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An Assessment of Potential Habitat Corridors and Landscape Ecology for Long-Tailed Macaques (MACACA FASCICULARIS) on Bali, Indonesia

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AN ASSESSMENT OF POTENTIAL HABITAT CORRIDORS AND LANDSCAPE ECOLOGY FOR LONG-TAILED MACAQUES (*MACACA FASCICULARIS*) ON BALI, INDONESIA

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by

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ABSTRACT

AN ASSESSMENT OF POTENTIAL HABITAT CORRIDORS AND LANDSCAPE ECOLOGY FOR LONG-TAILED MACAQUES (*MACACA FASCICULARIS)* ON BALI, INDONESIA

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The relationship between Balinese long-tailed macaques, Bali's cultural settings, and Bali's physical settings was studied. A Geographical Information System (GIS) database was developed and analyzed to determine if forest corridors exist on Bali that may provide habitat connectivity between 42 Balinese long-tailed macaque troops. The GIS database was also analyzed to determine if the landscape type that has the highest percentage of overlap with the 42 Balinese long-tailed macaque home range sites is forest. The results indicate that connectivity between troops located within Bali's western region is significantly higher than that for troops located in Bali's eastern region. The results also indicate that a high percentage of the Balinese long-tailed macaque home range sites overlap with forest. Implications for the future conservation of Balinese long-tailed macaques and the significance of Balinese long-tailed macaques for the development of global biodiversity management strategies are discussed.

ACKNOWLEDGEMENTS

The author would like to thank Dr. Agustin Fuentes for: introducing the author to Bali and Balinese long-tailed macaque research; serving as thesis committee chairman; editing numerous thesis drafts; assistance in writing grant proposals; going beyond the call of duty in keeping his office door open; his patience; support on behalf of the Balinese Macaque Project; and for his diligence in challenging the author to achieve ever higher levels of academic success.

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The author would like to thank Sigma Xi, Central Washington University's (CWU's) Office of Graduate Studies and Research, and CWU's Office of Student Affairs for providing research funding in the form of grants.

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The author would like to thank all of his family members for their support. The author especially could not have made it through the thesis development process without the love provided by Tina, Freemont, Hogan, ma Southern, ma Hagel, and pa Hagel.

Finally, the writing of this thesis would not have been possible without the generosity of: Lembaga Ilmu Pengetahuan Indonesia and the Governor of Bali (for permission to conduct research on Bali); staff members from the Universitas Udayana including Dr. I.D.K. Harya Putra, Artha Putra, Aida Rompis, and Raka Dalem; the Padangtegal Wisata Wanara Wana Foundation and I Wayan Selamet; Made Wedana (from The Archipelago Nature Conservancy Society or KONUS); staff members from the Bali Barat National Park; Ir. Nyoman Kami Artana (from P.T. Ganeshaglobal Sarana); and staff members from Pusat Pendidikan Lingkungan Hidup Bali (the Environmental Education Center).

The author would like to dedicate this thesis in memory of Dr. Komang Gde Suaryana. Dr. Komang passed away, as the result of injuries sustained in an automobile accident on Bali, shortly before the completion of this thesis. Dr. Komang served as director of the Universitas Udayana Primate Research Center and was the first person to greet the author at Bali's airport. Dr. Komang made major contributions to the development of this thesis by: sharing his knowledge of Balinese culture; by sharing his knowledge of Balinese long-tailed macaques; by showing the author various locations on Bali; and by assisting the author in inputting the locations of Balinese long-tailed macaque troops into the GIS database. Dr. Komang was unable to make comments on this thesis and a result, in the author's eyes, this thesis shall forever remain incomplete.

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The accompanying compact disk presents Figure 17: Individual monkey sites and buffer zones. The compact disk contains 42 individual Joint Photographic Experts Group (JPEG) files. Each JPEG file is identified with a number, that corresponds to the site numbers listed in Table 2: Site list and individual range analysis results. The JPEGs contain an image of each troop site as represented within this thesis project's GIS database. The black outline of a circle represents the extent of each troop's 100 hectare home range buffer zone. Each troop site is delineated on a portion of its corresponding Bakosurtanal map. Major cities and villages are represented on the Bakosurtanal maps in orange; rice fields in light blue; forested areas in green; and rivers, streams, and lakes in dark blue. In some cases a JPEG may contain a portion of an overlapping or neighboring troop's 100 hectare buffer zone. The 100 hectare buffer zone that corresponds to the troop being represented, within each JPEG, will always be a complete circle.

Troop site images were saved at varying scales in an attempt to provide location landmarks for each troop site. The relative location of each troop site may also be determined by referring to Figure 16: Balinese long-tailed macaque troop sites and 100 hectare buffer zones.

CHAPTER I

THESIS OVERVIEW

INTRODUCTION

Long-tailed macaques (*Macaca fascicularis*) are considered to be one of the most successful of the anthropoid primates. This species has generally been overlooked in the context of developing global biodiversity management strategies because:

- They are distributed throughout most of Southeast Asia.
- Their population numbers are relatively high.
- Evidence indicates that long-tailed macaques may have ranges that overlap with a wide variety of landscape types (i.e., have broad habitat specificity).

This thesis will argue that long-tailed macaques can contribute to the development of global biodiversity management strategies, because long-tailed macaques represent a species that is important to the development of understanding fragmentation in metapopulations of primates.

This thesis will establish the importance of long-tailed macaques, in the development of understanding fragmentation in metapopulations of primates by challenging the assumption that long-tailed macaques have broad habitat specificity. If long-tailed macaques do not have broad habitat specificity then the probability that localized populations of long-tailed macaques can experience reduced fitness or viability, either through the destruction of their core habitat or through the destruction of habitat corridors between home range locations, is most likely high. Although this thesis will not refute that the range of long-tailed macaques may overlap with a variety of landscape types, this thesis project will both review and expand upon an existing body of research evidence that indicates the "primary" habitat of long-tailed macaques is forested areas. This thesis will in turn suggest that, although long-tailed macaques might be capable of incorporating a wide variety of landscape types into their range, the viability of long-tailed macaque troops may ultimately depend upon whether or not their range overlaps with forest.

This thesis' challenge to the assumption that long-tailed macaques have broad habitat specificity will be based primarily upon the testing of the hypothesis:

> Although Bali has a diversity of landscape types, the landscape type that will have the greatest percentage of overlap with the home range of know Balinese long-tailed macaque troops, will be forest. In addition, forest corridors will exist between known Balinese long-tailed macaque home range sites.

Testing of this hypothesis will be based upon the development and analysis of a Geographical Information System (GIS) database and field verifications. The premises of this thesis' hypothesis will be utilized to discuss the biological and resource management implications of long-tailed macaques having habitat specificity that is primarily limited to forest.

The problem statement, hypothesis, and objectives presented in this thesis are each discussed within sub-sections of Chapter 1. The problem statement suggests there is need for additional research on long-tailed macaque habitat preferences and discusses some of the implications of long-tailed macaques having a habitat specificity that is primarily limited to forest. The hypothesis includes several premises about long-tailed macaque habitat preferences. These premises are based upon an existing body of evidence that indicates the primary habitat of long-tailed macaques is forest. This existing body of evidence is further discussed in Chapter 2, which focuses on long-tailed macaque paleontology and ecology.

In addition to the testing of the research hypothesis, other objectives of this thesis include the making of recommendations for future long-tailed macaque research projects and the making of recommendations for resource management projects. One of the challenges associated with merging a discussion on Balinese long-tailed macaque habitat preferences with resource management implications is that both discussions require different emphases on humans. In this thesis, the examination of Balinese long-tailed macaque habitat preferences emphasizes the establishment of a better understanding about the sympatric relationship between Balinese long-tailed macaques and Bali's forests. The discussion of resource management implications focuses on trying to establish a better understanding about the role that human land use practices may be playing in the viability of Balinese long-tailed macaque populations. Context for both of these discussions is provided in Chapter 3, which focuses on Bali's physical settings. This chapter establishes that Balinese long-tailed macaques, Bali's forests, and the Balinese may have a sympatric relationship that goes back in time at least 2 millennia.

Following the discussion on Bali's physical setting(s), an examination of Bali's cultural setting(s), the Balinese and globalization, and Bali's uncertain future are presented. These individual chapters provide context that is important to this thesis's discussion on resource management implications. Chapter 4 describes Bali's cultural setting(s) and provides examples of how the Balinese have altered Bali's landscape configurations in the building of a rice agricultural system, villages, and family compounds within a context of Balinese Hinduism. This chapter also provides examples of how the Balinese interact with Balinese long-tailed macaques. Based on these examples, the chapter on Bali's cultural setting(s) can be seen an extension of the chapter on Bali's physical setting(s). A distinction between Balinese land use practices and the cultural context within which land use decisions are made is established. This distinction is important for resource management because, although resource management involves translating knowledge about how people interact with their environment into the development and promotion of sustainable land use practices, there is a potential for resource management strategies to fail if they are developed without taking into account aspects of cultural form.

Incorporating aspects of cultural form in the development of resource management strategies represents one of the greatest challenges of conducting resource management projects. The discussions on the Balinese and globalization presented in Chapter 5 and Bali's uncertain future presented in Chapter 6, establish that the Balinese culture is evolving. The Balinese have the ability to alter their own cultural form, although, cross-cultural encounters have historically been a major driving force in the evolution of the Balinese culture. For resource management purposes, the significance of an evolving Balinese culture is that the ultimate cause of any given environmental problem on Bali today may be a series of cultural forms that have determined the history of Balinese land use practices.

