POTENTIAL HABITAT AND SPATIAL DISTRIBUTION OF ANOA (Bubalus spp.) IN LORE LINDU NATIONAL PARK

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BOGOR AGRICULTURAL UNIVERSITY

2010
STATEMENT

I, Beni Okarda, hereby stated that this thesis entitled:

Potential Habitat and Spatial Distribution of Anoa (Bubalus spp.) in Lore Lindu National Park

Is a result of my own work research during the period of April 2008 to October 2009 and has not been published before in any form for another diploma, undergraduate, nor post graduate degree to any University or other institutions. The content of the thesis has been examined by the advising committee and external examiner

Bogor, February 2010

Beni Okarda
ABSTRACT


Anoa (*Bubalus spp.*) is endemic to Indonesian islands of Sulawesi and Buton. These mammals are divided into two species: Mountain Anoa (*Bubalus quarlesi*) and Lowland Anoa (*Bubalus depressicornis*). Both live in undisturbed rainforest and avoid direct contact with human. This animal has been classified into endangered species by International Union of Conservation for Nature (IUCN), Convention on International Trade in Endangered Species (CITES) and fully protected under Indonesian Law. Threat for Anoa is coming from illegal hunting and habitat degradation. Habitat loss or degradation caused by agriculture wood plantations, infrastructure development, and human settlement reported as serious threat for Anoa population by IUCN. This research aims to develop Anoa habitat suitability model using logistic regression and analyze ecological factors in Anoa’s habitat preference. Approximately 2,300 hectare research area in Toro village, Lore Lindu National Park has been analyzed in generated Anoa habitat suitability model.

Logistic regression GIS coupled model use to predict Anoa habitat suitability in Lore Lindu National Park. Anoa presence and absence data were obtained from field survey while environmental variable used in model were taken from GIS data layer and remote sensing data. Environmental variable were consists of elevation, slope, distance from river, distance from settlement and distance from forest edge. Vegetation analysis also conducted in place where Anoa found.

As result, distance from settlement, distance from forest edge, slope and altitude has significant factor while distance to river has insignificant factor for Anoa in prefering their habitat. The overall classification accuracy assessment was resulted on 93.2% with 93.64% absence area and 93.17% presence area correctly classified. Habitat suitability model tested using Hosmer and Lemeshow goodness of fit resulted 0.942 and Nagelkerke’s R² score 76.3 % as result of variable representation in this model. The simulation result shows that suitable habitat for Anoa located in core zone area, deep in undisturbed forest. This result is consistent with Anoa behaviors that tend to avoid human activity area. This
result also indicating there are human activities inside national park that force Anoa to move deeply to undisturbed forest area.

From vegetation analysis result, 25 species from 14 families Anoa feed vegetation were found in sampling plot. *Pinanga caessia* Blume, *Alpinia sp.*, *Cyathea contamminans*, *Frecynetia insignis* Blume, *Syzygium accuminatissima*, and *Lythocarpus celebicus* were dominated. Dominant feed vegetation indicated the feed supply still can meet Anoa demand.

From morphological characteristic, two from five samples collected inside and around study area shown the characteristic of Lowland Anoa. The fact that inside and around study area is mountainous area has derive to possibility that Lowland Anoa has moving into mountainous area because pressure from human activities in lowland area around national park.

Anoa habitat suitability was affected by human activities. Anoa sign that found deeply into forest indicated there are disturbance from human activities inside the forest. The species sample taken from hunter also indicated there are pressures in lowland area that dominated with settlement and plantation area. From the model, distances from settlement and distance from forest edge that represent human activities parameter become the most influence factor. Those facts indicated Anoa tends to avoid human activities area in choosing their habitat.
SUMMARY

