Tackling biodiversity monitoring of the Fukushima evacuation zone

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Introduction

A serious nuclear accident at the Fukushima Daiichi power plants in 2011 was followed by mass and long-term evacuation from highly contaminated area. Although radiation levels in the most of the evacuation zone were considered not to be acutely lethal for wildlife (Garnier-Laplace et al. 2011), it has been hypothesized that land use change by decontamination and the cessation of usual anthropogenic activities such as farming and gardening significantly affect the biodiversity and ecosystem services in the zones. A meta-analysis of farmland abandonment suggests that this phenomenon has frequently had a negative effect on biodiversity in Africa, Asia, and Europe (Queiroz et al. 2014), where the history of anthropogenic land use is relatively long.

Furthermore, the most of the evacuation zone in Fukushima is assumed to have been historically covered by forests and farmlands, and the residents had been benefited from ecosystem services from SATOYAMA, Japanese traditional agricultural landscapes, characterized by rich biodiversity (Kadoya and Washitani 2011). Therefore, scientific monitoring of ecosystems and biodiversity is required to lead the return and reconstruction to success.

However, there are some difficulties for the effective biodiversity monitoring in the Fukushima. The evacuation zone is large and environmentally heterogeneous. Furthermore, entry to the evacuation zone has been strictly regulated. In addition, long-term monitoring including data sampling after return and reconstruction will be need to appropriately know what the evacuation has brought, because biodiversity data before the nuclear accident are quite limited. In order to conduct systematic and rigorous monitoring and obtain ecologically reliable data, monitoring protocols must be considerably-designed. Furthermore, the result of monitoring should be as transparent and open as possible to residents, because scientific conclusion based on unpublished data induce misleading and/or less credible for residents and fail to support decision-making.

In this paper, we will report protocols and current status of terrestrial biodiversity monitoring conducted as a part of the Environmental Emergency Research project in the National Institute for Environmental Studies, Japan (NIES), which aims to provide scientific supports of recovery and recreation of environment in the Fukushima disaster area.

Monitoring system

The terrestrial biodiversity monitoring by NIES has started from 2014, aiming to obtain knowledge on what the large-scale and long-term evacuation brought on biodiversity and ecosystems in the area, which can support return of residents once had been benefited from various ecosystem services before the accident. The monitoring was conducted mainly by ecologists and experts on remote-sensing and geo-informatics, including authors of the paper as core members. In order to conduct relatively long-term (at least about ten years) monitoring effectively by limited effort, we determined to focusing on Mammals, Birds, Frogs, Insects, Vegetation and Land Cover/Land Use Change. Not only they are quite important indicators of biodiversity and ecosystems, but also monitoring protocols of them can be improved to be automatic, cost-effective, and standardized, using digital devices that are remarkably developing. Digital devices can also make it easier to sharing data with local residents. We will show our attempt to establish monitoring protocols and the current status below.

Monitoring protocols and current status

Mammals

In 2014, monitoring faunal assemblages inside and outside of the evacuation zone using infrared camera traps (Fig. 1) has been started. Infrared camera traps can automatically take pictures or movies in response to reflected infrared from homothermal animals and present a well-standardized and cost-effective method for monitoring mammal dynamics (Ahumada et al. 2011). In particular, this automatic method is well-suited to monitoring in the restricted access area such as Fukushima evacuation zone, because they can dramatically reduce time and frequency of visitations for monitoring the area; investigators only have to visit the camera trap for data collection and maintenance a few times a year. Due to usefulness of the camera trap technique, the protocol for monitoring for mammals, which has been almost established, is as follows.

The 46 monitoring sites for mammals covering 9 municipalities were set for monitoring inside and outside the evacuation zone. All the monitoring sites are located in closed forest, and the most of them belong to the national forest as a socially stable place and suitable to long-term monitoring (landowner and land use of private land are relatively changed often.).

In 2014, the first year of the monitoring, an infrared camera was set at each monitoring site from May to August 2014. Then, the data collection and maintenance were conducted in October and partially in July. From the collected movie files, mammals that appeared in the movies were identified to species level as possible and recorded as data of detection. In addition, as the indicator of sampling effort, the duration between battery exchanges for each camera (called “occasion”) were also compiled. If a camera had become inactive due to a depleted battery or mechanical trouble, its end time was defined as the time when the last video was recorded.

