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Landscape Characteristics of Oriental Honey Buzzards Wintering in Western Part of Flores Island Based on Satellite-Tracking Data

Syartinilia[1,3], G H Al Farisi[1] and H Higuchi[2]

[1] Department of Landscape Architecture, Faculty of Agriculture, Bogor Agricultural University, Kampus IPB Darmaga, Bogor 16680, Indonesia
[2] Graduate School of Media and Governance, Keio University, Endo 5322, Fujisawa, Kanagawa 252-0882, Japan

syartinilia@yahoo.com

Abstract. Oriental Honey Buzzards (OHBs, *Pernis ptilorhynchus*) are migratory raptor that has been satellite-tracked since 2003. Some islands in Indonesia which are used for wintering habitat are Flores and Borneo. However, both islands have different characteristics of climate and land cover. The objectives of this research were to analyze the landscape characteristic of the OHBs wintering habitat in western Flores, and to subsequently compare landscape characteristic of the OHBs wintering habitat in Borneo. Landscape habitat characteristics were analyzed using Principal Component Analysis (PCA) combined with GIS and then compared to the previous study in Borneo Island. The result showed that the first of six principal components explained 79.14% and 77.59% of the observed variation in landscape characteristics of both core and edge habitats, subsequently. Habitat selection by OHBs at wintering site was influenced by the availability of thermal wind and food. Savannah was identified as the main landscape characteristic that was different between wintering habitat in Flores and Borneo. Savannah is well-known as a habitat for many species of amphibians, reptiles, and small mammals so that it can be a hunting area that provide alternative feed for OHBs.

1. Introduction

Migration is the globally animals movement caused by change of seasons, significantly. The ultimate goal of migration is to find food sources in order to survive. Migratory raptors need to have at least three different environments: breeding grounds, wintering grounds, and stopover grounds [1]. In general, most raptors in Asia are breeding in northern Asia and wintering in the southern Asia. Indonesia is an important wintering area for several species of migratory raptors that breed in the Eastern Palearctic [2]. From 69 raptors recorded in Indonesia, 39 species are migratory raptor and 26 species have categorized as intercontinentally migration (long-distance migration) [3].

Oriental Honey Buzzards (OHBs, *Pernis ptilorhynchus*) are the migratory raptors, which have wintering sites in many places in Indonesia. Satellite tracking (ARGOS) has been successfully used to track the OHB since 2003 in order to observe the migration route of OHBs. Based on the ARGOS satellite-tracking data, distribution of wintering habitat in Indonesia spreads over several islands in western part of Indonesia such as Sumatra, Java, Borneo and eastern part of Indonesia such as Flores and Kupang [4]. Borneo and Flores Islands are wintering habitat of OHBs, whereas both islands have

a different climate condition and land cover. Although different, OHBs still prefer both islands as their wintering habitat.

Recently, landscape characteristics of wintering sites in Borneo consist of core and edge habitat, where both characteristics are essential to be studied as a single entity of OHBs habitats [4]. Therefore, the study on the characteristics of wintering habitat in western part of Flores Island and comparing to landscape characteristics found in Borneo is important for understanding the ecology of wintering habitat of OHBs. Result of this study can be use as baseline information for providing a recommendation on the management of wintering habitat to maintain the existence of OHBs.

