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研究課題名（和文）High resolution species distribution model for conservation planning of critically endangered mammal

研究課題名（英文）High resolution species distribution model for conservation planning of critically endangered mammal

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研究成果の概要（和文）：本研究は現地の人々から得られる知識、リモートセンシングデータから生成された予測変数の詳細なマップ、および機械学習手法の組み合わせに基づいて、近絶滅種の哺乳動物の高解像度の種分布モデルを開発した。このモデルは、直接観測が制限された検出困難な種の高解像度空間分布を予測することに焦点を当てるものとなっている。当該モデルに関して、ベトナムの山岳地帯の熱帯林について検証を行った。本研究の成果により、保護地域と景観保全が優先される地域との間の生物多様性の既存の、そして潜在的な通路の特定が可能になる。そのため、本研究は世界の生物多様性保全計画・管理に貢献する。

研究成果の学術的意義や社会的意義
The study enriches the understanding of habitat characteristics and promotes efforts to save the target animal from extinction. It could contribute to biodiversity conservation not only for the case study area, tropical forests in Vietnam but also in other vital ecosystems around the world.

研究成果の概要（英文）：This research developed a high-resolution species distribution model of critically endangered mammal based on the combination of local knowledge, detailed maps of explanatory variables generated from remote sensing data, and machine learning methods. The model was focusing on predicting the fine-scale spatial distribution of the poorly known species despite the limitation of direct observations. Field surveys were conducted in a tropical forest in the mountainous area of Vietnam to collect habitat characteristics and to verify the model's effectiveness. Project achievements will enable the identification of existing and potential biodiversity corridors between protected areas and areas prioritized for landscape conservation.

研究分野：Ecological modeling

キーワード：Ecological modeling　Machine learning　Remote sensing　Spatial analysis　Wildlife corridor

１．研究開始当初の背景

Conservation, environmental planning, and wildlife management rely on understanding habitat characteristics and geographical distribution of species. Species distribution models (SDMs) provide predictions about the potential distribution of species by relating species occurrence data to relevant environmental factors. SDMs are currently the primary tools used to identify species distribution in various spatial scales, including accessible or hard-to-reach areas [1]. Although SDMs have received much attention over the last fifteen years, the distribution model of rarely-seen species, such as the saola (*Pseudoryx nghetinhensis*), is still scarce in the scientific literature.

First discovered in May 1992 [2], the saola was one of the most spectacular and surprising zoological discoveries of the twentieth century. It is an elusive and critically endangered mammal. Saolas live in the forests of Vietnam and Laos and have been seen in the wild only four times. They cannot survive in captivity; thus, the saola does not exist in any zoo in the world. Since their discovery, the number of saolas have dropped sharply because of hunting, and loss of forest habitat through logging and conversion to farmland. It is crucial to localize where they exist so that strong measures can be effectively taken to save them from extinction, which could happen in the near future.

The accuracy of SDMs is limited by the resolution of environmental variables, which are often coarse for large areas, and by species occurrence data, which are usually sparse or not rich enough to calibrate [1]. These limitations are particularly true in the case of hard-to-detect species. The saola was captured only one time by camera traps over the last twenty years. Therefore, there is a strong need for a high-resolution SDM that does not rely on direct observations to overcome the indicated disadvantages of available models.

２．研究の目的

The proposed research aims to: (1) build the high-resolution SDM of a critically endangered mammal with a case study of the saola in Central Vietnam (Figure 1); (2) locate potential biological corridors that maintain or restore connectivity among isolated habitat patches by using the resultant SDM.

３．研究の方法

3.1. Understanding habitat characteristics and distribution determinants based on indirect observations

The meetings for community-based mapping with local people were conducted in selected villages in the saola landscape in Central Vietnam. The local people, who know well about the forest and wild animals, revealed where they encountered the saola or where they saw its feces and footprints in the past. Those locations were marked on fine-scale paper maps, then digitalized and combined with data of previous surveys. By overlaying the community-based mapping data with the high-resolution layers of environmental variables, habitat characteristics, and distribution determinants of the species were identified.