Chapter 7 describes the research methodology and provides an overview of the procedures that were utilized to test this thesis' hypothesis. Procedures discussed include GIS database development, GIS database analysis, and the conducting of ground verifications. Chapter 8 discusses the body evidence that was established through the testing of this thesis' hypothesis. Chapter 9 inquires whether or not the body of evidence supports the hypothesis and discusses the significance of the results.

Chapter 10 provides the synthesis between discussions on Balinese long-tailed macaque habitat preferences and resource management implications. This chapter attempts to define deforestation as an environmental problem on Bali, in terms of both Bali's physical and cultural setting(s). In addition, this chapter further discusses some of the biological implications of Balinese long-tailed macaques having a habitat specificity that is primarily limited to forests. Beyond defining deforestation as an environmental problem on Bali and defining the potential impacts that deforestation may have on the viability of Balinese long-tailed macaque populations, the author was faced with the dilemma of how to make resource management recommendations.

One of the conclusions of this thesis is that although the Balinese are continuing to carry out land use practices on Bali, the Balinese have historically become removed as stakeholders in the development of resource management strategies for Bali. Therefore, the recommendations included in Chapter 11 do not make specific recommendations for forest management objectives and activities. Instead, this thesis makes recommendations for projects that will hopefully promote the development of an adaptive management system for Bali. That is, an adaptive management system that will hopefully, in turn, promote a greater degree of cooperation between the Balinese, the central Indonesian government, and foreign countries in conducting resource management projects.

PROBLEM

While there have been many studies of long-tailed macaques, the assumption that long-tailed macaques have broad habitat specificity has yet to be fully tested (Fooden 1995, 1-119). If long-tailed macaques do not have broad habitat specificity, then the probability that localized populations of long-tailed macaques can experience reduced fitness or viability, either through the destruction of their core habitat or through the destruction of habitat corridors that support the movement of males between core habitats, is most likely high. Habitat fragmentation and localized selective pressures can create genetic diversity in a metapopulation, which in turn can help to insure the survival of a metapopulation during times of environmental shift. The viability of a metapopulation may, however, also be dependent upon the re-establishment of localized populations in areas where extinction has occurred. So while temporary isolation of troops may not be harmful, the viability of a metapopulation may be diminished by the long-term isolation of its troops. If long-tailed macaques have a habitat specificity that is primarily limited to forested areas, there is a strong likelihood, because many parts of Southeast Asia are undergoing extensive deforestation, that some long-tailed macaque metapopulations are experiencing reduced fitness as a result localized population extinction.

THESIS HYPOTHESIS AND OBJECTIVES

The primary objective of this thesis project is to utilize a landscape ecology approach to test the hypothesis that:

> Although Bali has a diversity of landscape types, the landscape type that will have the greatest percentage of overlap with the home range of know Balinese long-tailed macaque troops will be forest. In addition, forest corridors will exist between known Balinese long-tailed macaque home range sites.

Although this thesis attempts to model the types of landscapes that Balinese long-tailed macaques might be utilizing as their home ranges, it is beyond the scope of this thesis project to directly test the degree to which Bali's forest corridors are supporting the movement of Balinese long-tailed macaques between troop locations. The secondary objective of this thesis project is to recommend future research that will further test Balinese long-tailed macaque habitat preferences and, hopefully, lead to an actual assessment of whether or not the Balinese long-tailed macaques are in fact using forest corridors.

A concern of this thesis project is that the conservation of Balinese long-tailed macaques be insured well into the future. Therefore, the final objective of this thesis project is to make recommendations for future research and resource management projects that may promote the conservation of Balinese long-tailed macaques. As a framework for making these recommendations, this thesis project proceeds under the assumption that the viability of Balinese long-tailed macaque troops is dependent upon the conservation of Bali's forests. In addition, this thesis will:

- Attempt to identify natural and cultural factors that may have historically conserved or destroyed Bali's forests.
- Attempt to establish a correlation between forest patterns that are identified through the testing of this thesis project's hypothesis and factors that are identified that may have historically played a role in the conservation or destruction of Bali's forests.
- Attempt to identify natural and cultural factors that will play a primary role in the future conservation or destruction of Bali's forests.

DEFINITIONS

Ecology and the Environmental Spheres

Ecology is the study of: ". . . the relationship between organisms and their environment." (Hickman, Roberts, and Hickman 1984, G-6). The environment of organisms can be subdivided into 4 principal components: lithosphere, atmosphere, hydrosphere, and biosphere. The lithosphere is the solid inorganic portion of the Earth, composed of the rocks of the Earth's crust as well as the broken and unconsolidated particles of mineral matter that overlies the solid bedrock. The atmosphere is the gaseous envelope of air that surrounds Earth, which contains the complex mixture of gases that are necessary to sustain life. The hydrosphere is comprised of water in all of its physical states and locations. The biosphere represents the entirety of the vast variety of earthly life forms or biota. These 4 components overlap and interact in a complex interface on the surface of the Earth (McKnight 1996, 5).

Geography and Landscape Ecology

Geography is the study of: ". . . the physical and human characteristics of the Earth's surface." (Blij 1996, R-31). Geography is an important scientific discipline because:

> . . . geography is . . . driven by the demands of survival and livelihood. Knowing places, knowing how to negotiate space, knowing the resources of one's environment, where and how far apart they are, knowing the rhythms of nature, their constraints and opportunities, are the sort of mental equipment every human individual and every society must have (Tuan 1990, 444).

Biogeography is the branch of geography that deals with the geographical distribution of plants and animals. In 1939, the German biogeographer G. Troll, while studying problems of land use and development in East Africa, recognized that ecological principals could be applied to aerial photographic interpretation and *vice versa*. Troll coined the term "landscape ecology" (Naveh and Lieberman 1984, 4). One current definition of a landscape is that it represents: "The part of geographic space showable on a map, including all its features." (Clarke 1999, 318). For the purposes of this thesis, the definition of landscape ecology is: the study of the relationship between organisms and their environment through the use of maps. In practice, landscape ecology can be thought of as a subdiscipline of biogeography.

When applied to ecological research, the types of questions that are being asked and the organism(s) being studied represent the geographical scale of a landscape. For example, a landscape model could be developed for the habitat of a single organism by mapping paths along which the organism moves, settles, reproduces, and eventually dies. The same parameters could be utilized to map several individuals in order to develop a landscape model for the habitat of a population. When scale flexibility is combined with the overlaying of maps for a single focal area and from multiple time periods to produce a model of environmental change, the landscape concept becomes a powerful tool for ecological and resource management research (Pulliam and Dunning 1997, 222-223).

CHAPTER II

LONG-TAILED MACAQUE PALEONTOLOGY AND ECOLOGY

LONG-TAILED MACAQUE PALEONTOLOGY

The earliest unquestionable fossil macaque was found at Wadi Natrun, Egypt, in deposits dating to about 6 million years ago (Eudey 1980, 56). After an origin in northern Africa, early macaques are believed to have spread into Eurasia via the Near East (see Figure 1: Hypothetical dispersal patterns of Asian macaques). One line of macaques moved eastward and reached India by the late Pliocene (approximately 1.8 million years ago). From southern India, this line continued to move along the coast to Burma and into peninsular Southeast Asia (Delson 1980, 23-25).

From peninsular Southeast Asia there are currently 2 debated scenarios for distribution (see Figure 1). Evidence indicates that lower sea levels during the Pleistocene (1.6 million to 10,000 years ago) created a unified landmass, called Sundaland, which connected the current islands of Indonesia with the Asian mainland. The first scenario is that the ancestral line split with macaques moving both northwards through mainland Asia and southeastward onto Pleistocene Sundaland. This scenario has *Macaca fascicularis* radiating throughout Sundaland and later moving back onto mainland Asia. As *Macaca fascicularis* radiated back across mainland Asia they came into conflict with other macaque lineages (Delson 1980, 23-27). In the second scenario, the ancestral line did not split in Malaya. Instead the ancestral line, now possibly represented by *Macaca fascicularis*, continued to move onto Sundaland prior to 40,000 years ago. By 20,000 years ago *Macaca fascicularis* had radiated throughout