2. Methods

2.1. Location and Time
The research location is located in the western part of Flores Island, precisely in regencies of West Manggarai, Central Manggarai, and East Manggarai (Figure 1). This study was conducted from March 2015 to June 2016.
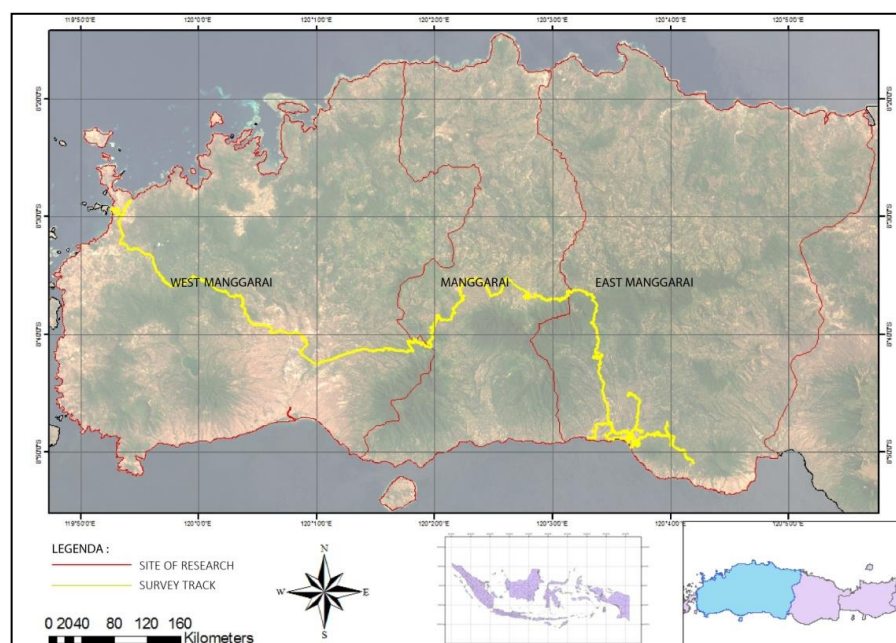

Figure 1. Study Site Map

2.2. Delineation analysis of core and edge habitat of OHBs
The Satellite tracking data used in this study wasfrom ARGOS data in 2006-2010. This study used a data sample from two individuals of OHBs which their tracks were recorded by the ARGOS satellite. The numbers of Platform Transmitter Terminal (PTT) as identity of the two individuals were 84427 and 66554. Recorded data from the satellite tracking of two individuals were 241 locations. In this analysis, kernel-density estimation (KDE) was used. This method is often used to analyze the spatial distribution. Using GIS, this method will create a line based on the intensity of use by calculating the average of the influence of point data. Kernel-density estimation method was selected because this method is often used to study a habitat. Delineation of wintering habitat of OHBs was produced using Fixed Kernel_95% (FK_95%) for edge habitat and Fixed Kernel_50% (FK_50%) for core habitat [4]. The aim of this analysis was to determine the core and edge habitats of OHBs based on point data of satellite tracking. In this discussion, the core is defined as an area and known to have the high intensity of the presence of OHBs, indicated from satellite tracking data recorded in the area.On the other hand,

the edge is habitat that surrounds the core and known to have the low intensity of the presence of OHBs, indicated by satellite tracking data recorded in the area. This analysis used the extension Hawth's tools on a menu of fixed-kernel density estimator.

2.3. Analysis of Landscape Characteristics of Wintering Habitat

In this analysis, making a basic map that would be used as an environment variable was conducted (Table 1). Environmental variables were required in principal components analysis to determine the characteristics of the wintering habitat of OHBs. Basic maps used for this study were the land cover, slope, and elevation. Land cover map was produced by supervised classification method. Imagery map used was Landsat 8 on September 14th 2014, with a resolution of 30 x 30. Ground truth check was done for obtaining the data for training area and predicting the accuracy of land cover map. Land cover classification in the western part of Flores Island was divided into eight classes: water body, forest, savannah, paddy field, shrub, build up area, plantation and bare land.

Table 1. Environmental variables

No.	Environmental variables	Abbreviation	Data source
1	Nearest distance to elevation of 0-300 m.a.s.l.	DE1	Extracted from ASTER
2	Nearest distance to elevation of 300-500 m.a.s.l.	DE2	GDEM that made as
3	Nearest distance to elevation of 500-700 m.a.s.l.	DE3	euclidean distance map
4	Nearest distance to elevation of 700-1 000 m.a.s.l.	DE4	
5	Nearest distance to elevation of >1000m.a.s.l.	DE5	
6	Nearest distance to slope of 0-3 %	DS1	Extracted from ASTER
7	Nearest distance to slope of 3-8 %	DS2	GDEM that made as
8	Nearest distance to slope of 8-15 %	DS3	euclidean distance map
9	Nearest distance to slope of 15-25 %	DS4	
10	Nearest distance to slope of 25-40 %	DS5	
11	Nearest distance to slope of> 40 %	DS6	
12	Nearest distance to water bodies	DWB	Extracted from land cover
13	Nearest distance to forests	DFR	map that made as euclidean
14	Nearest dista nce to savannah	DSV	distance map
15	Nearest distance to paddy fields	DPF	
16	Nearest distance to shrubs	DSR	
17	Nearest distance to build-up area	DBA	
18	Nearest distance to plantation	DPT	
19	Nearest distance to bare lands	DBL	

Land cover, elevation and slope maps had been obtained were then converted into a binary map, which had two values (0 and 1). Value of 1 was for the environmental variable that will be used as a distance map, and value of 0 was for the environmental variable to be removed. Furthermore, raster binary map was converted into vector maps. Then the vector map was converted into a Euclidean distance map that provided the nearest distance information of each pixel into a specific type of environmental variables.

