



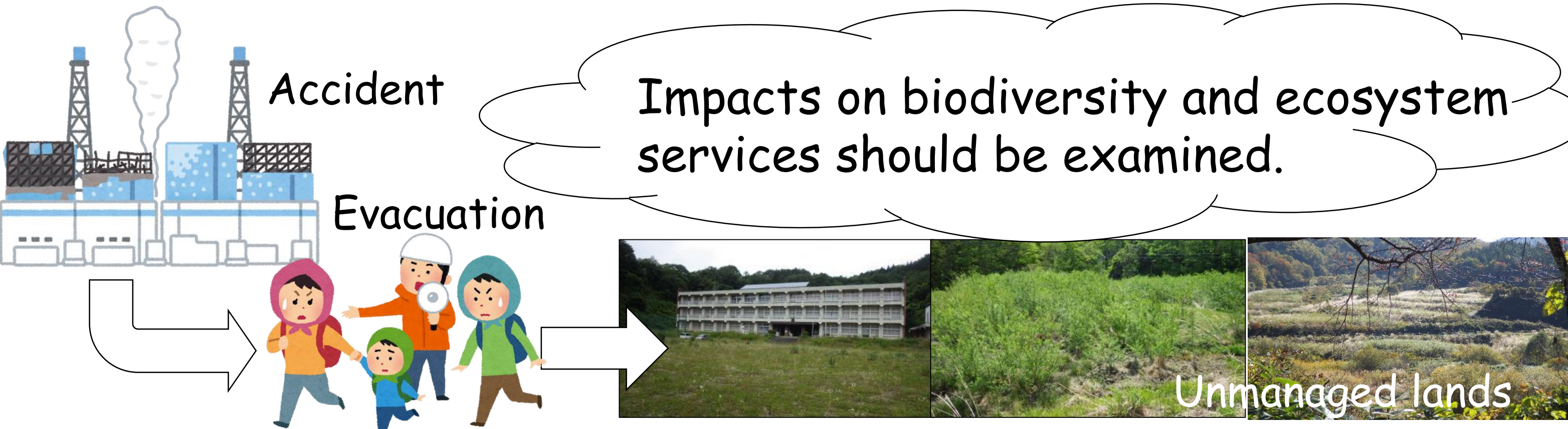
# Monitoring biodiversity in the evacuation zone brought by the accident of Fukushima Daiichi nuclear power plant

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## Ecosystem monitoring of the evacuation zone by NIES

◇ Following the nuclear power plants accident in 2011, a large evacuation zone was set. The environment of the evacuation zone has been substantially changed because anthropogenic activities such as farming were forced to stop.



### Study aim :

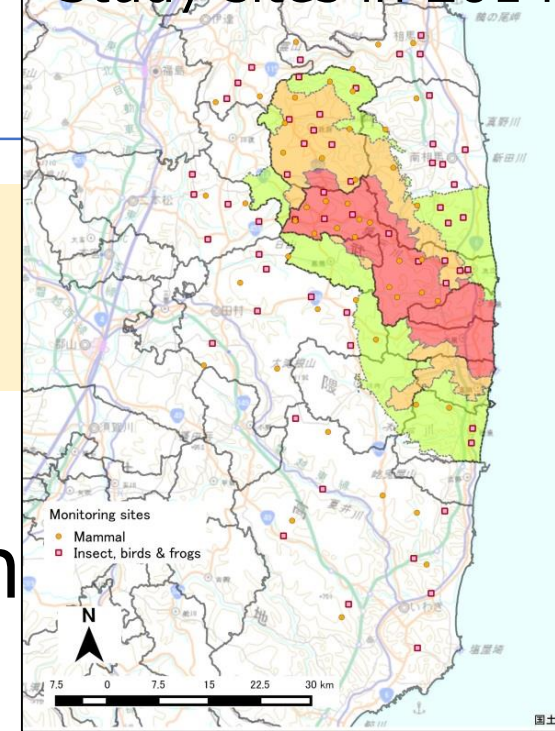
In order to obtain information on biodiversity status within the evacuation zone and support decision making by evacuees, monitoring has been conducted from 2014.