3.2. Building the high-resolution SDM by a machine learning method

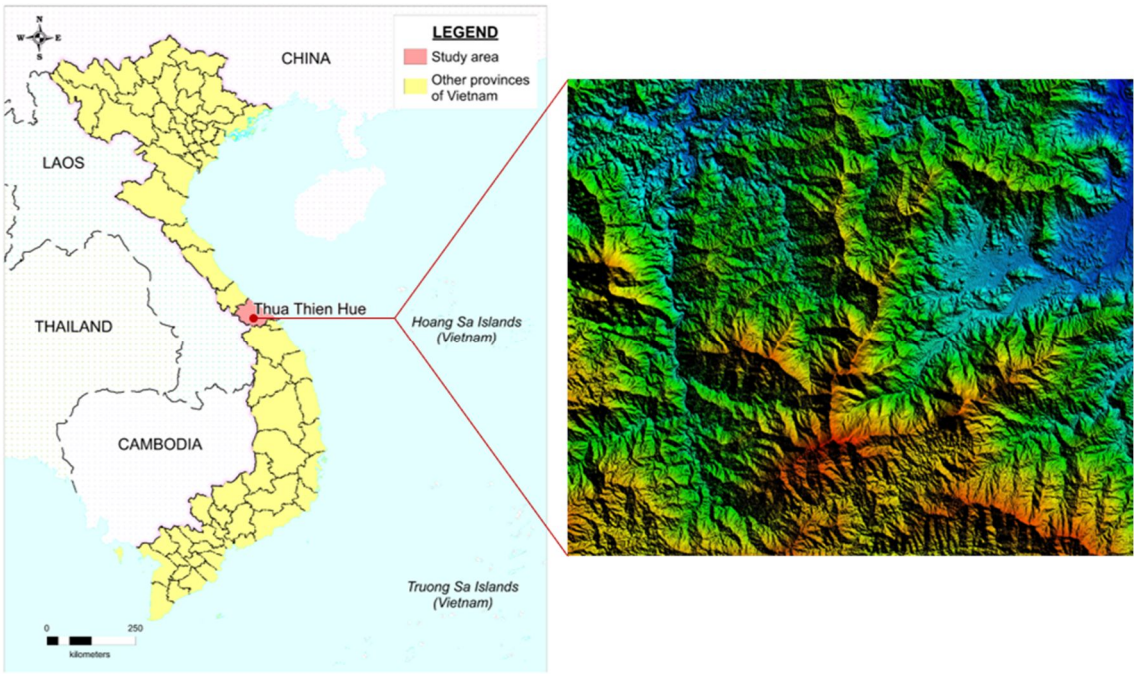

Figure 1. Location and the AW3D data of the study area.

The proposed model was developed by following the principles of supervised machine learning methods. The high-resolution map layers of distribution determinants were generated by the AW3D data (the world's first 5m-resolution 3D map of the Earth), reference maps, and drone mapping (Figure 2). Those map layers were divided into training and validation data with a consideration of the community-based mapping and field survey data. Several powerful machine learning methods were tested to find the most accurate SDM.

Figure 2. Drone photos of (A) monoculture plantation and (B) tropical forest in a mountainous area in Central Vietnam.

3.3. Predicting spatial distribution of the species and locate potential biological corridors

The resultant SDM was used to predict the spatial species distribution of the saola (Figure 3). The biological corridors were suggested by GIS-based multi-criteria analysis. Eight different criteria (forest cover, forest types, forest status, distance to roads, distance to surface water sources, distance to residential areas, slope and elevation) were used for delineating the most suitable biodiversity corridor. The weights of criteria were calculated based on the recommendations from the decision-making group. The suggested biodiversity corridor was found to cover approximately 12% of the whole area of Thua Thien Hue province and connect the three protected areas. Besides, camera traps will be placed at selected abundance sites to collect occurrence proofs of the saola.

４．研究成果

Drone surveys conducted over mixed-species forests and improvement of a hyperspectral transforming method aid a detailed identification of vegetation species. Camera traps were placed to validate the model at selected sites in a deep forest for three months. It is concluded that the targeted critically endangered mammal most likely hide in hard-to-reach areas close to the border between Central Vietnam and Laos. Biodiversity conservation solutions were discussed through meetings with local people.

This research will lead to valuable insights regarding the habitat preferences of the species. Because the saola is an icon for biodiversity in the Annamite mountains, knowing exactly where it exists will attract more investments and attention to wildlife protection in the whole area. The development of the high-resolution SDM is not only useful for the conservation efforts of the saola but also could be applied to other elusive species, particularly large mammals. Therefore, the project achievements must contribute to biodiversity conservation planning and management in the world.

Figure 3. (A) Prediction of the spatial distribution of the saola (potential for the distribution increases from green to red). (B) Installing camera trap, (C) a saola's head hung in a house of local people, and (D) a meeting with local people.

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５．主な発表論文等

〔雑誌論文〕　計1件（うち査読付論文　1件／うち国際共著　0件／うちオープンアクセス　0件）

１．著者名 Nguyen Tien Hoang, Nguyen Thi Hong, Katsuaki Koike	４．巻 30
２．論文標題 High versatility and potential of spatial data analysis with R programming	５．発行年 2019年
３．雑誌名 Geoinformatics	６．最初と最後の頁 3-14
掲載論文のDOI（デジタルオブジェクト識別子） 10.6010/geoinformatics.30.1_3	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

〔学会発表〕　計4件（うち招待講演　0件／うち国際学会　3件）

１．発表者名 Nguyen Tien Hoang
２．発表標題 Geospatial modeling for delineating biodiversity conservation corridors: A case study in Thua Thien Hue province, Central Vietnam
３．学会等名 Symposium of Integrative Biology: Biodiversity in Asia（国際学会）
４．発表年 2019年

１．発表者名 Nguyen Tien Hoang
２．発表標題 Spectral and spatial joint downscaling method of multi-spectral satellite imagery with geologic applications
３．学会等名 20th Annual Conference of the International Association for Mathematical Geosciences（国際学会）
４．発表年 2019年

１．発表者名 Nguyen Tien Hoang
２．発表標題 Species distribution modelling for conservation planning of critically endangered mammal in central Vietnam
３．学会等名 The International Society for Ecological Modelling Global Conference 2019（国際学会）
４．発表年 2019年

１．発表者名 Nguyen Tien Hoang
２．発表標題 Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery
３．学会等名 Japan Geoscience Union Meeting 2019
４．発表年 2019年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関