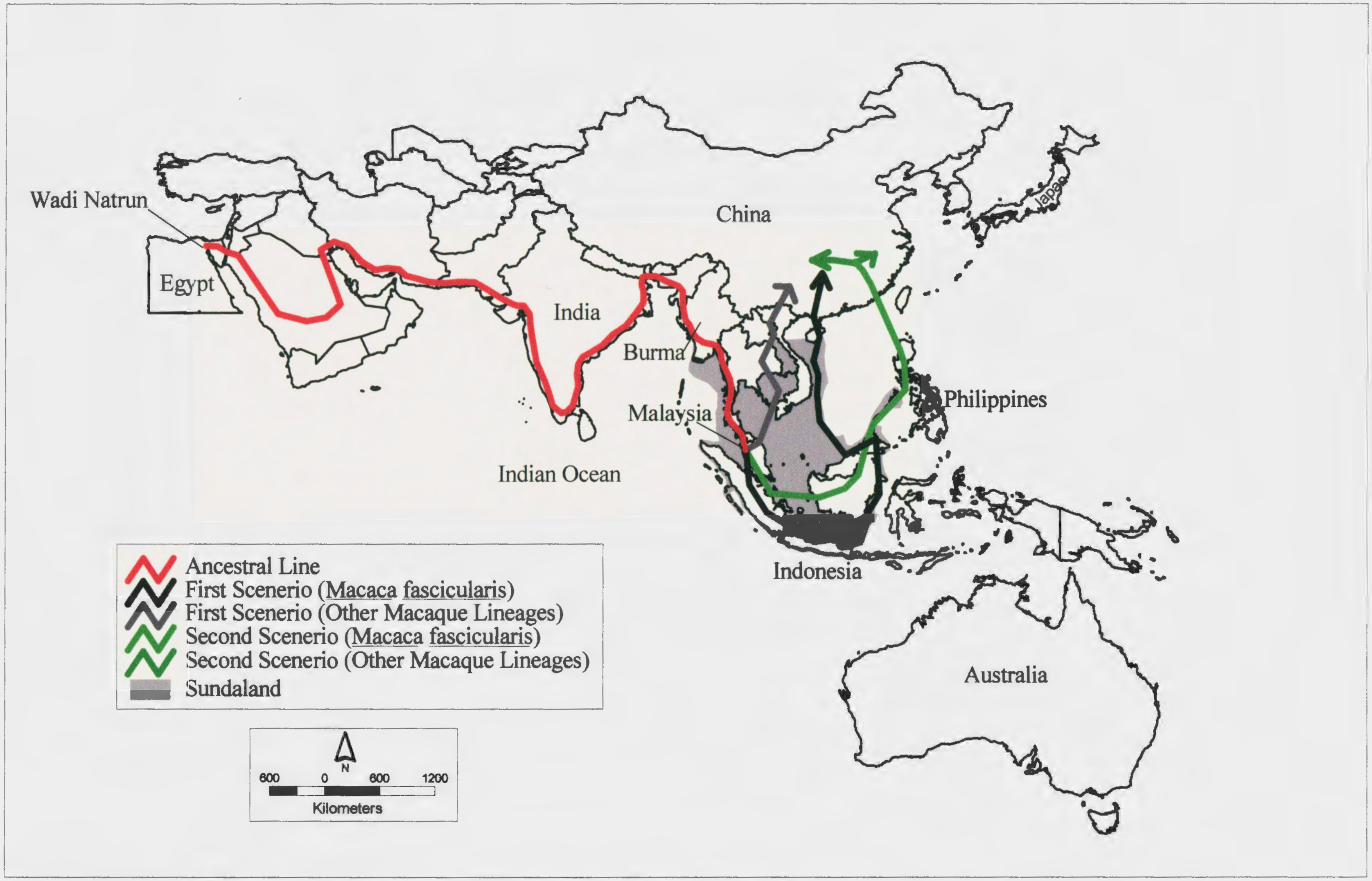

Figure 1: Hypothetical dispersal patterns of Asian macaques (Sundaland adapted from Bellwood 1985, 7)
(Country boundaries adapted from ESRI Data, World APR File, 1998).

Sundaland. Utilizing a land bridge extension into the Philippines, they then radiated onto the Asian mainland. Once on the Asian mainland, new lineages of macaques appeared from the ancestral populations of *Macaca fascicularis* (Eudey 1980, 67-69).

Either way, the relative success of long-tailed macaques, despite rapid environmental fluctuations during the late Pleistocene that almost entirely eliminated the tropical zone from China, has been attributed to several factors. These factors include their ability to exploit a wide variety of plant foods, short gestation times, short interbirth intervals, and smaller brains that required less metabolic demand (Jablonski 1998, 30-36). Paleontologists have also speculated that the long tail of *Macaca fascicularis*, which that it is primarily utilized for balance in arboreal environments, is a morphological trait indicating that the preferred habitat of *Macaca fascicularis* is tropical forests. However, the long tail of *Macaca fascicularis* may have also played a role in their ability to survive Pleistocene environmental conditions by allowing them to disperse along riverine forest corridors (Eudey 1980, 67-68).

LONG-TAILED MACAQUE ECOLOGY

Today, long-tailed macaques are distributed throughout all of Southeast Asia between 21° north and 10° south latitude, and between 92° and 26° east longitude (see Figure 2: Approximate distribution of long-tailed macaques) (Fooden 1995, 1). The results of a long-term *Macaca fascicularis* study conducted on the island of Sumatra, Indonesia, concluded that the core range of long-tailed macaque troops is between 25 and 100 hectares (Crockett and Wilson 1980, 168). The results of a study on genetic variations between troops of long-tailed macaques in Southeast Asia indicated that

Figure 2: Approximate distribution of Long-tailed macaques (Distribution adapted from Wheatley 1999, 9) (Country boundaries adapted from ESRI Data, World APR File, 1998).

males act as the units of gene flow between troops (Kawamoto, Ischak, and Supriatna 1984, 131-159). Several long-tailed macaque behavioral studies, conducted in the 1980s, indicate that long-tailed macaques tend to range no more than a few hundred meters inland from rivers (Crockett and Wilson 1980, 164, Eudey 1980, 69).

CHAPTER III

BALI'S PHYSICAL SETTING(S)

LOCATION

Bali is part of the Indonesian archipelago, which contains 17,000 islands (see Figure 3: Geographic location of The Republic of Indonesia). The Indonesian archipelago stretches from Sumatra in the northwest to Papua in the southeast (see Figure 4: The Republic of Indonesia) (Wheatley 1999, 7). Bali, with a land area of 5,560 square kilometers, is a relatively small island located midway along the archipelago (Whitten, Soeriaatmadja, and Afiff 1996, 5).

GEOLOGY AND TOPOGRAPHY

Bali is geologically young, having begun its formation approximately 3 million years ago (during the Pliocene) (Whitten, Soeriaatmadja, and Afiff 1996, 88). A line of volcanoes stretches across Bali from east to west. Several of Bali's volcanic peaks are over 2,000 meters tall and Gunung (Mount) Agung is over 3,000 meters tall (see Figure 5: Bali) (Lyon and Wheeler 1997, 16). Today, Gunung Agung and Gunung Batur remain volcanically active due to the continued northward subduction of the bed of the Indian Ocean (see Figure 6: The Indonesian Volcanic Arc) (Bellwood 1985, 5).

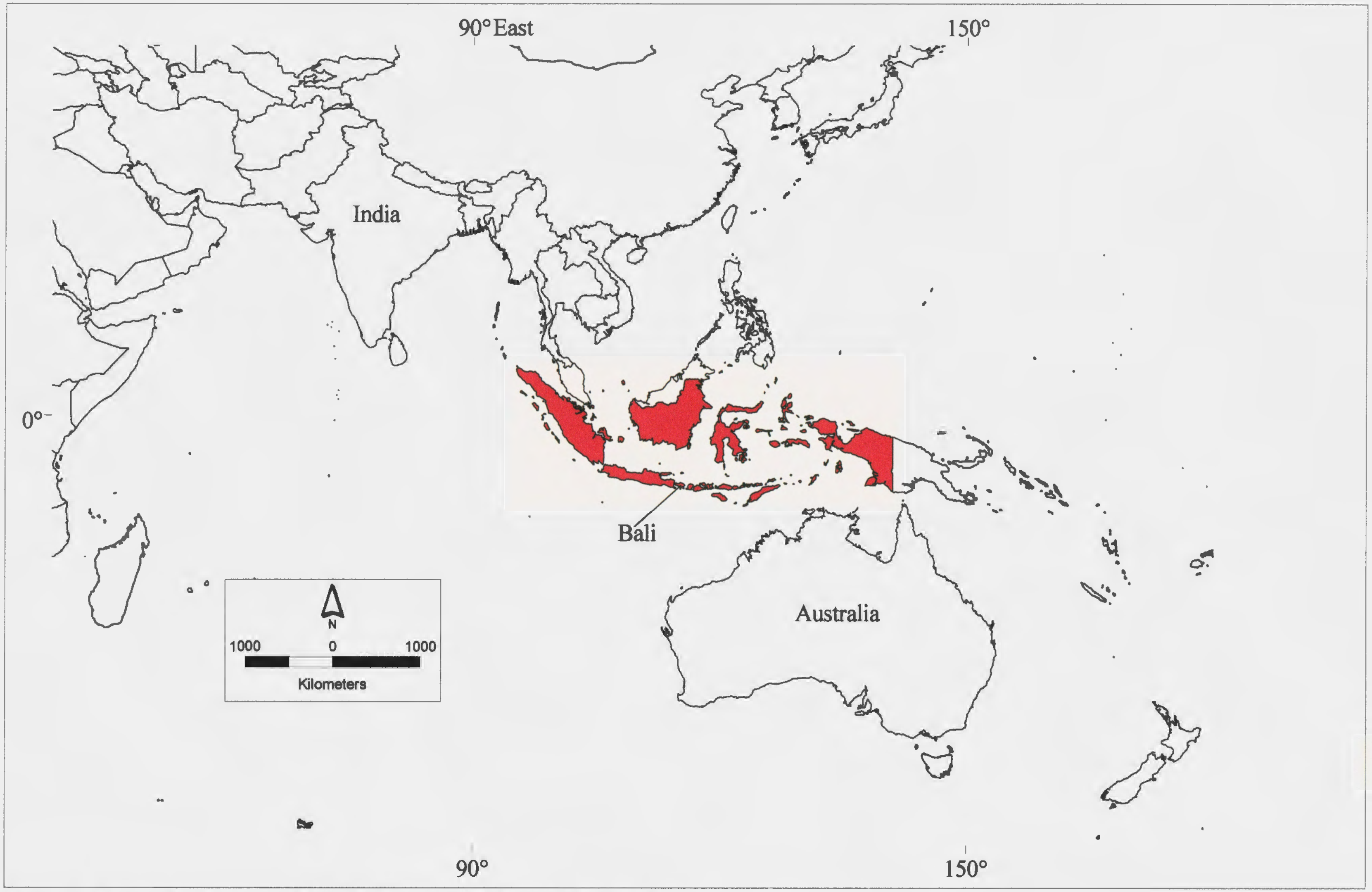

Figure 3: Geographic location of The Republic of Indonesia (shown in red).
Adapted from Environmental Systems Research Institute, Inc. (ESRI) data. World APR file, 1998.