Principal Component Analysis (PCA) was used to integrate 19 environmental variables and identify landscape characteristics of core and edge habitats used by OHBs. Subsequently, PCA was carried out with Varimax rotation with the Kaiser normalization to extract the principal component that characterize core and edge habitats. The analysis was performed using SPSS to get the importance level of environmental variables that became a principal component of wintering habitat of OHBs in western part of Flores Island.

2.4. Comparative Analysis of Habitat Characteristics

Characteristics comparison of the habitats in the western Flores and Borneo was obtained through descriptive comparison. The characteristics comparison of habitats was conducted on each

environment variable in the core and edge habitats at each location. The previous study was used for wintering habitat characteristics of OHBs in Borneo [4].

3. Results and Discussions

3.1. Distribution of Wintering Habitat of OHBs

The distribution of wintering habitat of OHBs included core habitat with an area between 0.06 to 40.29 km^2 with a total area of 165.86 km^2 and edge habitat with an area between 1.34 to 178.66 km^2 with a total area of 785.66 km^2 (Figure 2). Core and edge habitats of OHBs were predominantly distributed in the southern part of the western Flores. Highest distribution of core habitat was in East Manggarai regency (52.5%) and Central Manggarai regency (25.8%) and lastly West Manggarai regency (21.7%). On the other hand, highest distribution of edge habitat was in East Manggarai regency (50.24%) and West Manggarai regency (26.16%) and the last Central Manggarai regency (23.6%).
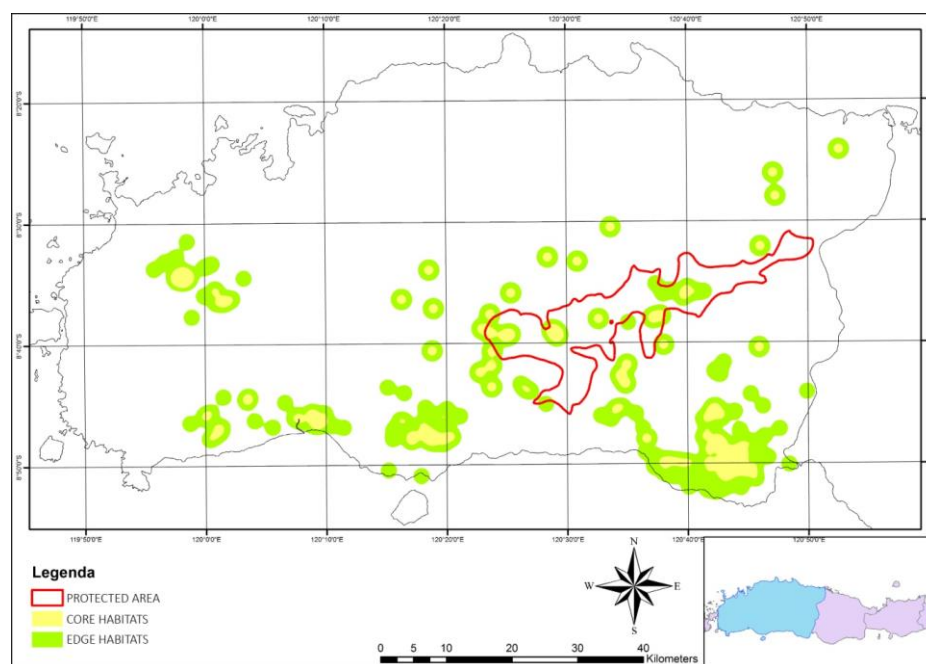

Figure 2. Distribution of core and edge habitats, and overlaid with protected area.

