論 文 の 内 容 の 要 旨

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論文題目

GIS-Bsed modelling of Javan-Hawk-Eagle (*Spizaetus bartelsi*) habitat distribution using multi-scale approach in Java Island, Indonesia

（インドネシア・ジャワ島におけるマルチスケールアプローチを用いた
ジャワクマタカ(*Spizaetus bartelsi*)ハビタット分布の GIS 利用によるモデリング）

Regarding to IUCN Red List of Threatened Species, the Javan Hawk-Eagle (JHE) is one of the world's rarest and most endangered raptor categories. Small population size, severe habitat loss, forest fragmentation, and illegal hunting have all contributed to the "endangered" status of the JHE. Few attempts have been made to model the habitat distribution of the JHE based on predictions formulated from habitat requirements, appropriate metapopulation model of this species, and distribution of remaining natural forest in West Java or throughout Java Island. Remote sensing/GIS technologies, spatial analysis, and modeling approaches can help to integrate the local-scale information based on the field investigations, to regional- and landscape-scale for development of habitat models for effective conservation and development planning, and more accurate representation of habitat modeling. The

main objective of this study is to develop a multi-scale habitat modeling approach for effective JHE conservation planning. The specific objectives of this study are to develop habitat distribution model of JHE from the nest-site scale, to validate the model in regional-scale and finally extrapolate it to entire Java Island, and to assess the implication of the model for habitat conservation planning. Subsequently, the habitat distribution models obtained can be implemented in conservation strategies for this species throughout Java Island.

This study is conducted in three spatial-scales i.e. Gunung Gede-Pangrango National Park (TNGP) and its surrounding area, one of the first five national parks in Indonesia which contains one of Java's few remaining larger habitat areas for JHE, as nest-site scale. Then, southern part of West Java and Java Island were selected as regional- and landscape-scale, respectively. Bird data sets were obtained from local and international NGOs and also from field survey. Chapter 1 and 2 are referring to the background and study objective, previous studies concerning JHE and other raptors, and descriptions of study site.

Chapter 3 is discussing on evaluation of nest-site selection in TNGP in order to determine the nest-site characteristics of JHE as well as to assess habitat requirements. The objective of this chapter is to determine the nest-site characteristics of JHE based on the evaluation of the current nest distribution data from 1996-2006 using environmental variable database in order to assess habitat requirements. A total of 11 nest-sites were analyzed and for each nest-site, several environmental variables were measured in order to quantify the habitat. In this study, I selected seven environmental variables (covariates) i.e. slope (SLP), elevation (ELV), normalized difference vegetation index (NDVI), sun index (SI), distance to the nearest river (DRV), distance to the nearest main road (DRD), and distance to the nearest settlement (DRS), to address the quantification of JHE habitat distribution. Principal Component Analysis (PCA) was carried out to reveal association of the variables for characterizing JHE nest-site. Three principal components were recognized as nest-site characteristics of JHE that are related to terrain characteristics and vegetation cover, proximity to human activity, and proximity to water source. Nest-site characteristics are useful for initial modeling of habitat suitability and simultaneously can be acknowledged as habitat requirements of JHE.

Chapter 4 is discussing on habitat suitability model development of JHE in TNGP and its surrounding area by proposing a new approach in creation of "pseudo-absence" data using NDVI from remote sensing data, and then its application of logistic regression (LR) and autologistic regression (ALR) probability models coupled with RAMAS GIS. This chapter found that ALR models improved overall accuracy with higher AUC values and predictive power which indicate superiority in estimating habitat distribution of JHE than LR model. It means spatial autocorrelation should be taken into account in predictive models to explain the JHE habitat distribution. ALR_50 model using 1,500 m neighborhood size (moving window of 50*50 pixels) was determined as the most appropriate neighborhood size which produced the most parsimonious autologistic model. Predicting species distribution from statistical models incorporating presence-only data sets and generated "pseudo-absences" could be a convenient and useful alternative when systematically gathered presence/absence data are unavailable or impossible to obtain.