Figure 4: The Republic of Indonesia.
Adapted from Environmental Systems Research Institute, Inc. (ESRI) data. World APR file, 1998.

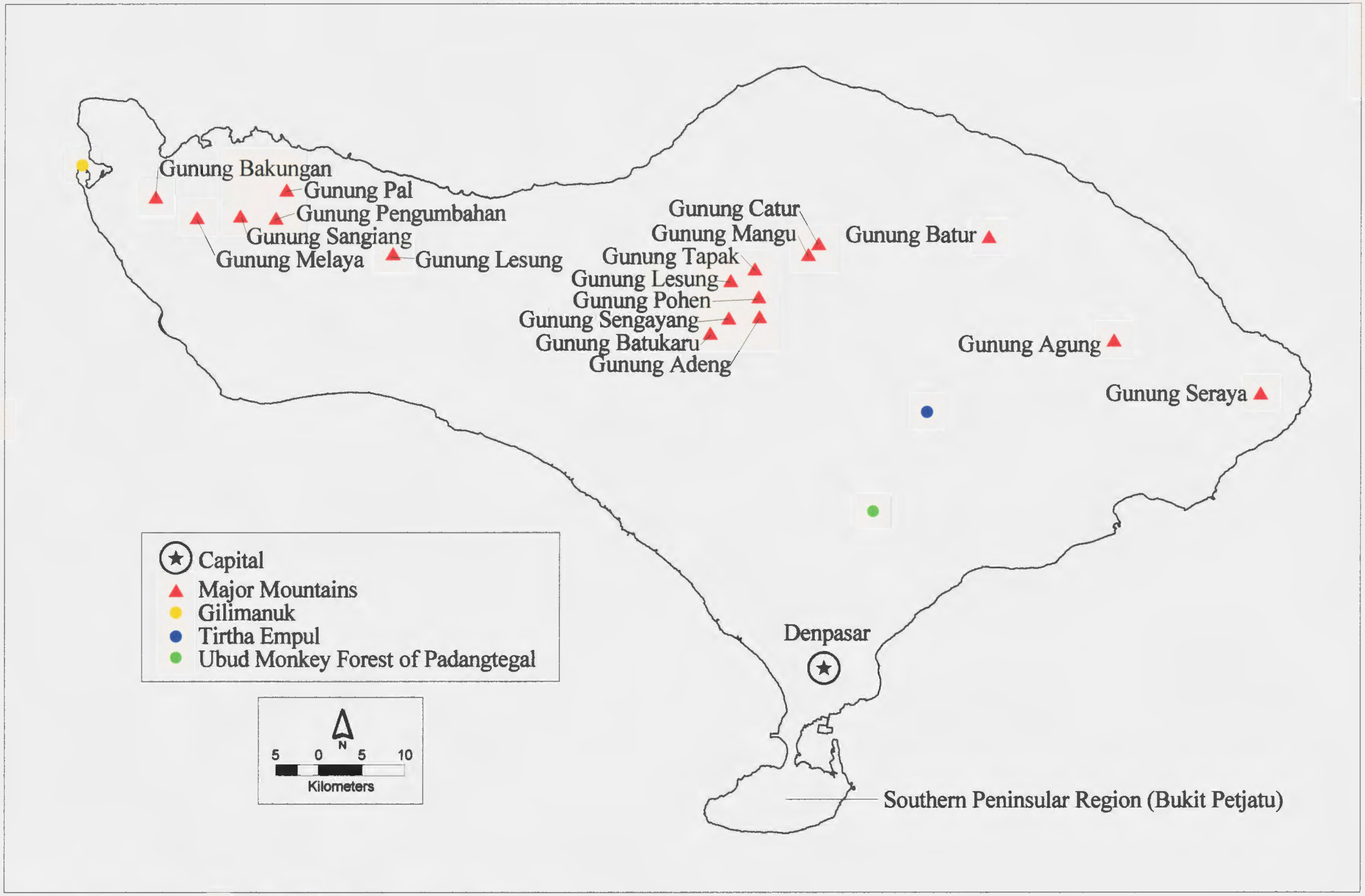

Figure 5: Bali (Adapted from Bakosurtanal 1:25000 maps).

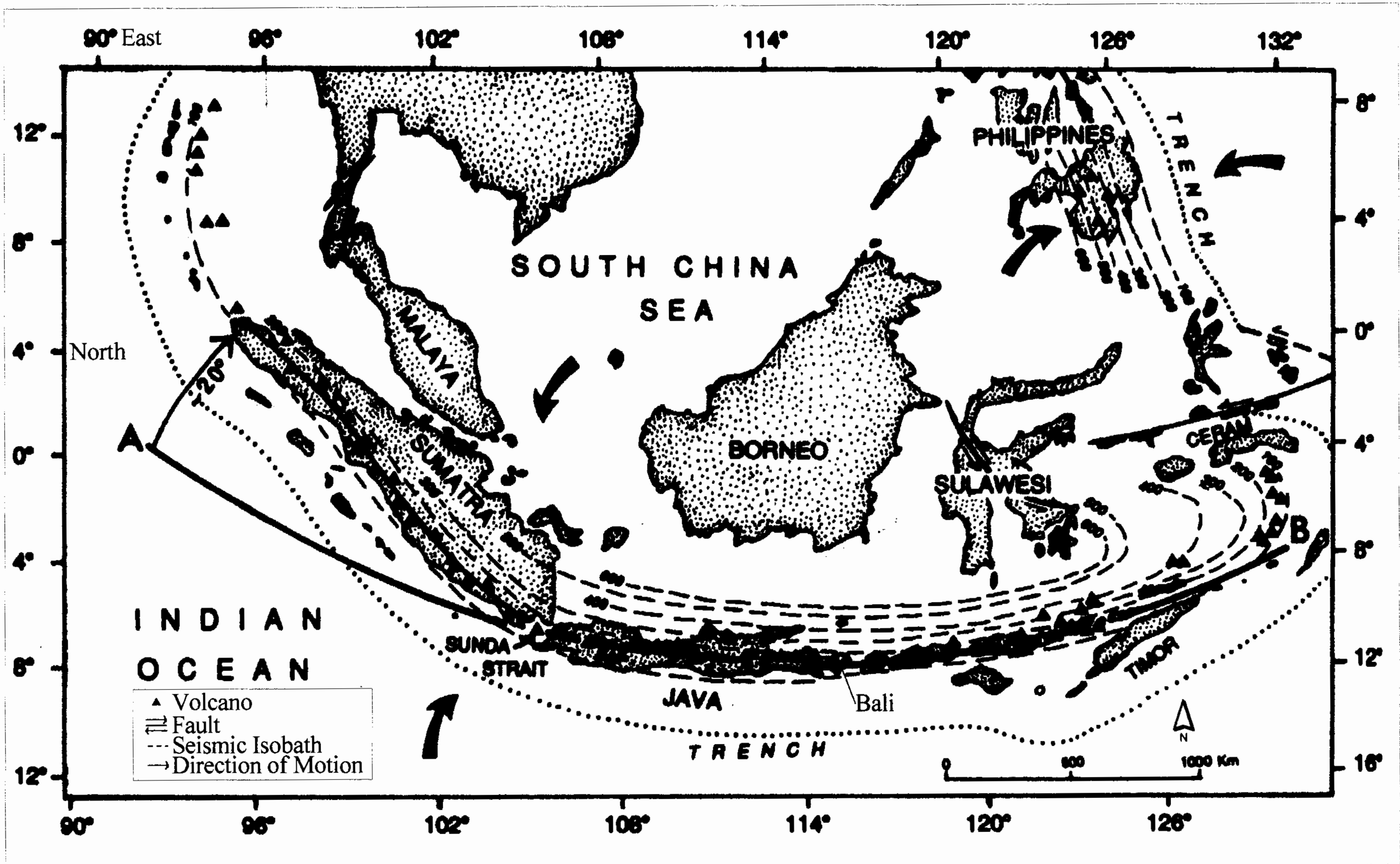

Figure 6: The Indonesian Volcanic Arc (Adapted from Thorton 1996, 42).

CLIMATE

Because Bali is located close to the equator and is surrounded by water, its average temperature stays close to 30° Celsius (mid-80s Fahrenheit) year round (Lyon and Wheeler 1997, 17). Rainfall patterns are highly variable throughout Bali because of seasonal shifts in wind direction and due to Bali's variable relief (see Figure 7a: Seasonal wind patterns and Figure 7b: Bali's annual rainfall patterns). From approximately April through September, Bali receives southeasterly winds. These winds originate out of a high pressure system in the Australian desert and are relatively dry. Prior to reaching Bali, these winds pick up some moisture as they pass over the Indian Ocean. Once these winds reach Bali, they are forced to uplift because of Bali's central mountain chain. As a result of orographic uplift and cooling of the air, mean annual rainfall levels at the summits of Bali's mountains can reach as high as 4,000 millimeters. The majority of Bali's southern tablelands receive a mean annual rainfall of between 1,500 and 2,000 millimeters. The major exception is Bali's southern peninsular region, which has a mean annual rainfall of less then 1,500 millimeters. Regions both north and west of Bali's central mountain chain are very dry during this time, because of the rain-shadow effect. However, this trend reverses during the other part of the year (between the months of October through March) as the prevailing winds shift to the northwesterly (resulting from a high pressure over the Asian mainland) (Kuipers 1993, 74-78, Lyon and Wheeler 1997, 17, Whitten, Soeriaatmadja, and Afiff 1996, 122-125).

