II. LITERATURE REVIEW

2.1. Lore Lindu National Park

Lore Lindu National Park is located in Central Sulawesi Province, covering 217,000 hectares, which consists of 20 % mountainous forest, 70 % hilly and lower mountainous forest and most of lowland forest (± 10 %). This National Park was established in October 1993, which was established from Lore Kalamanta Nature Reserve and Lake Lindu Recreation-Protection Forest. Much earlier before gazette as a national park, the Lore Lindu region has been declared as a “Man and the Biosphere Reserve” (MAB) by UNESCO in 1978 and it has been nominated as a World Heritage site for its astonishing cultural heritage of ancient stone megaliths dating from 1300 AD (Pangau-Adam 2003; TNC 2006).

The park is a major catchments area of Gumbasa and Lariang rivers and the mountainous topography harbors some of the largest unbroken tracts of forest on Sulawesi. This is providing the essential habitat for Babirusa or Pig Deer (*Babyrousa babyrussa*), Babi Hutan or Wild Boar (*Sus scrofa*), Tarsier (*Tarsius* sp.), Tonkean macaque (*Macaca tonkeana*), Hornbill (*Rhyticeros cassidix*), Maleo (*Macrocephalon maleo*) and other 227 birds, 77 of which are endemic to Sulawesi (The Nature Conservancy, 2006).

Lore Lindu National Park is also the habitat for Anoa or *Bubalus* spp. which is endemic species to the Indonesian islands of Sulawesi and Buton [Butung] in southeast Sulawesi Province, occupying an area approximately 5,000 km² (IUCN, 2004). In addition, base on IUCN’s observation in 2004, Anoa’s distribute across most of its known historical range, and founded in several protected areas, including Lore Lindu National Park.

2.2. Anoa (*Bubalus* spp.)

Anoa, or in local Kulawi language called *Lupu*, are divided into two species, Mountain Anoa and Lowland Anoa. Both species are endemic in Sulawesi. The name represents the habitat location in level of altitude.
Buchholtz (1990) described Mountain Anoa (B. quarlesi) to be similar in form to the Lowland Anoa (B. depressicornis). Mountain Anoa is the smallest of the extant wild cattle. It is also mentioned that the body is round and barrel-shaped, and the legs are slender. Body length is approximately 150 cm and shoulder height is typically 70 cm. Burton et al. (2005) also explain the Anoa are two species of dwarf buffalo, the Lowland Anoa (Bubalus depressicornis) and Mountain Anoa (Bubalus quarlesi) that are endemic to the island of Sulawesi, Indonesia. The classification of the subgenus Anoa within Bubalus is upheld by assessment of recent genetic and morphological research. The classification of Anoa into two species is still debated.

The coat of adults, especially females, is often thick and woolly into adulthood - rather than being grown specially, this appears to be merely retention of a juvenile characteristic. This woolly coat may be shed by increasing maturity, but if it is lost, the hair is never as sparse as in B. depressicornis (Groves, 1969). The color of adults varies from dark brown to black, with males approaching black and generally being darker than females (Groves, 1969; Feer, 1994). Compared to B. depressicornis, B. quarlesi has small and inconspicuous markings (Groves, 1969). The slender legs are brownish black along their entire length, and the small white spots which may be present just above the hooves are often difficult to see (Groves, 1969; Buchholtz, 1990). The groin region is lighter in color than the back, but is not white (Groves, 1969). The tail of the B. quarlesi is shorter than B. depressicornis, being 14.6-17.8 % of the total length (Groves, 1969).

There are usually no markings on the face, and there is never any crescent of white on the throat (Groves, 1969). The ears are small and relatively narrow (Buchholtz, 1990). Both male and female Mountain Anoa possesses a pair of horns. The horns are relatively short and conical, and can be distinguished from those of B. depressicornis by being round, rather than triangular, in section. The horns are smooth, without any marked ridges or external keel (Groves, 1969; Buchholtz, 1990). Horn length for both sexes varies from 14.6 to 19.9 cm (Groves, 1969).
The results of Anoa’s tracks study indicate that Mountain Anoa travel singly or in pairs, but never associate in larger groups (Sugiharta, 1994). However, Whitten et al. (1987) reported a herd of five animals on Mount Nokilalaki has been seen during his expedition. 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). The National Research Council (1983) reports that *B. quarlesi* is active primarily in the morning, seeking shelter under shade trees during the afternoon. Sugiharta (1994) found signs of Mountain Anoa under fallen trees with a diameter greater than 60 cm, in areas under the roots of live trees, and under large overhanging rocks along river banks as shelter. One individual was observed bedded in *Gleichenia linearis* at the border between forest and grassland in Lore Lindu National Park (Sugiharta, 1994). This animal wallows and bathes in pools of water and mud (National Research Council, 1983).

In terms of feed aspect, *B. quarlesi* feeds on plants in both forest and open areas, including those created by avalanches and characterized by secondary plant succession. The grass is their preference feed in Lore Lindu National Park. In other hand, to fulfill their mineral needs, Anoa visiting the mineral-rich hot springs and salt licks, it is also reports they may drink seawater (Sugiharta, 1994).

### 2.3. Animal Spatial Distribution

Animal distribution is patterns that characterize where animals are found around the globe. When scientists study the distribution of animals, they investigate why reindeer, for instance, are found only in certain parts of the arctic tundra, or why malaria-bearing mosquitoes proliferate in damp subtropical areas. Scientists study animal distribution to understand the spread of animal-borne diseases, to acquire knowledge about the preservation of rare species that may have special needs, and to become informed about the changing geography of the world, and our place in its history and its future. To understand these issues, scientists need to identify the specific climates, foods, and geographic features different animals require, and what areas best provide them. The study of animal distribution is called zoogeography.
Animals vary widely in their tolerance of environmental conditions. Some can survive in a variety of habitats, whereas others perish when removed from their natural surroundings. No animals other than humans can create sufficient artificial changes to enable them to exist in a totally strange environment without evolving through many generations of adaptation. The specific interactions of animals with their environments are the subject matter of ecology. The factors affecting animal distribution range from global geological events to local weather conditions.

