mobile terminals

2) Analysis/evaluation

Evaluation of impacts on organisms, ecosystems and habitats

3) Information management

Organism information (species, population, habitats etc.), database for genetic information etc.

4) Monitoring

Monitoring and observation of environment changes and organism behaviors

5) Education, propagation and enlightenment

Propagation of information and enlightenment of entire society through network communication technologies and image distribution technologies

Further, it is possible to contribute to biodiversity preservation by supporting economic activities, environmental considerations and productivity enhancement in the primary industries (agriculture, fishery, forestry, etc.), which directly involve the supply services that constitute the ecosystem services[1] (various benefits generated by biodiversity).

3. Mobile photo system/cloud services

For preservation of biodiversity and its sustainable use, it is critical to run a PDCA (plan-do-check-act) cycle. At first, it is necessary to understand accurately how many wild animals and plants live and grow in which location inside the targeted area ("check"). Then, it is essential to carry out analysis and evaluation based on this study and monitoring data and to understand the current status and the time-related changes ("act"). Thereafter, based on the analysis/evaluation results, it is requested to develop preservation and utilization plans to stipulate how the targeted area should be preserved and used, and who takes what action in which timeframe ("plan"). Following this stage, actions should be taken for preservation activities and sustainable use based on these preservation and utilization plans ("do"). Finally, the results are used as feedback for the next implementation plan.

The mobile photo system[2] is a tool that can be used in a series of phases (research/monitoring [check] and analysis/evaluation [act]) for biodiversity preservation and utilization. In the organism survey such as

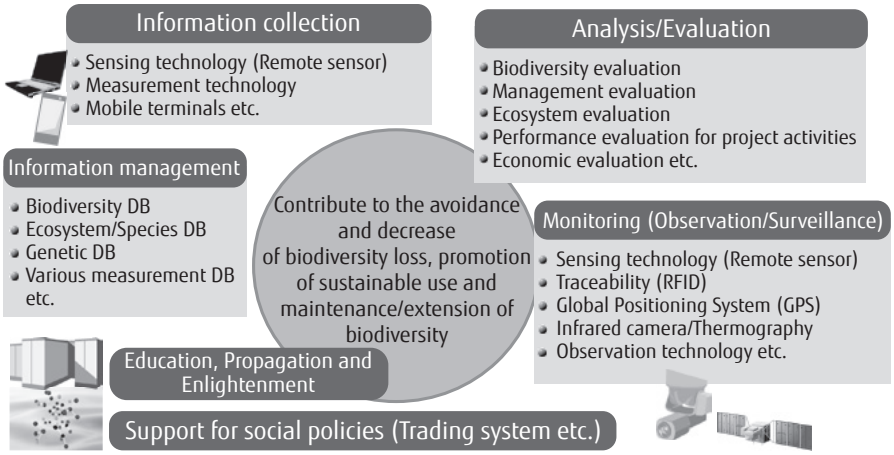

Figure 1
Possibility of biodiversity preservation using ICT.

Monitoring Site 1000 implemented by the Ministry of the Environment, species of organisms found by expert investigators are identified. Also their status including the observed locations and populations are recorded in the recording format. However, if the scope of a survey involves a wide area, this approach requires an enormous number of expert investigators. It also needs a lot of labor to identify the locations of observation and their precise plotting. On the other hand, the mobile photo system enables information to be collected in a vast area at a time, because the general public can participate in the survey by using their mobile phones or smartphones that are regarded as part of social infrastructure nowadays.

Figure 2 describes the function of the mobile photo system. Images taken by mobile phones or smartphones with a GPS feature are transmitted as attachments to a prespecified mail address. These pictures and the information recorded in the mails are accommodated in Biological Information database together with Exif information including the date, time and location of shooting that accompany the images. The accumulated information can be published after undergoing a sorting process by the administrator and upon judging whether or not they are suitable for public disclosure. When reviewing the information, it is possible to set search conditions such as research subject, date/time and location. It can be viewed as a list format or mapping format combined with topographic information. Further, because users are allowed to download the data in the database, professionals can analyze and evaluate the information at their discretion.