In the monitoring until October 2014 at the 45 sampling sites, fourteen species of large or middle-size mammals including invasive alien species such as raccoon *Procyon lotor* were recorded. Within the evacuation zone, large animals such as black bear *Ursus thibetanus*, Wild boar *Sus scrofa*, and Japanese serow *Capricornis crispus* were recorded. Indeed, most of large mammals distributing northeast Japan except for Sika Deer *Cervus nippon* were recorded in the monitoring for half a year. We are aiming to compile the data set once a year and published a data paper (Fukasawa et al. in press) in a way that make the data open, discoverable, and usable. In addition, we started providing a web service that you can browse distribution of mammals in the east Fukushima on Biodiversity Web Mapping System (BioWM) created by Center for Environmental Biology and Ecosystem Studies, NIES (http://www.nies.go.jp/biowm/index.php?lang=en).

Fig. 1 (left) Infrared camera for monitoring mammals

Fig. 2 (right) IC recorder for monitoring birds and frogs

Birds

Birds are good indicators for various environmental changes and a relatively popular taxon for general public. On the other hand, some studies on birds argued that some effects of radiation on birds after the nuclear accidents (Møller et al. 2015; Murase et al. 2015). Therefore, data-sharing with general public and the residents are particularly important.

As a measure for monitoring, we adopted recording song of birds using IC recorders with timer function (Fig. 2). Although this method is automatic and suitable to monitoring in the restricted access area, extracting data of presence of bird from amount of sound files is a challenge.

From 2014, the Bird monitoring by NIES has started at 52 sites covering 9 municipalities, including the evacuation zone. All the monitoring sites were located within schoolyards (including those that had been converted to community centers), which are relatively socially stable and can minimize differences in the local conditions.

The IC recorders record surrounding sound including song of birds for twenty minutes per day around sunrise from middle May to end of June. Then, from a part of sound files, presences of each bird species were checked by experts and documented.

Furthermore, we conducted an event called “Bird Data Challenge” collaborating with local branches of Wild Bird Society of Japan and extract and identified a part of the sound data with bird watchers in Fukushima prefecture. This was a new and important attempt to compile the data sampled by researchers simultaneously sharing with citizens. In addition to a data paper, we are preparing a paper reporting details of the event.

Frogs

Frogs need inland water ecosystems to complete their life-cycle. Thus, cessation of management of rice paddy fields within the evacuation zone can be problematic.

Their croaking has been also monitored using same IC recorders for bird monitoring in the same locations. Sound for ten minute per day around 20:00 on each day has been recorded from middle May to the end of June in 2014. As well as bird song, extraction of frog song is a challenge, though their song is relatively simple. Now, we are extracting song as training data and trying constructing automatic song detection system based on machine learning method.

Insects

Although insects play an important role in ecosystem functions and serve as pollinators, pests, and prey for birds and mammals, their diversity and small size make it difficult to conduct cost-effective and automatic monitoring. At first, we focused on flying insects, including important pollinators such as Apidae, and medically important pests, such as flies and hoverflies.

In 2014, we conducted sampling by Malaise traps (Fig. 3a) from the middle May to the early July in the location where the IC recorders for bird monitoring were set in order to survey a broad range of flying insects. In result, the abundance of carpenter bees *Xylocopa appendiculata* was detected to be lower within the evacuation zone. In contrast, those of most of the collected taxa including pollinators were even higher in the evacuation area, or not different between these areas. Please see Yoshioka et al. (2015) for further details of the data in 2014.

Fig. 3 (a) Malaise trap and (b) flight intercept trap for monitoring flying insects such as pollinators

From the 2015, in order to make the monitoring more efficient, the flight intercept traps (Fig. 3b) were introduced in the all monitoring sites. In addition, malaise traps were also set in a part of monitoring sites. Furthermore, development of other sampling technique using digital devices was under consideration to cover insect groups which could not be detected by these traps.

Vegetation and LCLUC

Vegetation and Land Cover/Land Use Change (LCLUC) were also a target of monitoring in our project. They are hypothesized to be dramatically changed by decontamination and land abandonment in the evacuation zone, and affect biodiversity and ecosystem services.

From 2014, we are compiling satellite images and ground-truth data by cameras with GPS and/or drive recorders sampled per year, in addition to aerial photos as supplement data. Using these data, we are developing model predicting and mapping vegetation based on machine learning method, focusing on dynamics of croplands. Publishing compiled map in future is also under consideration.

Conclusion

Although continuous biodiversity monitoring in the Fukushima is quite a challenge and it may take a time to obtain the outcome, our project has been developing cost-effective and automatic protocol to conquer these problems. These protocol will be support not only effective biodiversity monitoring in the Fukushima, but also effort-saving biodiversity monitoring at any other restricted access areas.

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