Ogasawara Project

Changes in an oceanic island ecosystem following the eradication of invasive non-native species: Proposal of management scenarios that consider environmental heterogeneity

Period: FY2013-FY2015

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Total budget: 32,800,000 yen

Funding: Grants-in-Aid for Scientific Research (KAKENHI) No 25241025

Research project overview

This project aims to ascertain the impact of eradication of introduced species on the balance and flow of materials within an ecosystem, and to propose management scenarios, including–ecosystem functions, to be implemented following the eradication of introduced species. Based on the findings of previous projects, this project will also consider environmental heterogeneity, including heterogeneity in spatial structure (vegetation species composition, distance from the sea, slope gradient, ground surface conditions).

To achieve these aims, we will (1) quantitatively evaluate changes in the ecosystem based on actual measurements; (2) construct an ecosystem model that reflects spatial structure, and use this model to make forecasts; (3) conduct a comprehensive evaluation based on the results of (1) and (2).

１．Quantitative evaluation of changes in the ecosystem based on actual measurements

We will measure seabird nesting, degree of soil runoff, primary production (vegetation biomass), soil nutrient content and other parameters, and investigate the relationship with spatial structure in the Ogasawara Islands, an oceanic archipelago in which introduced species (feral goats and black rats) have been eradicated. We will also conduct greenhouse experiments to investigate how the soil environment affects the growth of plants that comprise the vegetation of the islands.

2. Construction of an ecosystem model that reflects spatial structure, and forecasts using this model

Based on the measurements made in 1, we will construct a model that replicates the interactions between species and matter flow within the ecosystem taking into account spatial structure. We will then use this model to forecast the impact of eradication of introduced mammals on ecosystem recovery processes and ecosystem functions.

3. Integrated evaluation

Based on the results of 1 and 2, we will conduct a comprehensive evaluation of the impacts of introduced species eradication on ecosystem functions, and propose appropriate ecosystem management scenarios for implementation following the eradication of introduced mammals.

Details regarding each of the above three themes are introduced below.

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1. Quantitative evaluation of changes in the ecosystem based on actual measurements

(1) *The impact of seabirds and introduced mammals on primary production (vegetation biomass)*

① The impact of seabirds following black rat and feral goat eradication

Responsible researcher: Kazuto Kawakami

Predation by black rats and disturbance of habitat by feral goats caused a marked decline in seabird numbers. A recovery in the number of seabird nests has been observed in many different places since the eradication of black rats and feral goats (Figure 1). Research to date has shown that seabird excreta and physical disturbance caused by the recovery of seabird nest numbers after the eradication of introduced mammals has affected the primary production (vegetation biomass) and soil nutrient content of the grassland ecosystem.

The proposed project will evaluate the difference in impact between seabird species on soil nutrient quantities from a spatial structure perspective. More specifically, we will seek to forecast the area of potential impact of seabirds by comparing the composition of feces, patterns of distribution of feces at nesting sites, breeding site preferences (distance from the sea, gradient, surface conditions) and

feeding habits of the brown booby, black-footed albatross, wedge-tailed shearwater, Bulwer's petrel and other species of seabird inhabiting the Ogasawara Islands.

We will also investigate the species composition of invertebrates in the nests of each species of seabird and measure nest environment parameters (fluctuations in temperature and humidity) so as to evaluate the impact of recovery in seabird nest numbers on invertebrates.

Figure 1. The nest of a brown booby, one of the most common seabirds of the Ogasawara Islands

Note: The white feces are scattered around the nest in a radiating pattern.

② **The impact of feral goats**

Responsible researchers: Kenji Hata, Naoki Kachi

Disturbance by feral goats has caused loss of vegetation and concomitant soil runoff on the Ogasawara Islands. We will investigate the impact of this soil runoff on primary production (vegetation biomass) from the perspective of the spatial structure of local environments.

We will make belt-transect plots in locations differing in the degree of soil runoff on the island of Nakodojima to measure aboveground and underground biomass, physical and chemical soil properties, and degree of soil runoff at intervals of 1–2 m, and analyze the relationship between these factors from the perspective of spatial autocorrelation.

We will also seek to identify nutrients, pH, and other chemical properties of the soil that limit plant growth by collecting transect soil samples, adding specific nutrients such as nitrogen or phosphorus

etc., and then cultivating several plant species and comparing yields of several plant species in greenhouse.

(2) *Chemical analysis of seabird excreta, plants and soil*

Responsible researcher: Syuntaro Hiradate

Seabirds transfer nutrients for plants from marine to terrestrial ecosystems through their excreta. We will conduct chemical analyses to determine the amount of nutrient elements (mainly nitrogen and phosphorus) contained in seabird excreta. We will use nuclear magnetic resonance (NMR) spectrometer (Figure 2) to determine the soil chemical forms of C, N and P contained in these excreta. We will apply these results to 1-(1)-①. We will also analyze soil chemical properties such as soil pH, available phosphorus, salinity, total carbon, total nitrogen, etc. and apply these results to 1-(1)-②.