To accelerate the use of information for biodiversity preservation, the Fujitsu Group has deployed this mobile photo system on the Fujitsu Cloud Service platform, FUJITSU Cloud IaaS Trusted Public S5, and started offering this system as "the Mobile Phone System Cloud Service" to 13 organizations promoting biodiversity preservation (**Table 1**). Typical cases of use are introduced in the following subsections.

3.1 Census of bumblebees engaged in pollination

In the Graduate School of Life Sciences, Tohoku University, this service has been used to conduct a census on bumblebees engaged in pollination.[3)] While it is fairly difficult to carry out this survey by delegating expert investigators nationwide, use of mobile phones or smartphones allows the general public to participate in the survey and to work as investigators, which makes the nationwide survey possible. Even if a participant does not know about bumblebees, the experts can identify them based on the picture of the bees sent by the lay investigators.

Bumblebees are the primary pollinators not

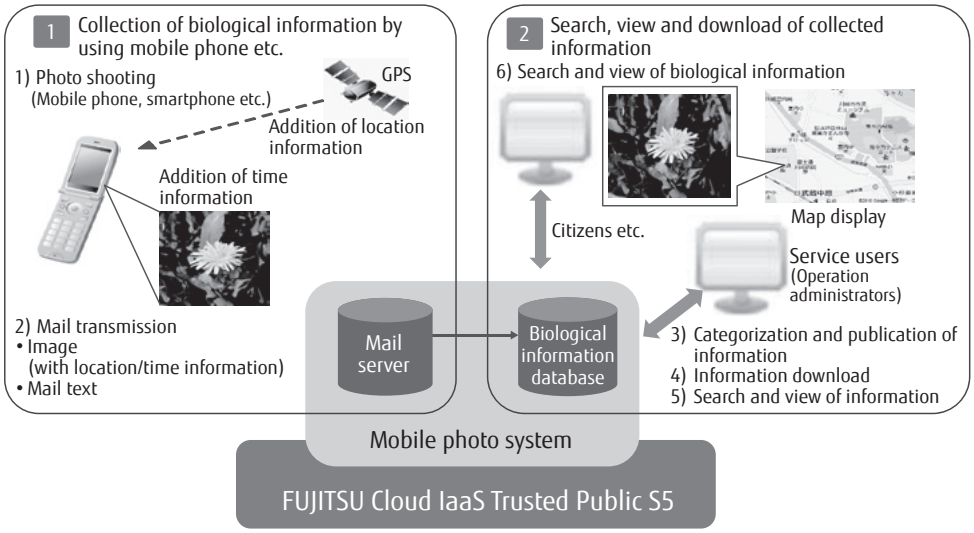

Figure 2
Mechanism of Mobile Photo System Cloud Service.

Table 1
User organizations for Mobile Photo System Cloud Service.

No.	Subject description	Organizaiton
1	Search for dandelions!	Aichi University of Education, Mikiko Watanabe's laboratory
2	Tama River Vegetation	Kawasaki City
3	Kawasaki City Kuriki Greenery Conservation	Kawasaki City and Fujitsu's Corporate Environmental Affairs Unit
4	Hakusan Non-native Plant Species Initiative	Chubu Regional Environment Office of Ministry of the Environment Hakusan Ranger Office For Nature Conservation
5	Survey of Living Things in the Chita Peninsula Green Belt	Interwined Life Project Office
6	Search for Kurashiki Plants and Animals	Kurashiki City
7	National Census of Bumblebees	Graduate School of Life Sciences, Tohoku University
8	Woodland Plants and Animals in Tsushima	MIT (General Incorporated Association)
9	General Survey of the Natural Environment of the Tokachi Coastal Wetlands	The Wetlands Institute of Northeastern Asia (General Incorporated Association)
10	TCE Animal and Plant Species Habitat Distribution Survey	Tokyo College of Environment (Educational Corporation)
11	Honeybees were here! Great Survey	A Thousand Flowers for Bees, an NPO registered in Japan
12	Woodland Living and Biodiversity	ECOPLUS, an NPO registered in Japan
13	Search for camellia! (Inochino-Tsubaki Project)	Michinoku Furusato Network, an NPO registered in Japan