Indonesian tropical forest is widely known over the world which having high value in biodiversity. World Resources Institute and Forest Watch Indonesia (2002) assert that tropical forest in Indonesia is a home for 11 percent of the world’s plant species, 10 percent of its mammal species, and 16 percent of its bird species. With this number of biodiversity value, Indonesia is ranked as the third richest in biological diversity after Brazil and the Democratic Republic of Congo. It also states that the forest types of Indonesia are diverse from evergreen lowland dipterocarp forests in Sumatra and Kalimantan to seasonal monsoon forests and also savanna grasslands in Nusa Tenggara and non-dipterocarp lowland forests and alpine areas in Irian Jaya (sometimes referred to as Papua). Many islands have been isolated for millennia, so levels of endemism are high. From 429 locally endemic bird species, for example, 251 are unique to a single island. Most of Indonesia’s insects are also endemic, with many genera confined to individual mountain tops.

Anoa (Bubalus spp.) is endemic to Sulawesi and Buton Island, Indonesia. These mammals are divided into two species: Mountain Anoa (Bubalus quarlesi) and Lowland Anoa (Bubalus depressicornis). Both species live in undisturbed rainforest condition and often avoid the direct contact with human. Lowland Anoa (B. depressicornis) and Mountain Anoa (B. quarlesi) are classified as endangered [C1+2a] by the International Union for Conservation of Nature (2004), and listed on Convention on International Trade in Endangered Species Appendix I (CITES, 2005). Bubalus spp. are fully protected under Indonesian law, although enforcement is difficult. IUCN (2004) explains that the total population of B. quarlesi is unlikely to be more than 3,000–5,000 animals, with the number of mature individuals likely to be less than 2,500.

Threat for Anoa existence is coming in directly and indirectly way. In direct threat, the major threat is caused by hunting. Natives’ people from Sulawesi get advantage of Anoa for their hides, meat, and horns. Anoa horn is very popular among local people in Sulawesi and become the identity symbol for native Sulawesi. Mustari (2003) reported, despite Anoa being formally protected, the animals are still hunted throughout Sulawesi by people using traditional method such as leg snares, hunting with spears with the assistance of dogs or setting sharp-tipped bamboo stake along the natural paths of the animals. There still no data recorded for Anoa in illegal wildlife trafficking or smuggling. Indirect threat for...
Anoa is coming from habitat degradation. Habitat loss or degradation caused by agriculture activity, infrastructure development, and human settlement has reported as serious threat for Anoa (IUCN, 2004).

Ministry of Forestry (2008) reported deforestation in Indonesia reach 1.17 million hectare per year between 2003 to 2006. In this report also include deforestation in protected area reach 55.6 thousand hectare per year or 4.75% from total deforestation in Indonesia. Central Sulawesi province classified as high deforestation in protected area with deforestation reach up to 9.2 thousand hectare per year.

There still inadequate research about Anoa species distribution and habitat which might affected in planning national park zone management. Species and habitat distribution will give important information in planning and monitoring the species and habitat condition. This research aims to develop Anoa habitat suitability model using logistic regression and analyze ecological factors in Anoa habitat preference.

The field work was taken place in primary forest around Toro village in Lore Lindu National Park, Indonesia. The study area located in 120°2'53“ – 120°7'44“E and 1°27'3“ – 1°30'51“S. This area administratively is part of Toro Village, Sub District of Kulawi Central Sulawesi Province. Study area was approximately taken 2,300 Ha of Lore Lindu national park area with 1,151 Ha sampling area and 1,149 Ha accuracy assessment area. From data observation, study area has altitude range from 814 meter above sea level in Toro Village settlement area up to 2173 meter above sea level in top of mountain with various slopes from 0 up to 62 percent. Lore Lindu is tropical rainforest with high humidity with temperatures vary from 26-32 °C. High altitude areas are significantly cooler with temperature drops 6 °C every 1100 m. The annual rainfall in Lore Lindu National Park varies between 2000 – 4000 mm per year with heaviest rain periods between November to April.