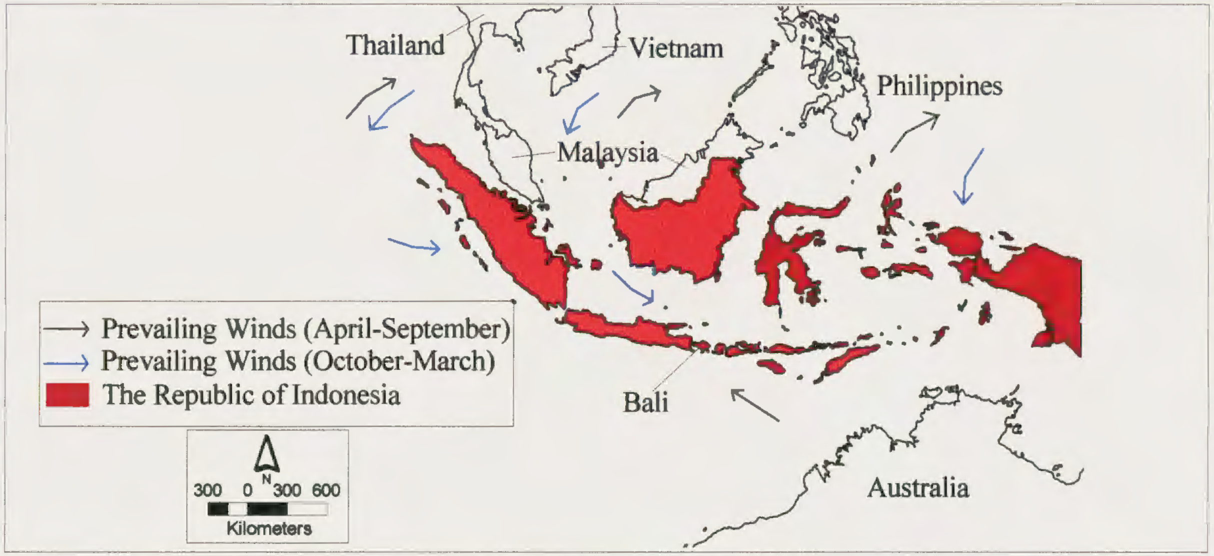

Figure 7a: Seasonal wind patterns (Adapted from National Geographic Society 1996 map of Indonesia) (Country boundaries adapted from ESRI Data, World APR File, 1998).

Figure 7b: Bali's annual rainfall patterns (Adapted from Whitten, Soeriaatmadja, and Afiff 1996, 122-123).

FLORA

Due to diverse rainfall patterns, Bali is rich in terms of floral species. Some of Bali's vegetative formation classes include: evergreen rain forest; semi-evergreen rain forest; moist deciduous forest; dry-deciduous forest; aseasonal montane forest; seasonal montane forest; mangrove forest; swamp forest; dry-evergreen forest; and thorn forest (Whitten, Soeriaatmadja, and Afiff 1996, 190-191).

FAUNA

Because Bali is geologically young, most of its living things have migrated from elsewhere (Lyon and Wheeler 1997, 18). During the Pleistocene, many animals migrated onto Sundaland and found favorable conditions in the lower latitudes for survival. Some examples of animals which migrated across the Pleistocene Sundaland bridge include: rhinoceros that may have originated in Europe; elephant and hippopotamus whose ancestors may have evolved in Africa; tapir, which today are known outside this region only in South and Central America; and tigers that may have migrated from grasslands north of China (Griffiths 1990, 10). As previously discussed, long-tailed macaques are also believed to have arrived on Bali having migrated across the Pleistocene Sundaland bridge.

HUMAN IMPACTS ON BALI'S LANDSCAPE

Human fossil remains dating to 1.8 million years ago have been found on the island of Java (see Figure 4) (Poirier and McKee 1999, 225). Humans are also thought to have migrated across Sundaland, at least 50,000 years ago, to inhabit both Australia and Papua (see Figure 4) (Lansing 1995, 11). However, Bali was probably not extensively inhabited by humans until after the end of the ice age when Austronesians emigrated from what today is Taiwan.

The first extensive human inhabitation of Bali was probably around 2,500 B.C. (Blij 1996, 281). The human impact on Bali's landscape has been one of creating new disturbance regimes. Initially, because of small human population sizes relying on hunting and gathering technology, these disturbances were probably low in relative intensity and frequency. However, as human populations grew, the need to harness new energy resources increased. Eventually, hunting forced many animals, including the Bali tiger, into extinction (Whitten, Soeriaatmadja, and Afiff 1996, 706).

Similarly, the initial disturbances caused by agriculture may have been low. The development of canals for intensive irrigation agriculture probably required the use of metal tools. While the earliest evidence for metal tools on Bali dates to the first millennium A.D, rice specimens have been found dating back approximately 2,660 years. This evidence has led anthropologist Dr. Stephen Lansing to hypothesize that early rice was grown using natural rainfall and swampy areas (Lansing 1995, 13).

Since drainages throughout Bali consist of deep ravines carved into volcanic rock, Dr. Lansing has further hypothesized that Bali's first kingdom developed centered around the spring of Tirtha Empul in south-central Bali (see Figure 5). Later, as the valley became fully occupied with people and cropland, more water was needed for irrigation. The Balinese utilized metallurgy to create implements to clear forests, dig irrigation canals, terrace hillsides, build dams, and radiate outward across the landscape (Lansing 1995, 13-15).

Today, Bali is best described as an island of stark contrasts. The western third of Bali and some of the higher elevations still contain remnants of the dense tropical forests that were found on the island prior to the arrival of humans (Lansing 1995, 10). The south and central portions of Bali support very fertile rice fields and some of the densest human population concentrations in the world. Bali's 1996 population was estimated to be 2,924,400 with an average density of 526 people per square kilometer (Wheatley 1999, 7).

CHAPTER IV

BALI'S CULTURAL SETTING(S)

PRE-HINDU

At the end of the last ice age, as sea levels rose, Taiwan became an island inhabited by human populations that supported themselves by hunting and gathering. Around 8,000 years ago, food crops like rice and millet were domesticated on the Chinese mainland. Colonists brought this agricultural way of life across the sea to Taiwan about 6,000 years ago. Between 3000 B.C. and A.D. 400, Austronesians continued to utilize seafaring to colonize most of the habitable islands of the Pacific (see Figure 8: Stages of Austronesian expansion). The ancestors of the modern Balinese were probably Austronesians who settled on Bali to take advantage of its fertile soils (Lansing 1995, 11-12).

Excavations of archaeological sites at Gilimanuk (see Figure 5) have revealed aspects of pre-Hindu Balinese culture. The pre-Hindu Balinese were familiar with the art of weaving, manufacturing pottery, and metalworking. Although meat from hunting represented an important part of their diet, Bali's fertile volcanic soils and climatic conditions facilitated the development of rice agriculture (Phalgunadi 1991, 6-7). Their religion centered around animism and ancestor worship (Phalgunadi 1991, 8, Slattum 1992, 14). Prosperity was believed to be associated with a relationship that existed between the living and the dead. Therefore, prosperity was something that could only be achieved through intense worship and the obtainment of blessings from ancestors