only for wild plants but also for many crops. They are a significant means of pollination for human beings. Nevertheless, a global decrease in the bumblebee population has been reported recently due to a series of factors including a change in human land use, decrease of resource plants, use of pesticides, and infectious diseases. In Japan, settlement of exotic species (Bombus terrestris; common names are buff-tailed bumblebee or large earth bumblebee) in wild environments impacts the native bumblebee species. Some investigators have pointed out that a decreasing trend was observed for bumblebees even in regions where there was no impact from exotic species. Therefore, it was imperative to promptly establish a monitoring system nationwide. While ecological distribution surveys for bumblebees have been conducted in the Hokkaido and Tohoku areas so far, it was necessary to understand the current status of each sub-species of bumblebee on a nationwide basis to identify their entire ecology. To be specific, it was necessary to identify the nationwide distribution of bumblebee sub-species and find out which sub-species had a changing or decreasing distribution. To address these tasks, Tohoku University started to use this service to develop a prediction-based nationwide distribution map of bumblebees in collaboration with Yamagata University.

3.2 Monitoring of expanding distribution of exotic plant species in Hakusan area such as plantain and effective countermeasure against exotic species

Three organizations, i.e., Chubu Regional Environment Office of Ministry of the Environment Hakusan Ranger Office For Nature Conservation, Ishikawa Prefecture and Association for Conservation of Circum Hakusan Area, are using this service for monitoring exotic plant species including plantain that are expanding their habitats in the Hakusan area[4] and for taking an effective countermeasure against them. Some parts of Hakusan National Park are alpine and sub-alpine zones encompassing areas higher than 2000 m above sea level, centered on Gozengamine (main peak), Ohnanjimine and Kengamine. Alpine plant communities in the alpine area frequently covered with residual snow are located in the most western region in Japan. It is the habitat of many unique alpine plant species including Primula cuneifolia Ledeb. var. hakusanensis Makino (Primula cuneifolia's common names are Wedgeleaf or Pixie-eye primrose). Because many of these alpine plants are rare species, Hakusan is an important place from the standpoint of biodiversity preservation.

However, the recent increase in the number of

mountain climbers has expanded the distribution of exotic plant species such as alien plants and lowland plants that do not belong to the indigenous flora of Hakusan National Park. As a consequence, hybridization of indigenous species and exotic species as well as an undesirable influence of exotic species on indigenous species have occurred, and they have led to concerns about negative impacts on ecosystems and biodiversity.

This service has been used to try and understand the current distribution of exotic plants and to support activities of volunteers engaged in their removal. Besides, it is also used for public relation activities targeting mountain climbers and the general public with the purpose of announcing and promoting countermeasures against exotic species in the Hakusan area.

In the previous approach, an approximate distribution of exotic species was indicated on a map reproduced on individual recording sheets. However, by using the system linked with map information, it is possible to visualize the current status of the entire Hakusan National Park region. This initiative has helped improve the survey efficiency and accuracy.

3.3 Use of the mobile photo system for citizen-participation-type basic survey on ecosystem within the regional strategies for biodiversity in Kurashiki City

Urged by a necessity to make more effort than ever to understand the current status of ecosystems in the municipal region on a long-term basis, the city of Kurashiki has started to use this service for its citizen-participation-type basic survey on ecosystems within the regional strategies for biodiversity.[5] At present, a series of local governments is engaged in developing regional level strategies for biodiversity. Kurashiki is one of these local governments. The concerned parties are currently developing Kurashiki's regional level strategies for biodiversity including comprehensive and systematic countermeasures by evaluating the current status of ecosystems in the city scientifically and identifying the characteristics and challenges specific to the region so that they can set specific targets for an ideal natural environment in the future.

Meanwhile, it has become difficult to continue with the conventional mode of citizen participation including field research due to the decrease in number and aging of citizen group members who have supported the survey activities so far.