The fieldwork data collection was conducted from April to July 2008 including the process of vegetation identification which conducted in Herbarium Celebenses, Tadulako University, Central Sulawesi. While the data processing and thesis writing conducted in Laboratory of Remote Sensing and GIS, MIT-BIOTROP Bogor, from July to August 2008 and University of Tsukuba from August 2008 to August 2009.
This research was funded by BMZ and STORMA program. STORMA (Stability of Rainforest Margin in Indonesia) is an Indonesian-German collaborative Research Centre funded by the German Research Foundation (DFG).

The environmental variables are the predictor in determining habitat suitability based on species occurrence and viability. Sugiharta (1994) explain Anoa inhabit in undisturbed mountainous rainforest with hilly landscape. In behavioral aspect, Anoa tends to avoid direct contact with human or approaching human activity area like village. Observations of tracks indicate that Mountain Anoa travel singly or in pairs, but never associate in larger groups. A pair of Mountain Anoa is most likely to be comprised of a mother and her offspring, or an adult male and female (Sugiharta, 1994). However, Whitten et al. (1987) reported a herd of five animals on Mount Nokilalaki running past his expedition.

<table>
<thead>
<tr>
<th>Abbreviation</th>
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<th>Unit</th>
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<tr>
<td>ALT</td>
<td>Altitude</td>
<td>Meter Above Sea Level</td>
</tr>
<tr>
<td>SLO</td>
<td>Slope</td>
<td>Degree</td>
</tr>
<tr>
<td>DTR</td>
<td>Distance to River</td>
<td>Meter</td>
</tr>
<tr>
<td>DTS</td>
<td>Distance to Settlement</td>
<td>Meter</td>
</tr>
<tr>
<td>DTFE</td>
<td>Distance to Forest Edge</td>
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The variables collected for the model is topographic factor include altitude (ALT) and slope (SLO), proximity of water resources (DTR) and proximity of human activity area (DTS and DTFE) for predicting the suitable habitat of Anoa. (Table 1).

The environmental variables were taken from various GIS database layer. Topographic variables layers were using digital terrain elevation data generated from Satellite Radar Topographic Mission (SRTM) imagery. Slope layer was derived using degree slope unit while elevation layer was taken directly from digital elevation model. Digital maps of river stream and settlement are available from Indonesia National Coordination Agency for Surveys and Mapping at a scale of 1:50,000. Forest edge layer derived from Landsat ETM image path 114 row 061 acquisition date October 6th, 2005. The proximity variables generated using Euclidean Distance method. Euclidean distance is the most common use in generating distance and examines the root of square differences between coordinates among objects. In attempt to analyzed suitable habitat for Anoa, we
use 100 meter grid square that considered as observation unit for each parameter variable which use in generate the model in statistical analysis. Image processing and topographical analysis were conducted using ERDAS Imagine (Leica Geosystems, Norcross, GA, USA). Spatial analysis and spatial layer input were performed using ArcGIS (ESRI, Redlands, CA, USA) and Hawth Tools extension (Beyer, 2004).

The analysis of species and environment relationship has always been increased and turning into wide variety of statistical analysis including logistic regression (Pereira and Itami, 1991; Osborne and Tigar, 1992; Walker, 1990; Rodriguez, 1997). Austin (2002) explains there are three major components in any framework for statistical modeling in ecology. There needs to be an ecological model, a data model, and a statistical model. The ecological model consists of the ecological knowledge and theory to be used or tested in the study. The data model consists of the decisions made regarding how the data are collected and how the data will be measured or estimated. The statistical model involves the choice of statistical method, error function and significance tests. Each model interacts in both obvious and subtle ways with the other models to determine the success of any statistical modelling exercise. Robertson et al. in 2000 attempted to determine whether correlative models could perform as well as mechanistic models for predicting species potential distributions, using a case study. The profile technique was based on principal components analysis (PCA) and the group-discrimination technique was based on multiple logistic regressions (LR). The result of that study conclude that, using the scale of agreement proposed by Monserud and Leemans (1992), the Kappa Statistics indicated “very good” agreement for the PCA and “excellent” agreement for the SWB model and “perfect” agreement for the LR model.