Specifically, we are aiming to conduct cost-effective, labor-saving, and open-data monitoring focusing on these question...



- Have agricultural and medical pests increased?
- Have Pollinators and natural enemies decreased?
- What has happened to familiar nature?

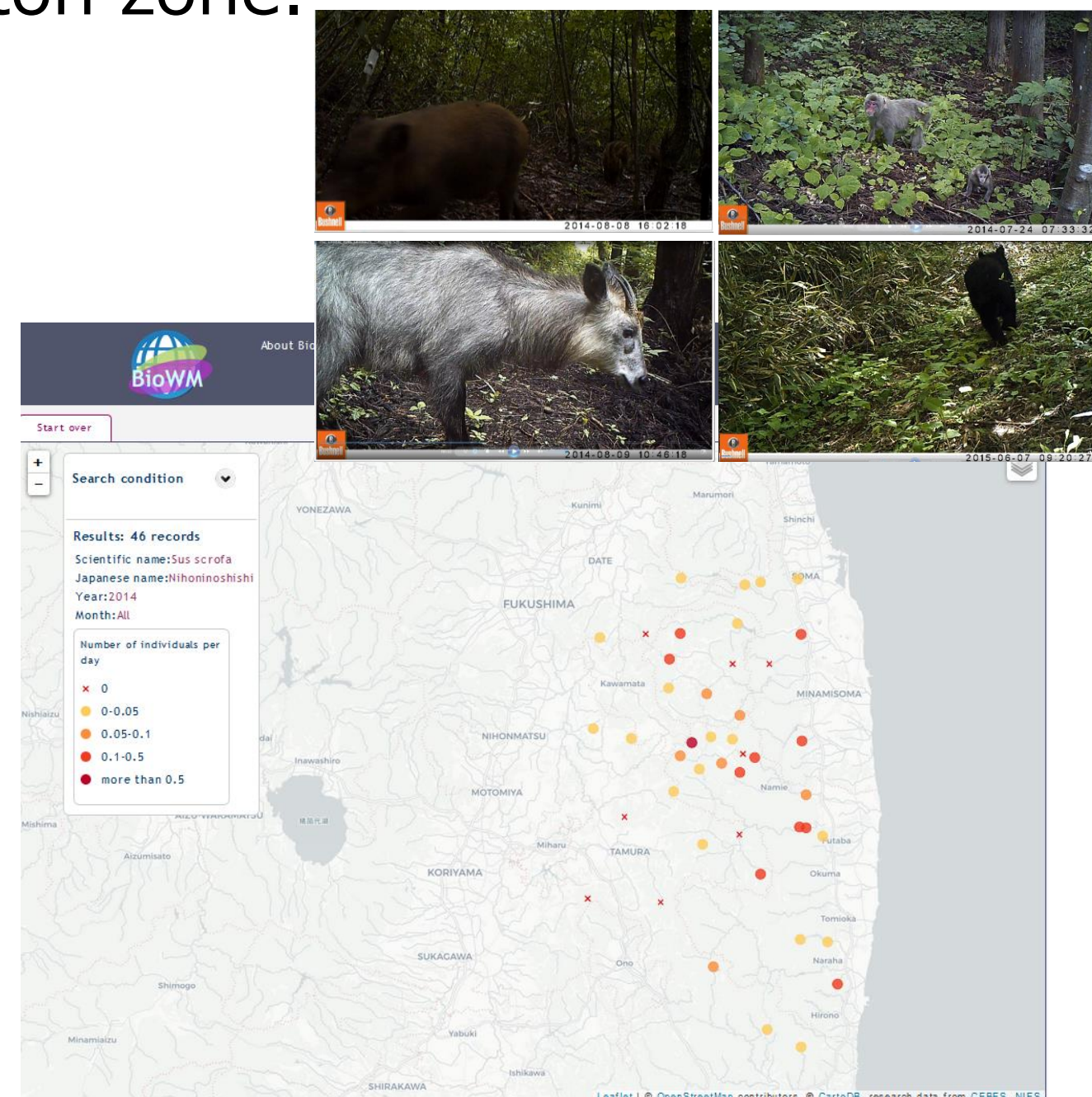
Study sites in 2014



## Mammals

• Large and midium-sized mammals has been monitored using camera traps set in the forests inside and outside the evacuaition zone.

- Totally 14 species such as wild boars were recorded up to now.
- The records have been published as open data (Fukasawa et al. 2016).
- We can also browse the mapped records from a web site called BioWM, presented by NIES.