Animals don't live completely free in a wild state because their living space is confined by boundaries that are often invisible to the casual observer. The size of the area used is determined often by individual and species needs and environmental limitation. Distribution or range is the geographic distribution of the species. Within this range only areas of suitable habitat are occupied. Home range is the living area normally occupied and inhabited by an animal. It may belong to a single individual, a mated pair or a social unit, a cohesive group with a single dominant individual. Within the home range there is often a defended area which is identified as a territory. Typical behavior is usually associated with establishing and defending or protecting the animal's territory. This behavior and reproductive behavior associated with the territory is unique for each species, and allows several different animal species to live in the same space without rivalry, using different niches within the habitat. The home ranges of different groups often overlap, and in the overlap areas the groups will tend to avoid each other rather than seeking to expel each other. Within the home range there may be a core area that no other individual group uses, but again this is as a result of avoidance rather than defense.

2.4. Logistic Regression

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). The distribution of a species may be related to many independent variables identified by Geographic Information System layers. Many layers may be irrelevant and the
knowledge about the ecology of the species could reduce the number of the unnecessary independent variables included in analysis.

Logistic Regression model is regression model for binary response variable. Logistic regression equation is shown below

\[ P = \frac{1}{1 + e^{-(\beta_0 + \sum_{j=1}^{n} \beta_j x_{ji})}} \]

Where P is probability value in range 0 to 1 with 0.5 as threshold value for suitable and unsuitable classification, \( \beta_0 \), \( \beta_j \) represent constant, \( x_i \) represent environment variable and \( exp \) is natural logarithm.

Walker (1990) used logistic regression to map the distribution of three kangaroo species in Australia against climate parameters. The model was built with an inductive approach using a Classification and Regression Tree (CART) function within a GIS that established decision-rules, as well as a probability function (logistic regression model) for mapping the probability distribution of species. A comparison between the two methods revealed that commission error (areas where presence of kangaroos was predicted but not recorded) was higher with logistic regression than with CART.

Miyamoto et al. (2004) investigated the effect of environmental variables on the presence of the Formosan squirrel using logistic regression analysis in the Ofuna area. Logistic regression analysis showed that the area of a wood, the proportion of cultivated fields surrounding the wood, and the proportion of broad-leaved evergreen trees in the wood influenced the presence of the Formosan squirrel. Logistic regression analysis was used to determine the effect of ten environmental variables related to wooded area, distance between woods, vegetation in each wood, and land use surrounding the wood by using a stepwise procedure.

Austin (2002) explains there are three major components in any framework for statistical modeling in ecology. There needs to be an ecological, a data, 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.

A wide variety of statistical models are currently in use to represent and simulate the spatial distribution of terrestrial animal and plant species as well as biomes and processes, and GIS are being increasingly used to model wildlife-habitat relationships. The selection of significant parameters is essential for successfully model any process, thus the identification of causal variables is the most critical step in model development (Guisan and Zimmerman, 2000).

Robertson et al. (2000) attempted to determine whether correlative models could perform as well as mechanistic models for predicting species potential distributions, using a case study. Robertson compared potential distribution predictions made for a coastal dune plant (*Scaevola plumieri*) along the coast of South Africa, using a mechanistic model based on Summer Water Balance (SWB), and two correlative models (a profile and a group discrimination technique). The profile technique was based on Principal Components Analysis (PCA) and the group-discrimination technique was based on multiple Logistic Regressions (LR). Kappa (κ) statistics were used to objectively assess model performance and model agreement. Model performance was calculated by measuring the levels of agreement (using κ) between a set of testing localities (distribution records not used for model building) and each of the model predictions. The result of the study showed the utilisation of agreement proposed scale 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.
2.5. Vegetation Analysis

Vegetation analysis is conducted in order to get detail information about vegetation structure and domination. In this research, this kind of data will support the model that will be developing spatially. The vegetation structure will explain the condition that cannot explain by spatial model. From vegetation analysis result, expectably, will show the type of vegetation that known as Anoa feed and it condition. This data will be complementary data in explaining suitable habitat for Anoa.

Mustari (2001) explain that Anoa is ruminant herbivore type animal. Anoa feed are from many kind of vegetations consisting leaves, shrub, bush and many kind of grass. Grzimek in 1968 explain that Anoa feed consist of leaves, shrub and bush, Pteridophyta, grass, fallen fruit, Palmae and aquatic vegetation. While Whitten et al. (1987) reported from faecal analysis in South Sulawesi, Anoa is browser type herbivore that consumes woody vegetation, Pteridophyta, grass, moss, and monocots plant. Mustari (1995) also reported about 33 species from 18 families are identified as Anoa feed sources. Part of the plant that being consumed were consist of leaves, sprout, palm-cabbage and root. Anoa was also known temporarily visiting salt-lake-spring, like Anoa that lives in Nantu forest, Gorontalo.

Anoa has large variation of vegetation that well adapted as feed. Pujaningsih (2005) reported eleven type of vegetation was founded and known as delicates feed for Anoa, that vegetation are Areca sp., Elatostema sp., Rubus sp., Zingiber sp., Nephrolepis sp., Cyrtandra sp., Begonia sp., Erasgrotis sp., Saccharum sp., and two other species from family Palmaceae and Utriceae. From those species, Areca sp., Elatostema sp., Zingiber sp., and Cyrtandra sp., was concluded as dominant in Anoa feed preference.