However, by using this service, it is possible to have a larger citizen population involved in survey activities. This makes it possible to carry out ecosystem surveys in a wider area of the city, and also enables deployment of more effective biodiversity preservation measures by creating a database based on the collected habitat information of living creatures. Besides, because this system makes it easy for citizens to participate in the survey, their familiarity with ecosystems is nurtured, and this deepens the general public's understanding of biodiversity.

4. Birdcall recognition system for Blakiston's Fish Owl

Blakiston's Fish Owl is specified as "Endangered Species Class IA" in the Red List of Ministry of the Environment (high risk of extinction in the wild). In Japan, a population of only about 140 has been confirmed, centered on the central and eastern areas of Hokkaido. Since 1984, the Ministry of the Environment has been engaged in a project to protect and proliferate Blakiston's Fish Owls. In March 2013, the Ministry developed the Environment Improvement Project.[6] Besides, many other organizations are engaged in protecting and carrying out habitat research on Blakiston's Fish Owls. The Wild Bird Society of Japan (a public interest incorporated foundation) is also engaged in activities to protect them.[7] A part of its activities, the Society is implementing a survey to understand the habitats of Blakiston's Fish Owls. Because this species is nocturnal, it is difficult to find them during the daytime. Therefore, it is necessary to carry out a survey based on sound. While, in the conventional approach, the investigators entered the habitats and confirmed the sound by listening to the birdcall directly, it entailed some risks such as possibly encountering brown bears. Therefore, since 2011, IC recorders have been installed in the areas of the survey. The environment sounds were recorded for about 3 hours during the evening and the recorders were collected the next morning. After collecting the IC recorders, whether or not the recording contained any birdcalls by Blakiston's Fish Owls was judged based on analysis of the recorded environment sound data by using commercial sound analysis,

where a call spectrum was confirmed visually or by listening to the recorded sound. However, when working manually, it requires about one hour to analyze three hours of recording data, causing a significant workload for the investigators. In addition, because the birdcalls included in the record were very weak in many cases, the investigators were often faced with challenges in identifying the call of Blakiston's Fish Owls by visual or auditory approaches due to background noises.

To address this problem, the Fujitsu Group developed software for recognizing the call of Blakiston's Fish Owls that can identify the birdcall of only Blakiston's Fish Owls by using its sound processing technology and offered the system to the Wild Bird Society of Japan.[8)]

In many cases, Blakiston's Fish Owls live as a pair. They have a habit in which a male and a female exchange their birdcalls in the same place from the evening to the night hours. The Fujitsu team developed the recognition method by focusing on the patterns of the sound spectrum observed in such a situation. While there is some difference from bird to bird, there are still common characteristics in the birdcalls of the Blakiston's Fish Owl species. By using these patterns that are characteristic to the species as a template, the birdcall of the species is extracted automatically based on a matching with recorded data. So that even very weak birdcalls can be detectable, the team applied results from various technologies developed for recognition and identification of signal sounds and environmental sounds.[9)]

By using this software, a drastic improvement in the survey efficiency was achieved by reducing the analysis time of three hours to only several minutes (**Figure 3**). Besides, this system means that the very low birdcalls overlooked in the manual confirmation could be detected, and this helps improve the survey accuracy.

This software is still in the process of undergoing further improvement by integrating feedback from various investigators. Some new features were added recently including a feature to display a frequency spectrum of the detected sound segment as well as a feature to enable time-series display of the occurrence of birdcalls and their frequencies (**Figure 4**). Blakiston's

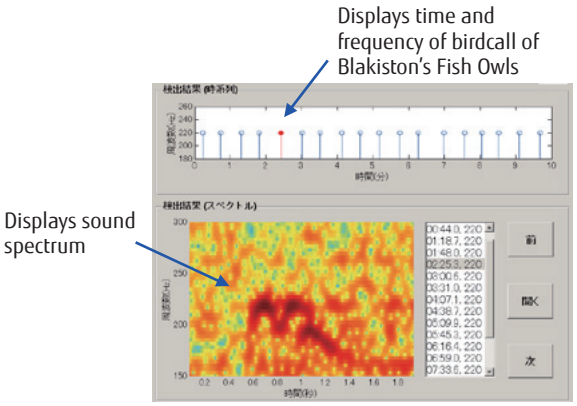

Figure 4
Blakiston's Fish Owl Call Recognition Software.