Habitat suitability model was developed using logistic regression approach. The habitat suitability map was constructed by coupling field data with geospatial information derived from satellite imagery and other parameter spatial resources. Habitat suitability model were build using ecological parameter and testing it against current Anoa locations. The logistic regression approach uses the environmental parameter layers to characterize the habitat of known Anoa locations as well as those areas with no Anoa. Areas throughout the Lore Lindu National Park exhibiting environment variable characteristics similar to locations where Anoa was observed in the field were associated with suitable habitat in the
derived map. To assess fit and relative strength of the selected model, we used the Hosmer and Lemeshow goodness of fit test and Nagelkerke's rescaled R² respectively. The probabilities from the logistic regression were derived a predictive habitat map from the significant habitat characteristics across the landscape at threshold values. The results of the regression produced variable coefficients then applied to the area and the entire study area ranging from 0 to 1, where values greater than 0.5 were considered to be suitable for Anoa.

In order to get detailed information about structure and composition of vegetation in Anoa presence location, we conducted Vegetation Analysis method using Purposive Random Sampling. By knowing the structure and composition in each land cover class, it will describe the vegetation condition which might have specific characteristic. In vegetation analysis we use line transect method to distribute nested plots for vegetation analysis. In line transect method the plants are classified into tree (woody plants which has diameter at breast high more than 20 cm), poles (woody plants which has diameter at breast high from 10 to 20 cm), sapling (woody plants which has diameter at breast less than 10 cm and height more than 1.5 meter), seedling (woody plants with height up to 1.5 meter), and undergrowth plant like herbs, ferns, liana, and grasses. The plot sizes in vegetation analysis are 20 x 20 m for trees, 10 x 10 m for poles, 5 x 5 m for sapling and 2 x 2 m for seedling and undergrowth plant.

<table>
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<tr>
<th>SIGN</th>
<th>ALT</th>
<th>SLO</th>
<th>DTR</th>
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<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Foot Print</td>
<td>1,478</td>
<td>2,164</td>
<td>0</td>
<td>39</td>
<td>100</td>
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<tr>
<td>Feces</td>
<td>1,539</td>
<td>2,164</td>
<td>2</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>Shelter Horn</td>
<td>1,482</td>
<td>2,164</td>
<td>1</td>
<td>34</td>
<td>100</td>
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Anoa take a shelter under the fall down tree, concave landscape, or hole on mountain side which mostly found in the top of the mountain. There is no specific vegetation that identified as the shelter place for Anoa. Shelter place known by identified the foot print inside the shelter and feces found spread around the shelter. Anoa tends to have a clean environment inside the shelter. There are no found of manure or moss inside the shelter. Shelter ground covered by soil and there is no sign of feces or urine inside. In some shelter, Pallili fruit which knows as Anoa feed is found inside the shelter. Foot print rarely found
around shelter because the ground are covered by manure and moss. Foot print is mostly found in lower hills with less ground vegetation and the grounds are not covered by manure.

A logistic regression analysis generated randomly on 1,151 sample squares from 2,300 grid squares total research area while the other 1,149 sample square was use in accuracy assessment. The model resulted correctly classified 93.64% of presence squares and 93.17% of absence with overall classification accuracy 93.21%. We using five environmental variables in predicting the model of which distance to settlement, distance to forest edge, altitude, and slope had significant coefficient in increasing the suitability factor for Anoa habitats while distance to river variables resulted significance number more than 0.05 which mean those parameter have no significant effect into model. The model explained 76.3% of the variance of the independent variable using Nagelkerke’s R2. This mean there are 23.7% environment variable that not represented in this model. Hosmer and Lemeshow goodness of fit resulted chi-square 2.879 with significance 0.942 which is above that required. The Hosmer and Lemeshow goodness of fit test result indicated this model is fit with the observation data and can be accepted.