We will investigate the nutrient contents of plant species growing on Nakodojima in the Ogasawara Islands by analyzing the plant nutrients contained in plants. We will also investigate the relationship between soil properties and topography.

Figure 2. A nuclear magnetic resonance spectrometer for analyzing the chemical forms of carbon, nitrogen and phosphorus contained in seabird excreta

Figure 3. A soil profile found under forest vegetation on Nakodojima in the Ogasawara Islands (yellow bar length 10 cm)

(3) ***Analysis from the perspective of spatial structure using a GIS***

Responsible researcher: Takeshi Osawa

We will investigate grassland vegetation biomass, soil nutrient content, seabird nesting and extent of soil runoff based on a geographic information system (GIS) that includes positional information on soil collection locations, and examine the relationship between these factors from a spatial structure perspective (vegetation species composition, distance from the sea, gradient, ground surface condition).

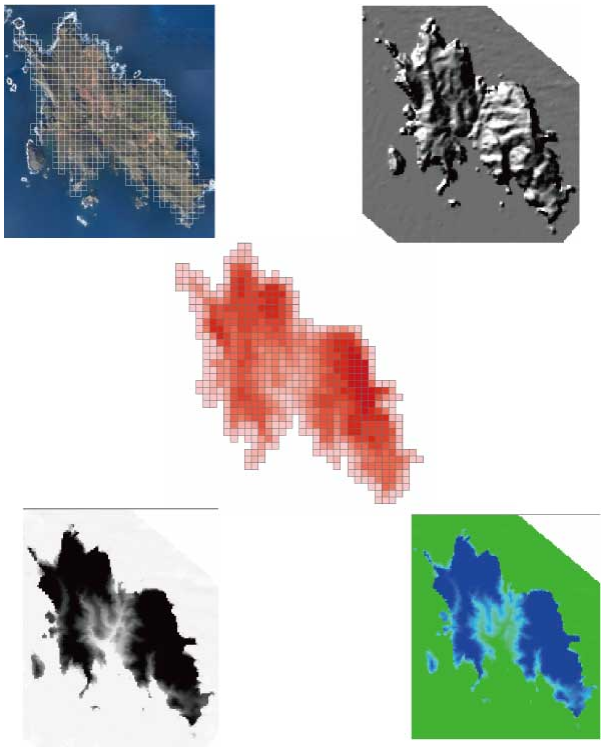

Figure 4. Predicting potential distributions on alien invader species based on aerial photo images and terrain analysis

2. Construction of an ecosystem model that reflects spatial structure, and forecasts using this model

Responsible researcher: Katsuhiko Yoshida

Based on the ecosystem model constructed from findings of research conducted in 2010–2012, we will construct an ecosystem model incorporating spatial structure that reproduces the environmental heterogeneity of the island. The model will incorporate multiple blocks differing in environmental conditions such as distance from the sea, gradient, and soil surface condition. We will calculate mass flow within each block. We assume that distributions of organisms in the blocks are according to their respective preferred environments, and will also enable movement and dispersal between

respective blocks. We will use this model to conduct simulations of the effects of eradication of introduced mammals, and to forecast ecosystem recovery and changes in ecosystem functions after eradication according to differences in topography, distance from the sea and other environmental conditions on a detailed spatial scale.

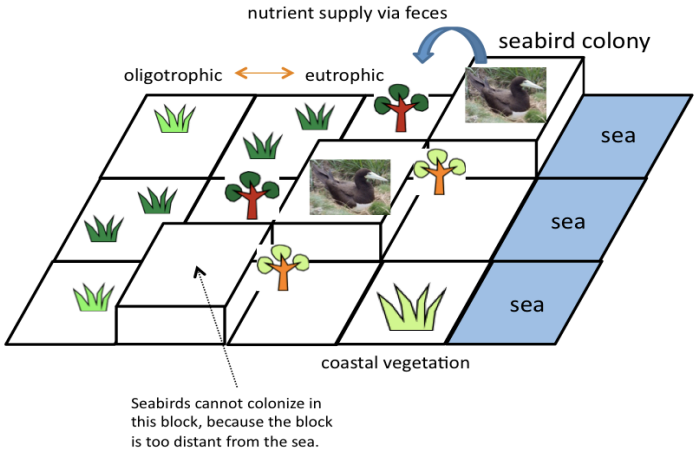

Figure 5. Ecosystem model incorporating spatial structure (We will create a model in which biota adapted to their respective locations develop, and generate forecasts on a detailed spatial scale of changes following eradication of introduced species.)