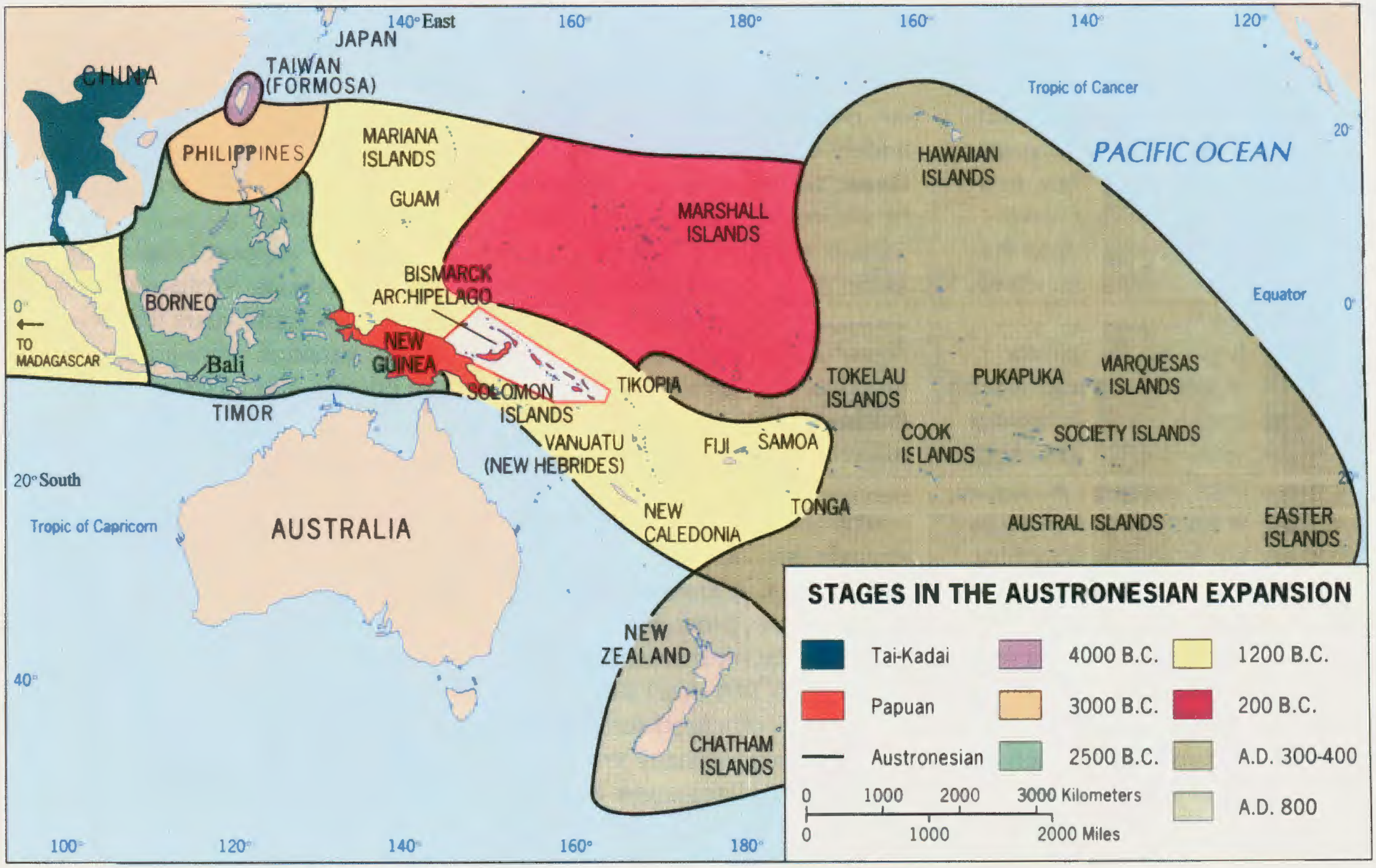

Figure 8: Stages of Austronesian expanansion (Adapted from Blij 1996, 281).

(Phalgunadi 1991, 6-8). Animism represents the belief that inanimate objects and other elements of the natural landscape posses souls, which can help as well as hinder human efforts on Earth (Blij 1996, R-27). Although social divisions existed between common people and the chieftains, who enjoyed high prestige, early Balinese society was semi-democratic and members of the village elected a chief. Society was responsible for the common welfare of the people and customary laws were developed to maintain social order (Phalgunadi 1991, 7).

HINDUISM

Hinduism is believed to have begun, approximately 4,000 years ago, in the region of the Indus Valley located mainly in what today is Pakistan (Blij 1996, 307-309). The fundamental doctrine of Hinduism involves the concept of reincarnation or the transferability of the soul. All living things are believed to be able to take part in reincarnation (Blij 1996, 307-308).

After death, how an individual soul is reincarnated in terms of body or form is determined by a social caste system representing steps on a universal ladder and whether or not the individual had behaved "badly" or "good" in life (Blij 1996, 307-308). By 500 B.C., there were 4 major social castes, or varnas, in Indian Hinduism: the Brahmans (priests), Kshatriya (nobles), Vaisyas (commoners), and Shudras (slaves) (Harries and Norris 1986, 97). Individuals that behaved well could move up the universal ladder, ultimately become united with the Brahmans, and escape the eternal cycle of reincarnation (Blij 1996, 308). Brahmans are believed to be people of intellect and as such are expected to utilize their magic to compel the gods and maintain cosmic order (Hiebert 1982, 291).

While Hinduism had always been highly polytheistic, beginning in the first millennium A.D., 3 major gods emerged that took over the function of some of the local gods. These 3 gods are Brahma (the creator), Siwa (the destroyer), and Wisnu (the preserver) (Harries and Norris 1986, 97).

The dissemination of Hinduism from India, throughout Southeast Asia, was a slow process that began around the third century B.C. As Hindu empires established trade connections with various empires and kingdoms throughout Southeast Asia, Brahmans often times remained with local rulers to serve as advisors (Means 1982, 445). Some of the earliest evidence for Hinduism on Bali dates to the sixth century A.D. (Forman, Mrazek, and Forman 1983, 16). No evidence has been found indicating Bali was ever conquered or colonized by an Indian kingdom. Rather, the evidence suggests that Balinese rulers both adopted and fostered various aspects of the Hindu culture (Lansing 1983, 23).

Around A.D. 1343, Bali was attacked and conquered by the Majapahit Empire. The Majapahit Empire, based in east Java, extended throughout the Indonesian archipelago and into the Malay Peninsula. In A.D. 1389, Majapahit king Hayam Wuruk died and Majapahit power began to recede from Bali. Majapahit power returned to Bali during the fifteenth century A.D., during which time Mohammedans (followers of the Islamic religion) were conquering Java. Bali became a refuge for Majapahit Hindu holy men and nobles trying to escape Java. The last Majapahit prince is believed to have escaped to Bali in A.D. 1478 (Forman, Mrazek, and Forman 1983, 20-22). This arrival of Majapahit holy men and nobles represented a peak in Indic influences on Balinese culture and Hinduism emerged as the primary religion of Bali.

BUDDHISM

Buddhism was founded by Gautama (the Buddha) in northeastern India, around 560 B.C. (Harries and Norris 1986, 97). Like Hinduism, the fundamental doctrine of Buddhism involves reincarnation (Huxley 1968, 30). However, Gautama founded Buddhism primarily as a protest to the Indian caste system (Blij 1996, 310). Gautama taught his followers that humans can be liberated from the ceaseless cycle of reincarnation by abandoning desires that create misery in the world and by removing spiritual ignorance (through meditation) (Huxley 1968, 31).

The diffusion of Buddhism from India was limited until around the third century B.C., during which time the Indian emperor Asoka began promoting Buddhist missionary activities (Harries and Norris 1986, 98). Dr. I Gusti Putu Phalgunadi suggests that Buddhism was a flourishing religion on Bali by the fifth century A.D. (Phalgunadi 1991, 83).

BALINESE HINDUISM

For the Balinese, Hinduism represents more than a faith. It is a way of life that, over many centuries, has shaped Bali's landscape, created social order, and has maintained cosmological balances. Although Hinduism is the primary religion of Bali, it is unlike the Hinduism practiced in other parts of the world today. Balinese Hinduism combines aspects of Hinduism, Buddhism, animism, and ancestor worship.

The Balinese adopted the 4 varna Indian caste system, however, because lower castes outnumber the higher castes by nearly 10 to 1 on Bali, the Balinese caste system is not as rigid as its Indian counterpart (Blij 1996, 309). The Balinese caste system further divides the Brahmana into the Saiwite Brahmana (Brahmana-Siwa) and Buddhist Mahayana Brahmana (Brahmana-Buddha) (Phalgunadi 1991, 79).

The Balinese have maintained Brahma, Siwa, and Wisnu as their 3 primary deities, but unlike Indian Hinduism, Siwa is the supreme Balinese deity. The shapeless form of Paramasiwa (the Almighty God), which is referred to as Sang Hyang Widhi Wasa, represents Siwa (Phalgunadi 1991, 89, Tantrayana 1997, 5). The concept of an Almighty God (Paramasiwa) existed in Balinese Hinduism prior to the arrival of Christian missionaries on Bali, but the Balinese adopted the name Sang Hyang Widhi Wasa as a way of communicating their belief in an Almighty God to Christian missionaries (Tantrayana 1997, 5).

Although reincarnation remains an important part of Balinese Hinduism, it is also believed that the spirits of ancestors and deities can wander the Earth and even inhabit objects. Because these spirits might be capable of doing harm, a number of ritual acts are performed to make sure the spirits are appeased (Kuipers 1993, 93).

Within Balinese Hinduism, the Tri-Hita Karana doctrine states that the Gods blessed life, created nature, and created its contents. This doctrine also states that nature offers subsistence, nourishment, activities, and other needs to human beings. In turn, human beings have an obligation to establish traditional village structure, to build temples in which to worship, to hold various ceremonies, to make daily offerings, to preserve nature, and to discuss and solve problems together. In short, prosperity and happiness are only obtainable when humans respect and observe the 3 harmonious relationships: man and god, man and man, and man and environment (Padangtegal Wanara Wana Foundation 1999).

Combined, there are 3 things that help to guide the Balinese on their spiritual journey towards fulfilling obligations as stated within the Tri-Hita Karana doctrine: Tatwa (philosophy); Susila (etiquette/moral codes); and Upacara (rituals). Out of the Tatwa come the temples dedicated to the deities and ancestors, the belief in reincarnation, and Karma law. Karma law maintains that if a person does something bad to somebody else, negative effects will fall upon the doer. Within Susila are the moral codes that guide good behavior. The Upacara represents a classification of important ritual ceremonies (Access Bali Online 1998).

BALINESE HINDUISM AND BALI'S LANDSCAPE

Today, it is very difficult to describe Bali's landscape without including a discussion of the influences of Balinese Hinduism. Balinese Hinduism and Bali's landscape have existed together for many centuries in a dynamic relationship in which each has acted to shape the other. The two would appear to be inseparable and yet, as previously discussed, they did not always co-exist. At the heart of their relationship are the Balinese who fostered Hinduism and ultimately gave it shape within Bali's landscape. As will be discussed in the following sub-sections, the Balinese have traditionally incorporated Balinese Hindu cosmological beliefs into the building of their villages, family compounds, and even their rice agricultural irrigation system.