Delineation of core and edge habitats resulted in the largest core habitat in forest area (43.22%), shrubs (36.16%), savannah (8.96%), and the garden (7.29%) if it was overlaid with land cover map. Largest edge habitat was in the area of forest (36.31%), shrub (33.22%), savannah (14:43%) and plantation (9.16%). It was indicated that the formation and types of land cover exist both in core and edge habitats were similar, but the only difference was the percentage proportion of area of each land cover type. Forests still had the highest proportion of both core and edge habitats.

Comparing the core wintering habitat to existing protected area boundaries showed that only 21.13 km^2 (12.7 %) of the core habitat is protected; the remaining area extends far outside the protected areas. Dominant core and edge habitats in East Manggarai regency were in protected area, while the rest were in the Central Manggarai regency. Core and edge habitats were not found in the protected area of West Manggarai. Overall, it can be concluded that more than 80% of the core and edge habitats area were outside protected areas. It should be a concern of local government and managers of protected areas in order to maintain sustainability habitat of OHBs in the Flores Island.

3.2. Characteristics of Wintering Habitat of OHBs in western part of Flores
The first of six principal components explained 79.14% and 77.60% of the observed variation in landscape characteristics of core and edge habitats, respectively (Tables 2 and 3). Based on these results, we focused on the first three principal components in each core and edge habitat, which explained about 54.09% and 50.15% of data variance, respectively.

Table 2. Principal component analysis result for core habitat

Environmental variable	Principal Component (PC)					
	1	2	3	4	5	6
DFR	0.914					
DS6	0.895					
DE4	0.854					
DE3	0.767					
DS5	0.732					
DPT						
DE5		0.855				
DBL		0.787				
DWB		-0.755				
DE2			0.760			
DE1			0.721			
DSV			0.718			
DPF				0.825		
DSR				0.688		
DBA						
DS4					0.716	
DS1						
DS2						0.877
DS3						
Eigenvalue	4.721	2.973	2.584	1.690	1.609	1.460
Variance (%)	24.845	15.649	13.600	8.894	8.467	7.682
Cumulative (%)	24.845	40.494	54.094	62.988	71.455	79.137

The first principal component of the core habitat (PC1) was interpreted as characteristics associated with forest (DFR), slope more than 25% (DS5, DS6), elevation of 500-1000 m a.s.l (DS3, DS4). The second characteristic was associated with an elevation of over 1000 m a.s.l and bare land and water body (DBL, DWB). The third component was associated with the savannah (DSV) and elevation of 0-500 m a.s.l. (DE1, DE2). Unlike the core habitat, forest and elevation were not included in the first principal component of the edge habitat, only the slope of 0-15%. The second component was associated with the elevation of 0-700 m a.s.l (DE1, DE2, DE3) and savannah (DSV), while the third main component in edge habitat was forest (DSF), elevation of 700-1000 m a.s.l (DE4) and slope more than 40% (DS6).

OHBs tend to prefer their wintering habitat based on the abundance of food and the presence of other predators [4]. Forest became the first factor in the core habitat and became the third factor in edge habitat. It indicated that main food source for OHBs was available in forest. Food is a major driving factor for the bird in selecting their habitat during nonbreeding season. Habitat preference of OHBs was significantly related to the existence of a nest of honey bee colonies. *Apis dorsata* was most bee usually found in the study site. *Apis dorsata* was categorized as giant rock bee because it is larger than other honey bees. *Apis dorsata* usually establishes colonies in areas that have sufficient availability of food, especially in the forests area and plantations around forest in the area of core habitat. During the survey, there were three locations of trees beehives of *Apis dorsata*. Based on interviews with local residents, the local name of the tree is Mbete.

A difference in the characteristics of the core and the edge habitat was savannah that turns into a hunting area for OHBs in edge habitat. It was indicated from the savannah that was in the second

principal component in edge habitat (PC2). Savannah provided many alternatives food for OHBs such as reptiles (lizards and snakes) and small mammals (mice). It showed that the food was potentially available in the both habitats, but the difference was only in terms of quality, the potential of bees as the main food and honey was more commonly found in the core, while edge provided alternative food such as reptiles, amphibians, and small mammals.