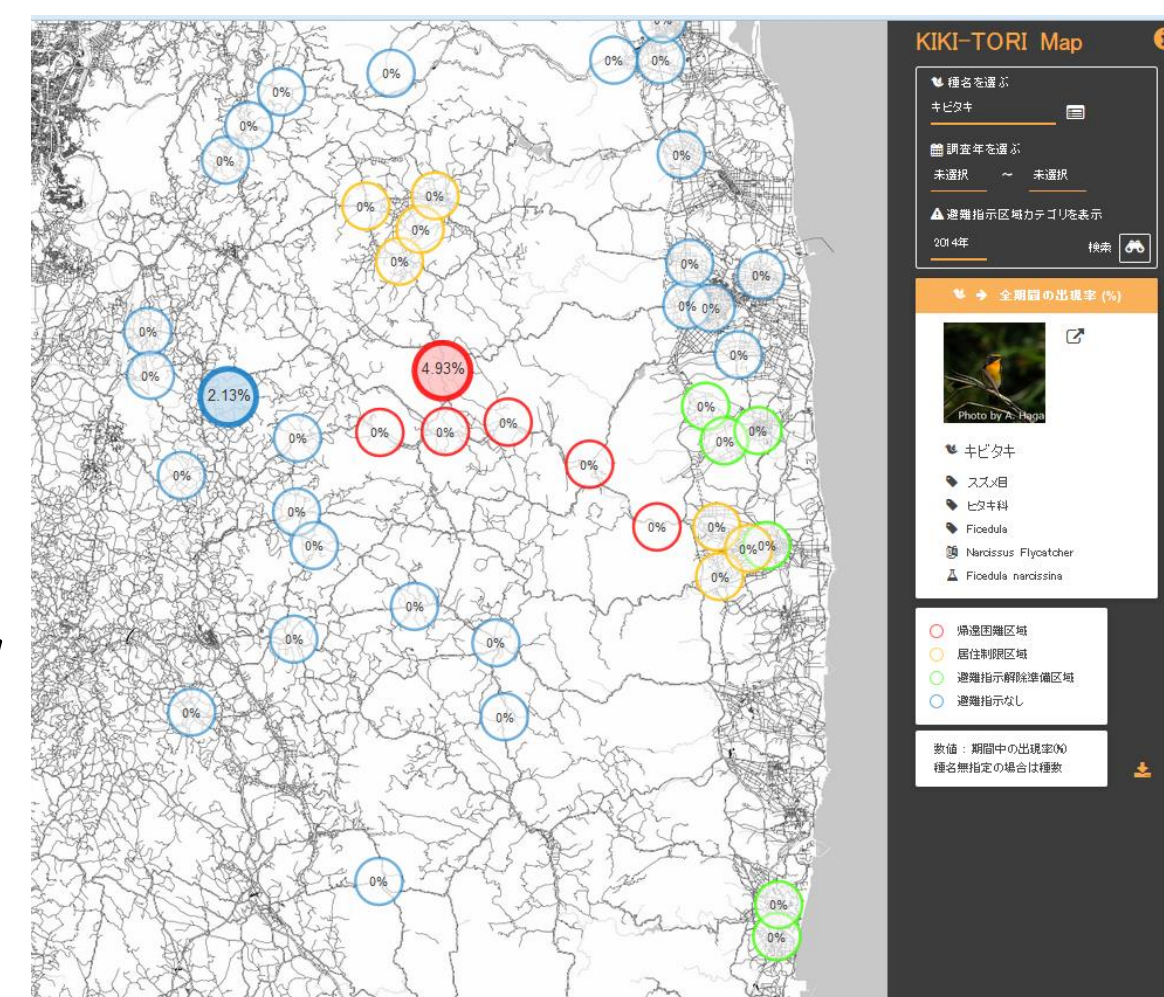
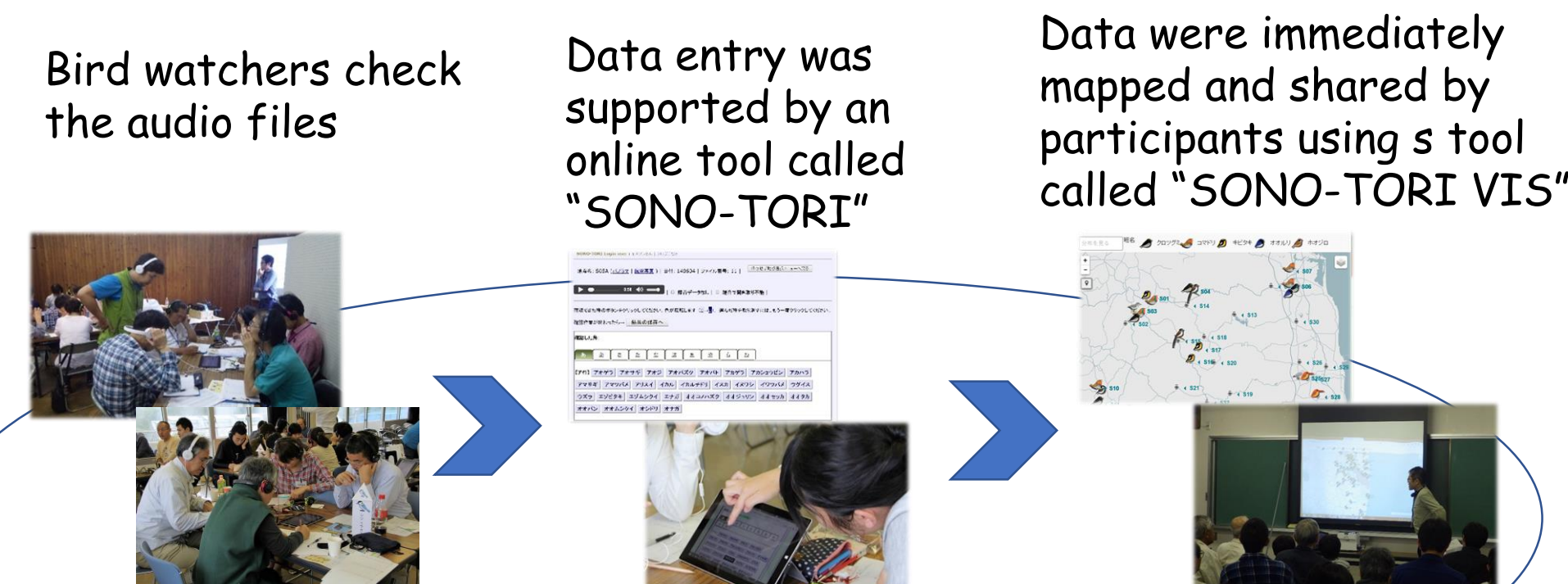
<http://www.nies.go.jp/biowm/contents/fukushima.php?lang=en>

## Birds and Frogs



- Acoustic monitoring has been conducted using digital voice recorder set in the schoolyard inside and out side the evacuation zone.
- The recorded audio files were checked by experts to obtain distribution records of bird and frog species.
- On birds, the dataset have been already published as open data (Fukasawa et al. 2017) and can be browsed in the web site called KIKI-TORI map (in Japanese), presented by NIES.