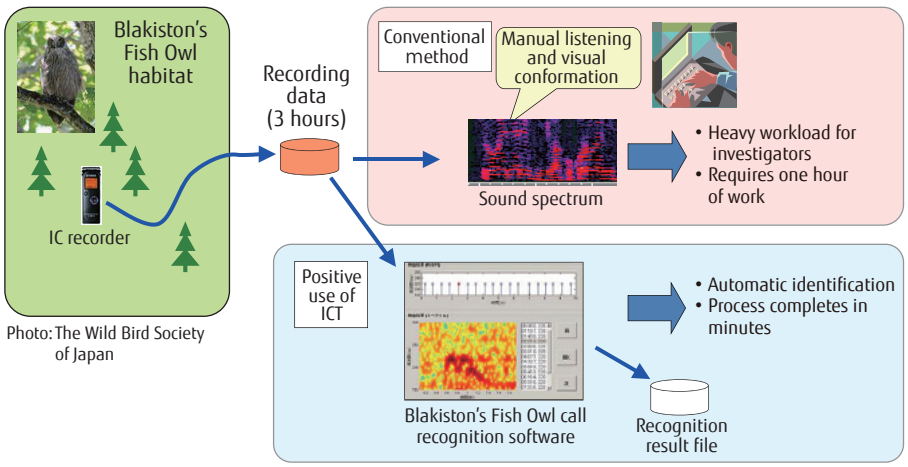

Figure 3
Research on habitat of Blakiston's Fish Owls using ICT.

Fish Owls have a habit in which they call periodically at a specific frequency. Therefore, it is possible to confirm that the birdcalls of Blakiston's Fish Owls are detected correctly by examining the chronological display. By using these features, it is possible to verify the results of automatic birdcall recognition.

In spring 2013, the Wild Bird Society of Japan started to make full use of this software for the habitat survey of Blakiston's Fish Owls, and the survey took place from spring to summer that year. In this wave of surveys, the Society collected several hundred recording data sets (3 hours/set) and analyzed them with the software. The workload of the investigators has been drastically reduced and the survey efficiency has been improved. Without being concerned about the analysis time, it is possible to increase the number of survey spots.

In this project of call recognition for Blakiston's Fish Owls, the team is continuing its approach to further improve the analysis accuracy by ways including having a better identification of individual owls. The target is to register and recognize the characteristics of individual Blakiston's Fish Owls based on a fine profile of their audio spectrum and time interval. The habitats of individual owls may change over time due to environment changes and the fledging of young birds. If recognition of individual birds is possible in such cases, it will be possible to identify their relocation and to take appropriate measures for protecting their habitats.

Application of the sound-based survey of wild species is likely to expand in the future. This can be applied to many other creatures besides Blakiston's Fish Owls. In addition to birds, it may be applied to organisms such as insects that have characteristics sounds. Looking at this technology as a survey system, the storage and analysis of data on a cloud platform or making positive use of smartphones can be considered by referring to the mobile photo system. Future development of this technology in diverse applications is expected, with the Blakiston's Fish Owl project serving as the starting point.

5. Conclusion

It is often said that whether it is possible or not to sustain our relatively stable environmental conditions that have supported the lives of human beings for the past ten thousand years depends on our behaviors in the coming ten to twenty years. We are currently at a pivotal point where it will be determined whether we can prevent biodiversity loss or not. At such a critical point, we consider "information" and its "positive use" to be essential keys for moving in the right direction by understanding complicated natural environments globally and also understanding them on regional and species levels. To address this international environmental initiative, the Fujitsu Group is committed to continuing with approaches for biodiversity preservation and its sustainable use based on positive use of ICT.

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