A Balinese Hindu Creation Myth

According to an ancient Balinese legend, in the beginning there was nothing. All was emptiness and there was only space. Through meditation the world serpent, Antaboga, created the turtle, Bedawang. On top of Bedawang rest 2 coiled snakes (as the foundation of the world) and a lid (the black stone). In a cave below the black stone there is no sun, no moon, and no night. This is the underworld whose gods are the male Batara Kala and the female Setesuyara. Kala (who lives in the center of the Earth) created the light and Mother Earth over which extends a layer of water. Over this are consecutive domes or skies. The lowest dome is one of mud (which dried to become the earth and the mountains). The middle dome is the sky (atmosphere). Beyond the middle dome, in order, are the: dark (blue) sky, containing both the sun and moon; perfumed sky, which is beautiful, full of rare flowers, and home to both Tjak (a bird) and Taksaka (a serpent); Gringsing Wayang (flaming heaven of the ancestors); and the great gods who keep watch over everything (Covarrubias 1937, 7).

This legend also says that Bali was originally flat. When Java fell to the Mohammedans the disgusted Hindu gods decided to move to Bali. The gods needed to build dwelling places high enough for their exalted rank and so they created 1 mountain for each of the cardinal points. Gunung Agung was erected in the east, Gunung Batur was erected in the north, Gunung Batukaru was erected in the west, and the tablelands of the south were raised to form Bukit Petjatu (see Figure 5) (Covarrubias 1937, 7). Several of the lesser gods emerged from the erupting Gunung Agung and took control of the land and waters of Bali. The goddess, Dewi Danu, took her seat at the second highest mountain (Gunung Batur). Her male counter-part took his seat at the highest and most sacred of mountains (Gunung Agung). As the male and female deities of the highest mountains, these deities form a complementary pair and are the supreme gods of the island (Lansing 1995, 77-78).

Balinese Hinduism and Village Organization

Just as ancient creation stories divided the cosmos into the upper world of the gods (swah), the middle world that humans occupy (bwah), and the lower world beneath the Earth (bhur), the Balinese also apply these same divisions to Bali's landscape. Bali's mountains are referred to as swah, the plains as bwah, and the sea as bhur. The Balinese also refer to "downstream or towards the sea" as "kelod" and "upstream or towards the summit" as "kaja" (Lansing 1995, 22-26).

These cosmological principals also apply to how villages are organized. Temples dedicated to the celestial deities are located on the kaja side of villages in the area called swah, community temples are located in the area called bwah, and temples dedicated to death are located on the kelod side of villages in the area called bhur. Combined, these 3 temples control the sakti (magical energy) that flows through humans (Forman, Mrazek, and Forman 1983, 67).

Balinese Hinduism and Family Compounds

Traditional Balinese homes are built inside walled compounds. A smaller rock wall, or aling aling, is usually built directly inside each compound entrance. An aling aling helps provide some privacy by preventing people passing by a compound entrance from looking directly inside. However, aling alings also serve another purpose. If an individual tries to enter into a compound, they must first enter a main gate and then navigate around an aling aling. Since it is believed that evil spirits have a hard time navigating around corners, an aling aling becomes a line of defense against evil spirits entering into a compound (Lyon and Wheeler 1997, 38).

Traditional Balinese family compounds usually contain a family temple, separate buildings for each bedroom, a shrine, a building that serves as the kitchen, a building that serves as the bathroom, a rice barn, garden areas, and areas to keep livestock (Lyon and Wheeler 1997, 38). Family compounds, like villages, are built based upon cosmological principals. For example, shrines to gods and ancestors are located towards the kaja (upstream or towards the summit) corner of the family compound. In comparison to rice barns, kitchens are usually built more towards the kelod (downstream or towards the sea) side of the family compound. This is because rice is considered to be sacred and eating is believed to be an animalistic act (Lansing 1995, 22-26).

The Balinese Rice Agricultural System

Rice agriculture has remained an important part of Balinese culture. Through extensive research, Dr. Stephen Lansing has been able to show how Bali's rice irrigation system incorporates aspects of Balinese Hinduism. Each cardinal mountain point contains a major temple dedicated to its corresponding deity. For example, Dewi Danu has a temple located at the top of Gunung Batur (see Figure 9: The Balinese rice agricultural irrigation system). The temple at Gunung Batur has 24 permanent priests

Figure 9: The Balinese rice agricultural irrigation system (Figure is not to scale nor based upon a specific canal system on Bali).

that are chosen at birth as lifelong servants of the goddess. A single high priest serves as the earthly representative of Dewi Danu and is believed to have powers that originate from Lake Batur. The high priest controls all the water flowing from Gunung Batur's crater, at the main Temple of the Crater Lake (Lansing 1995, 80-81).

At the headwaters of each river or spring is a temple where people can make offerings to Dewi Danu. A series of weirs divert river or spring water into large irrigation canals. Each weir also has a temple associated with it where farmers can make offerings to Dewi Danu. Following a main irrigation canal, waters are in turn diverted into smaller secondary canals. Located at each secondary canal weir is a temple called Ulun Swi. The Ulun Swi temples are dedicated to making offerings to Ida Bhatara Pura Ulun Swi (Deity of the Ulun Swi Temple). This deity's power is believed to extend over all of the terraces watered by an irrigation canal (Lansing 1995, 85).

Water that is diverted into secondary canals ultimately ends up servicing 1 or more Subaks (Lansing 1995, 80-85). Each sawah (individual rice field) owner must belong to a Subak. Subaks are village associations that organize rice terraces (Lyon and Wheeler 1997, 412). Several Subaks may share a Masceti (regional water temple). Subaks determine how much water each sawah owner will get. A Subak temple is located next to where each Subak receives and distributes water (Lansing 1995, 85).

Finally, at the bottom of Bali's irrigation systems are the sawah. Each sawah contains a field shrine (bedugul) located next to the point where water first enters. Field shrines represent a place where farmers can make offerings to Dewi Sri (the goddess of rice) (Lansing 1995, 85). Because Bali contains many radial drainages and each drainage can support hundreds of rice fields, Bali's landscape is dotted with thousands of temples and shrines that help to regulate agricultural irrigation.

BALINESE HINDUISM AND CULTURAL PRACTICE

It is easy to speculate that rice agriculture would have developed on Bali, to its present day extent, even if the pre-Hindu Balinese had not adopted Hinduism. After all, archaeological evidence indicates that the pre-Hindu Balinese already had an extensive knowledge of how to grow and harvest rice. Expanding rice agriculture, without advanced metallurgy technology, was probably not initially difficult. Bali has many natural springs, marshes, and low-lying drainage areas. Because rice is both a very nutritious and productive crop, any expansion in rice agriculture most certainly reflects that the pre-Hindu Balinese also experienced some population growth. As a result, even without considering draft animals, the development of an adequate labor force was probably not a major limiting factor in the expansion of rice agriculture. While advances in metallurgical technology undoubtedly played a major role in facilitating the expansion of rice agriculture on Bali, this technology's dissemination to Bali was facilitated primarily as a component of trade and predates Balinese Hinduism. The question remains as to why Hinduism became so widely reflected within the Balinese rice agricultural system.

While there are no exact answers to this question, a closer examination of the Balinese rice agricultural system offers some clues. The expansion of rice agriculture on Bali has been controlled primarily by labor, technology, the Balinese, and Bali's carrying capacity. Labor and technology can exist together in combinations that bring to bear varying degrees of energy towards harnessing natural resources. For the most part, the pre-Hindu Balinese could have controlled how energy returns on their agricultural investments were, in turn, re-invested into labor and or technology. What the pre-Hindu Balinese could not control was Bali's carrying capacity. With each labor and technological re-investment into expanding rice agricultural production, there were bound to be some new diminishing returns. Maintaining social order, while expanding rice agriculture, has historically required modifications of Balinese cultural form. As will be discussed in the following chapter, within Balinese history there have been many wars and social uprisings.