• A part of the bird data set was checked by local bird watchers through a citizen-scientific event called "Bird Data Challenge"



<http://www.nies.go.jp/kikitori/contents/map/index.html>

## Concluding remarks

- ✓ Data of mammals, birds, frogs and insects have been semi-automatically and efficiently collected using digital devices and traps.
- ✓ The Dataset of mammals and birds has already been published and freely available, partly involving local residents.
- ✓ On flying insects including pollinators and pests, effects on the evacuation were statistically analyzed using the monitoring data and shown to be not remarkably serious.

Our monitoring protocol can not only be effective to examine the status of the Fukushima evacuation zone, but also provide a model case of regional biodiversity monitoring which is sustainable, transparent, and useful for statistical analysis (in particular, in areas which is hardly accessible).

## Insects



- Flying insects including pollinators and medical pests were investigated using Malaise traps set in the school yards inside and outside the evacuation zone.

The effect of the evacuation zone on the abundance of each insect taxa was evaluated using Bayesian statistical model.

Abundance of focal insect taxa in the site  $i$  is modelled as...

$$y_i \sim \text{Poisson}(\mu_i)$$

$$\log(\mu_i) = a_0 + b_0 \cdot a_1 \cdot E1_i + b_0 \cdot a_2 \cdot E2_i + b_0 \cdot E3_i$$

Effects of the evacuation zone (Ordinal scale)