Beside food, core and edge habitats preference was also based on the fulfillment of the thermal wind to fly. Slope and elevation are the physical variables that shape the topography of an area which associated with the availability of thermal wind [4]. The combination of slope and elevation variations can cause thermal wind used by OHBs in soaring and gliding. Variations of slope and elevation became important variables to OHBs in soaring. Solar radiation and variation of landforms may influence the thermal [5]. Either in the core or edge, there was a potential for wind thermals, but the core habitat had higher thermal wind potential than the edge habitat. It was evidenced by the first principal component of the core habitat that had a variation of steep slope with a slope of > 25% (DS5, DS6) and the first principal component of the edge habitat which had a relatively flat slope variation with a slope of 0-15% (DS1-DS3).

Table 3. Principal component analysis result for edge habitat

Environmental variable	Principal Component (PC)					
	1	2	3	4	5	6
DS1	0.841					
DS2	0.799					
DS3	0.777					
DBL						
DE2		0.916				
DE1		0.794				
DSV		0.715				
DE3		0.649				
DFR			0.897			
DE4			0.673			
DS6			0.635			
DPT						
DBA				0.880		
DWA				-0.683		
DE5				0.621		
DPF					0.861	
DSR						
DS5						0.790
DS4						0.782
Eigenvalue	3.699	2.977	2.853	2.198	1.537	1.480
Variance (%)	19.466	15.669	15.015	11.567	8.088	7.790
Cumulative	19.466	35.135	50.150	61.717	69.805	77.595

3.3 Characteristics comparison of wintering habitat of OHBs in western Flores and Borneo
Comparison of wintering habitat characteristics of OHBs in Borneo with Western Flores either in the core or edge showed similarities in environment variables used as the main reason in selecting wintering habitat. The variables as the main reason in selecting wintering habitat were the forest, variations of both slope and elevation. Landscape characteristics of core and edge habitat in Borneo were highly influenced by the availability of thermal winds and food. However, the more frequent presence of OHBs in core habitats indicates that habitat selection is basically influenced by increased thermal winds associated with particular landform characteristics [4].

The similar characteristic found in core and edge habitats in both islands was on the existence of forests. It was concluded that, in the hunting area requirement, OHBs require a combination of forest

and vegetated areas. It suggests that variation in land cover is an important factor that makes the dietary needs of OHBs can be met throughout their wintering habitat. Variation of land cover as landscape attributes caused heterogeneity that has an important role in the ecological system. Heterogeneity can describe the spatial complexity of a landscape mosaic [6].

The difference characteristic found in core and edge habitats in both islands was on mosaic of landscape that was affected by the abundance of food that could be hunting area for OHBs. The results of this study found that the savannah became the distinguishing characteristic landscape of wintering habitat in western part of Flores Island with Borneo Island. According to the "Honey Buzzard", wintering habitat is in rainforest or savannah forest [7]. The presence of savannah is very important, because the savannah can provide alternative foods such as amphibians (frogs), reptiles (lizards and snakes) and small mammals (mice) that play important roles to establish the body fat when existence of bees was less. Hunting areas on Borneo had a mosaic landscape composed of natural land (forests) and modified land by human activity (developed land, paddy fields, and gardens).

Wintering habitat of OHBs in Borneo has similarities to breeding habitat that is landscape mosaic of Satoyama in Japan. Satoyama comes lexically from the word of "sato" that means habitable areas and "yama" that means mountain. As developed in the agricultural system in Asia, this system is a complete mix between the natural environment and human settlement areas. These results have similarities with the results of previous studies [4], [8], [9] in West Java that represent wintering habitat characteristics of OHBs in western part of Indonesia. Characteristics of wintering habitat of OHBs in western Indonesia tend to be similar with the mosaic landscape of native habitat of OHBs in Japan i.e. Satoyama landscape mosaic where savannah as land cover does not exist in Japan.

4. Conclusions

This study was successfully delineated the core and edge habitat of OHBs. Fixed kernel-density successfully identified 165.86 km^2 of core area, while the edge area was 178.661 km^2. Core and edge habitats of OHBs were predominantly distributed in the southern part of the western Flores Island. Principal component analysis revealed that the characteristics of wintering habitat of OHBs were influenced by both the thermal wind and the availability of food. Thermal winds and the food were equally present in both habitats, core and edge, which distinguished only in terms of quality. Potential of food and higher thermal winds occurred in the core habitat so that visiting frequency of OHBs was higher in the core than in the edge. The similar characteristic found in core and edge habitats in Borneo and Flores Islands was on the existence of forests. Savannah became the main characteristics that distinguished landscape of wintering habitat of OHBs in Flores and Borneo.

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