Table. 3 Logistic Regression Result

<table>
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<tr>
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<th>B</th>
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<td>0.228</td>
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</tr>
<tr>
<td>DTS</td>
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<tr>
<td>DTFE</td>
<td>0.006</td>
<td>.001</td>
<td>49.964</td>
<td>1</td>
<td>.000</td>
</tr>
<tr>
<td>Constant</td>
<td>-54.426</td>
<td>6.570</td>
<td>68.627</td>
<td>1</td>
<td>.000</td>
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From result, Anoa tends to prefer lower altitude with less significance to the model. This is mean that Anoa were found in various altitude level in sampling area. Other topographical factor, slope, has significance influence to the model shown from significance value less than 0.05. Anoa prefers to live in flat landscape area according to model shown by negative response in slope parameter. This mean Anoa sign mostly found in lower level of slope tough there is probability Anoa can climb in steep landscape in browsing activities because from field observation several Anoa sign were found in steep landscape.
Significance influence of distance from settlement and distance from forest edge indicated the Anoa effort to avoid direct contact from human activities. River becomes not significant parameter to the model which might because rivers were spread from top of mountain down to settlement area. Though Anoa seem to avoid river in lower altitude since people around national park use the river in lower altitude as access to collecting rattan inside national park.

From 24 sampling plot of vegetation analysis, recorded 81 species from 41 families found in place where Anoa found. Where 25 species from 14 families were identified as Anoa feed. Anoa feed vegetation like *Pinanga caessia* Blume, *Alpinia* sp., *Cyathea contamminans*, *Frecynetia insignis* Blume, *Syzygium accuminatissima*, and *Lythocarpus celebicus* were dominated in sampling plot from the high importance value result. Beside those dominant vegetation, there also found others Anoa feed vegetation like *Elastotema* sp., *Begonia* sp., *Pandanus* sp., *Piper* sp., *Dinochloa* sp., *Garcinia* sp., *Syzygium* sp., *Drynaria rigidula*, *Smilax leuchophylla*, and some species from *Zingiberaceae* and *Arecaceae* family in sampling plot.

From species morphological characteristic, two from five samples collected inside and around study area shown the characteristic of Lowland Anoa. The fact that inside and around study area is mountainous area has derive to a possibility that Lowland Anoa has moving into mountainous area because pressure from human activities in lowland area around national park.

Anoa tend to make a distance from human activity area even in the lowest human activities area or other area that already disturbed by human. Local people activities, like collecting Rattan and Gaharu inside national park, has disturbed habitat of Anoa. A human activity inside national park forest has force Anoa to move deeply into top of mountain area. Distances from human activities area become the most influence factor for Anoa in determining its habitat.
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POTENTIAL HABITAT AND SPATIAL DISTRIBUTION OF ANOA
(Bubalus spp.) IN LORE LINDU NATIONAL PARK

BENI OKARDA

A Thesis submitted for the degree of Master of Science
of Bogor Agricultural University

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RESOURCES MANAGEMENT PROGRAM
GRADUATE SCHOOL
BOGOR AGRICULTURAL UNIVERSITY
BOGOR
2010
Research Title : Potential Habitat and Spatial Distribution of Anoa (*Bubalus* spp.) in Lore Lindu National Park

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Highest appreciation also addressed to my beloved “kuburan crews” for unbelievable moment, odds support and brotherhood.
Beni Okarda was born in Jakarta, on October 21, 1982. He spent his childhood in East Jakarta and finished his high school at SMUN 58 Jakarta. He achieved his undergraduate degree in 2005 from Bogor Agricultural University, Faculty of Forestry, majoring in Forest Resources Conservation and Ecotourism.

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He also Research Fund Grantee from Deutsche Forschungsgemeinschaft (DFG) under Multidisciplinary Collaborative Research Program Stability of Rainforest Margin Areas in Indonesia (SFB 552 - STORMA) and as the result from that program, he proposed “Potential Habitat and Spatial Distribution of Anoa (Bubalus spp.) in Lore Lindu National Park” for his thesis.
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