$$+ b_1 \cdot PC1_i + b_2 \cdot PC2_i + b_3 \cdot PC3_i + b_4 \cdot PC4_i$$

Confounding effects

$$+ \varepsilon_i(X_i, Y_i, \varphi, \tau)$$

Random effect incorporating spatial autocorrelation

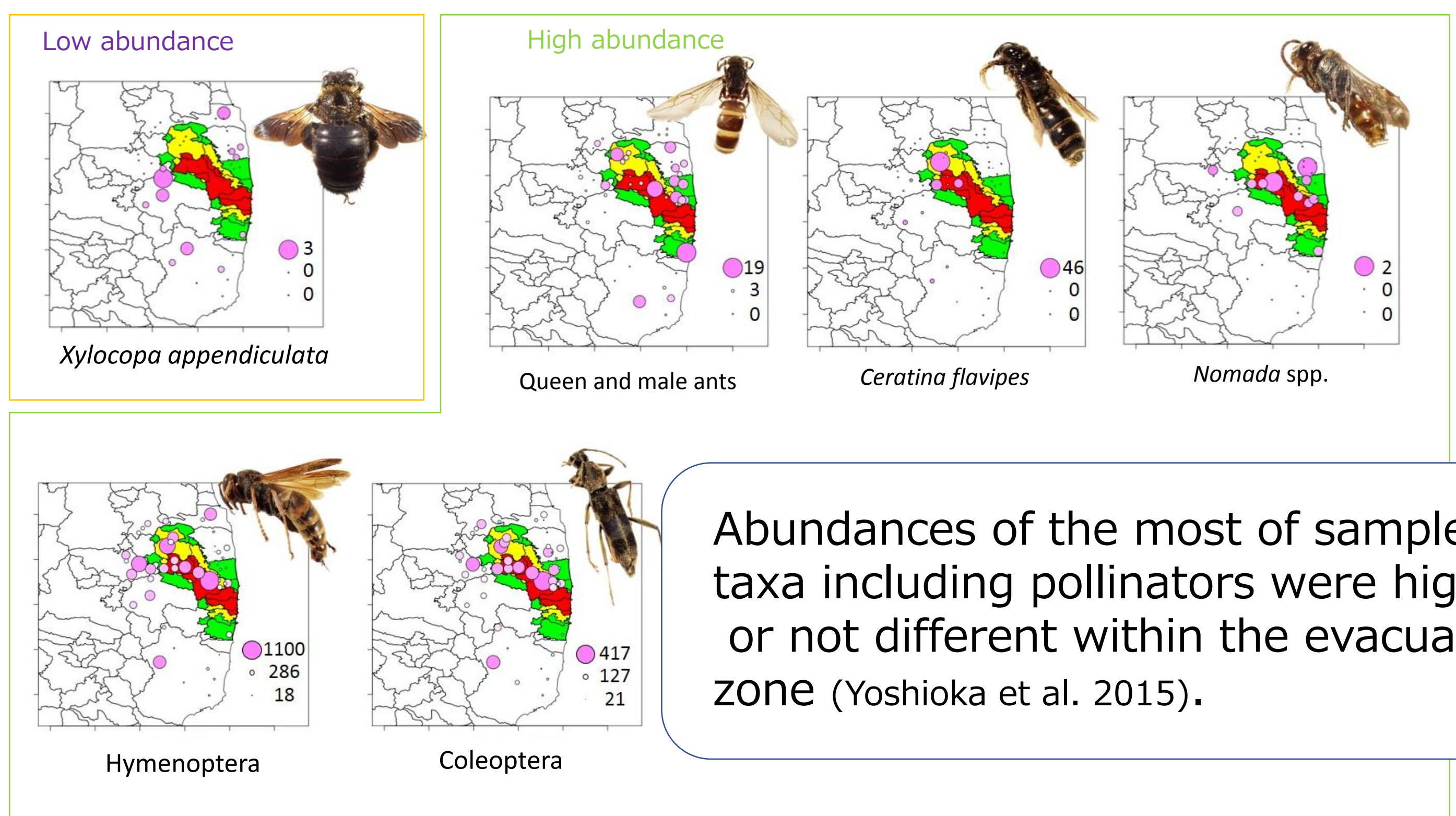
⚡ if the credible interval of  $b_0$  does not include zero, the effect is statistically remarkable.

$a_0, a_1, b_0, b_1, \varphi, \tau$ : Parameters of the statistical model.  
Note that  $0 < a_1 < a_2 < 1, \varphi > 0, \tau > 0$

$E1-E3$ : Dummy variables corresponding to the level of evacuation  
 $E1$ : the subzone preparing for the lifting of the evacuation order,  
 $E2$ : restricted residential areas,  
 $E3$ : the subzone to which it was difficult to return

$PC1-PC4$ : Confounding environmental factors  
PCA score based on Population, landuse, elevation, slope etc. before the accident  
 $X, Y$ : Geocoordinates of the site

Taxa on which a remarkable effect of the evacuation were detected.



Abundances of the most of sampled taxa including pollinators were higher or not different within the evacuation zone (Yoshioka et al. 2015).

- From 2015, flight interception traps were introduced as a more labor-saving monitoring tool for pollinators
- In addition, original camera trap for red dragonflies is also under development to examine impacts of loss of irrigated rice paddies on aquatic insects.



• Fukasawa K., Mishima Y., Yoshioka A., Kumada N., Totsu K., Osawa T. (2016) Mammal assemblages recorded by camera traps inside and outside the evacuation zone of the Fukushima Daiichi Nuclear Power Plant accident. Ecological Research, 31(4), 493

• Fukasawa K., Mishima Y., Yoshioka A., Kumada N., Totsu K. (2017) Acoustic monitoring data of avian species inside and outside the evacuation zone of the Fukushima Daiichi power plant accident. Ecological Research, 32(6), 769

• Yoshioka A., Mishima Y., Fukasawa K. (2015) Pollinators and other flying insects inside and outside the Fukushima evacuation zone. PLOS ONE, 10 (e0140957), 1-16