In chapter 5, the models developed in previous chapter were tested in regional-scale particularly in southern part of West Java for model validation. Two types of errors were detected in the validations that are an omission error and a commission error. Appropriate metapopulation model was also determined in this chapter. The ALR_50 model was successfully validated in southern part of West Java with 20% omission error rate. Commission error found in this study suggests that future survey should focus on potential locations (unoccupied patch) because the commission error may be caused by incomplete field surveys or low detectability of the species. This predicted probability model showed that the mainland-island model is more appropriate than the patchy population model.

Chapter 6 is discussing on the potential of MODIS 250m NDVI multi-temporal imagery for identifying forest cover distribution in Java for 2002 to identify remaining natural forest in Java Island. This chapter demonstrated successful identification of natural forest distribution in Java for 2002 is possible using MODIS NDVI 250 m multi-temporal imagery. The approach described herein provides high classification accuracies (overall accuracy = 91.06%) which is comparable to those of maps derived from higher resolution data. Given that accuracy results are comparable, data variability is greater, costs are lower, and the approach is simpler, than other techniques typically used in large projects. Moreover, temporal classification may provide a viable alternative for regional or national classifications.

Afterward, model extrapolation of habitat distribution in whole Java Island and then comparison with natural forest distribution and population estimation are discussed in Chapter 7. The ALR_50 model was also successfully extrapolated to entire Java Island and estimated suitable habitat of JHE covered about 3,407 km^2 with 85% accuracy comparing to historical localities record after 1980. The estimated number of JHE pairs would place the population size of 155-777 (median = 466). Comparison with the natural forest distribution indicated that the suitable habitat is not only consisting of natural forest but also of the aggregation of land covers including natural forest, plantation, estate, and agriculture land.

General discussions and conclusions are remarked in Chapter 8. The nest-site scale models based on medium-resolution data provide accurate assessment of the potential and present habitat suitability of specific locations. The most important result of the nest-site scale model is determining the 1,500 m neighborhood size or moving window of 50*50, 17*17, 6*6 pixels for nest-site-, regional- and landscape-scale, respectively, as the appropriate operational scale in modeling habitat distribution of JHE by ALR model. The difference in the three window sizes used for nest-site, regional- and landscape- scale model is caused by different pixel sizes used in each scale. The regional-scale models based on coarse GIS data generated the spatial distribution of suitable habitat for large regions. The landscape-scale models based on extrapolation of the site-scale model using GIS and remote sensing-based data could provide spatial explicit assessment of the potential and present habitat suitability at the scales of the greatest practical needs. Although the estimated number of pairs based on ALR_50 model (median = 466 pairs) is higher compared to other studies, JHE had always been described as either rare or very rare. The apparent discrepancy between this estimated population and others, which might not suggest as increase in present JHE, but may be explained by several reasons such as increased accessibility to formerly unexplored habitat, and more recent satellite imageries and GIS technique application used in estimation of suitable habitat of JHE.

Based on these results, seven strategies for the conservation management of the JHE habitat are recommended. *Strategy 1* requires that conservation management for the mainlands should be integrated by means of a conservation management network among the mainlands. *Strategy 2* proposes to maintain and/or restore large and structurally complex patches of forest. This strategy also purposes to provide core habitat for JHE which depends on forest availability. *Strategy 3* proposes that all unprotected habitat areas to be given Wildlife Reserve status based on Government Regulation (PP. No.68/1998). *Strategy 4* proposes to maintain and/or establish connectivity between remnant habitat patches. A combination of three broad types of landscape connectivity features (wildlife corridors, stepping stones, and soft matrix) is proposed for this strategy. *Strategy 5* proposes to maintain and/or restore a landscape matrix that is structurally similar to forest. The purpose of this strategy is to provide habitat connectivity throughout the entire landscape and reduce structural contrast between modified and unmodified areas, thereby reducing edge effects throughout the landscape. *Strategy 6* proposes that future surveys should be focused on the unoccupied patches that are likely to be occupied by JHE and have not yet been surveyed. *Strategy 7* proposes that stakeholders living nearby JHE habitats shall be organized for effective conservation management. This strategy may be useful to avoid conflicts between stakeholders and to control encroachment and illegal hunting, by increasing the stakeholders' sense of responsibility with regard to maintaining the JHE habitat.