It would appear that sawah owners, located at the end of the irrigation system, are powerless. In reality, each temple represents more than just a place where farmers can make offerings to deities. Temples also provide a place where farmers can meet and discuss irrigation problems. If a problem occurs which cannot be worked out between farmers, a priest can be called upon to act as a final arbitrator (Lansing 1995, 81-84). In this sense, when the Balinese adopted and expressed aspects of Indic cultural form, through cultural practices, the Balinese found practical solutions to their growing natural resource and social management problems (See Figure 10: Model of Balinese cultural ecology and historical influences

BALINESE HINDUISM AND BALINESE LONG-TAILED MACAQUES

The Tri-Hita Karana is an especially important part of Balinese Hinduism and it forms a philosophical basis for how the Balinese relate to their environment. Many Balinese villages either incorporated or are surrounded by forested areas. At some of

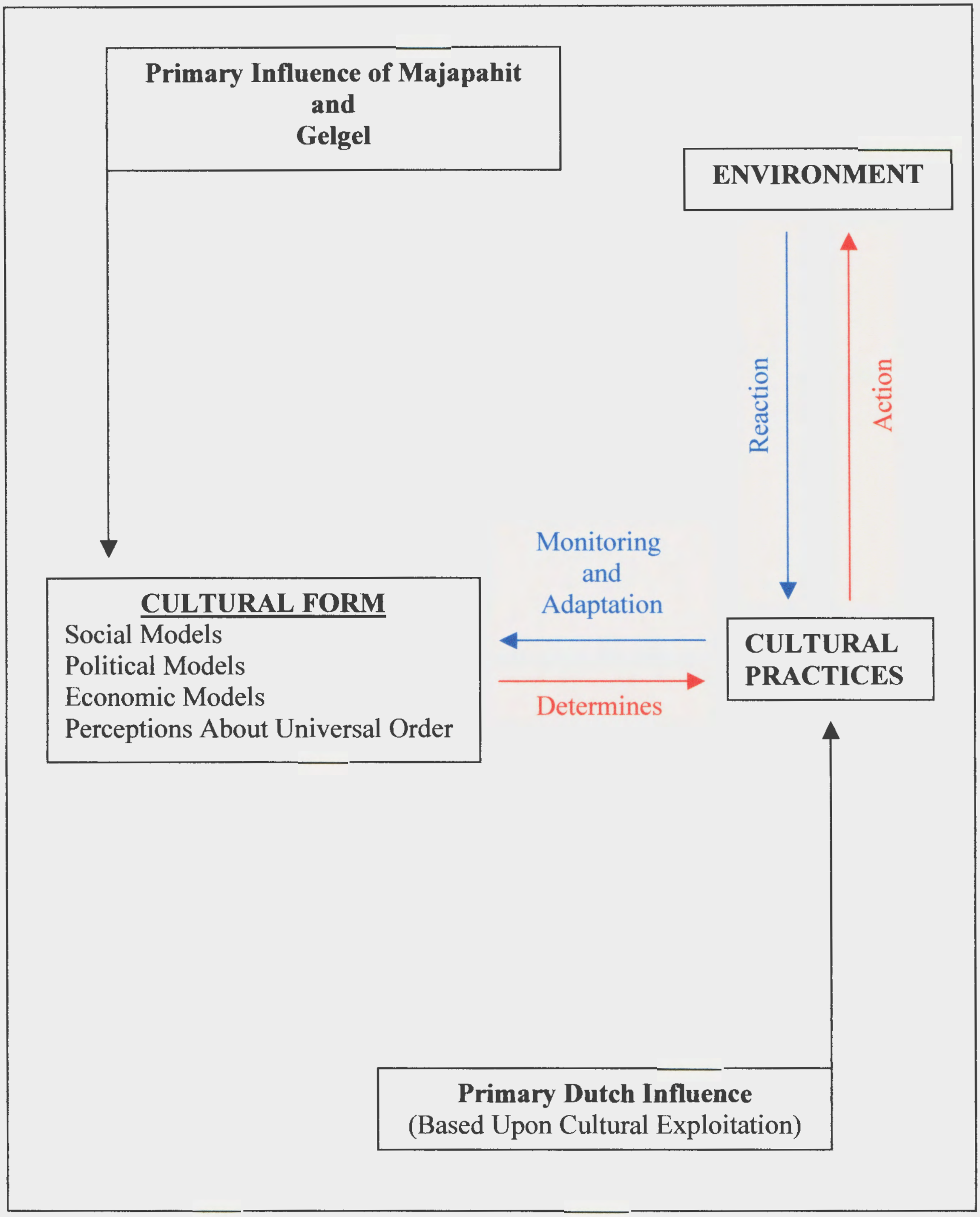

Figure 10: Model of Balinese cultural ecology and historical influences.

these forested sites the sympatric relationship between humans and Balinese long-tailed macaques has become so extensive or has existed over such a long time period that the Balinese refer to them as "monkey forests". Places such as the Ubud Monkey Forest of Padangtegal (see Figure 5) are important to the Balinese because they conserve nature, provide a place for the Balinese to socialize, and provide a place for the observance of religious events.

The Ubud Monkey Forest of Padangtegal is only 11 hectares in size and yet it supports 3 temples, 151 Balinese long-tailed macaques, upwards of 80 species of trees, and numerous other species of both fauna and flora. Special ceremonies, such as the Tumpek Kandang where people make special offerings to long-tailed macaques (and to all animals in general), are held within the Ubud Monkey Forest. Another ceremony is the Tumpek Nguduh, where plants are equally celebrated (Padangtegal Wanara Wana Foundation 1999).

Given the doctrine of the Tri-Hita Karana, it might appear contradictory that Balinese farmers would chase and sometimes even attack long-tailed macaques that are caught in their fields. However, the actions of the Balinese cannot be strictly evaluated based upon a single doctrine. The Balinese believe that for every positive force there is also a negative force. In most western philosophies, good and evil exist in a dichotomous relationship where one side can completely subsume the other. In Balinese Hinduism, it is believed that while ritual acts may be able to tilt the balance between positive and negative forces, neither side can ever truly be eliminated (Slattum 1992, 14). In terms of holistic Balinese Hindu cosmology, long-tailed macaques can be the embodiment of both positive and negative forces. The belief that long-tailed macaques can be negative in nature is reinforced when they raid fields. The belief that long-tailed macaques can be positive in nature is reinforced when they occupy sacred areas. Within Balinese Hindu cosmology monkeys are believed to be capable of guarding sacred sites (such as temple areas). Because of this belief, monkeys that occupy sacred areas are commonly protected and given offerings by the Balinese. Because the Balinese both loathe and revere long-tailed macaques, the Balinese react to them in many different ways (Wheatley 1999, 32-35).

The dual nature of monkeys is especially reflected in a very popular Indian epic poem, the Ramayana, which dates to approximately 1,500 B.C. (Narayan 1977, xi). The Ramayana is portrayed within many different Balinese art mediums, but it is most important within the form of Balinese dances and plays (Covarrubias 1937, 217). The Ramayana is very popular among the Balinese because it contains lessons of morality and characters that are involved in a struggle for power (Slattum 1992, 10-12). In the Ramayana, Rawana (the giant and selfish king of Alengka) abducts the beloved bride of Rama (an incarnation of Wisnu). In Rama's quest to find Sita he goes to the mountainous forest regions of Kiskinda. Kiskinda is ruled by monkeys endowed with extraordinary intelligence, speech, strength, nobility, and also godly parentage (Narayan 1977, 97-98, Slattum 1992, 50-57). Rama calls upon the monkey king Sugriwa to help him find and retrieve Sita. In turn, Sugriwa dispatches his general Hanuman. Hanuman performs miraculous feats of agility and strength to discover where Sita is held. In the end, a great army of monkeys assists Rama in a terrific battle. Hanuman, Sugriwa, and Laksmana (Rama's brother) all battle and defeat Kumbakarna (a very large giant that is the older brother of Rawana). There is also an antagonist monkey, Subali, who is the twin brother of Sugriwa and who is also a good friend of Rawana. Rama ultimately defeats Subali. Millions of monkeys and raksasas (demon followers of King Rawana) are slain before Rawana is killed and Sita is rescued (Covarrubias 1937, 239-241, Slattum 1992, 50-57).

Within the Ramayana, individual characters would appear to be either positive or negative. For example, Sugriwa and Hanuman are good monkeys and Subali is a bad monkey. Rama is a positive character and Rawana is a negative character. The Balinese also see the duality of positive and negative forces as being able to exist within a single individual. In this sense, Rawana might have been a horrible tyrant for abducting Sita, however, in the end he did display some admirable traits by trying to defend his island against Rama's invading army. The same lessons that exist within the Ramayana can also be applied to the gods. There are some gods who are demonic by nature and therefore feared by the Balinese. There are also gods who are mostly revered. However, it is important to remember that all of the gods are ultimately incarnations of the supreme god, Sang Hyang Widhi Wasa, who is the embodiment of both positive and negative forces. Because this duality also applies to individual long-tailed macaques, it is possible for a long-tailed macaque to both receive protection in sacred areas and be chased out of rice fields.

CHAPTER V

THE BALINESE AND GLOBALIZATION

INTRODUCTION

Globalization has been described as being one of the most important challenges facing the world in the twenty-first century. One definition of globalization is that it is: ". . .the increasing interconnectedness of people and places through converging processes of economic, political, and cultural change." (Rowntree et al. 2000, 1).

Ralph Waldo Emerson once said about history: "Time dissipates to shining ether the solid angularity of facts." (Bartlett 1963, 121). The Balinese have been in contact with other cultures for thousands of years, but as the Balinese enter the twenty-first century the lines between what is "real" and what is "ideal" about Bali are greatly blurred. Today, Bali is one of the most popular tourist attractions in the world. Its success within the global tourist economy is due in large part to decades of marketing, which have painted Bali as being a utopian destination where tourists can easily escape the pressures associated with modern life. In this sense, Bali has come to be seen as a sort of antithesis to a world of rapidly evolving and complex globalization problems.

This point of view has become so reinforced within the global psyche that many of Bali's tourists overlook the fact that they are staying in luxury hotels, choosing from a large selection of world cuisines, shopping at malls, and being driven around Bali through congested urban streets. Instead, most tourists pay to see tropical forests, sunny beaches, ancient temples, and the Balinese "happily" laboring in rice fields. As the following quote illustrates, many scholars have played into this conception of Bali by creating analogue models for the Balinese culture which draw direct inferences between the past and present:

> Many a flourishing civilization of the past was eclipsed just because it violated man's balanced relationship with nature. Elsewhere the sad remnants of architecture, of sculpture and sometimes even literature are eloquent testimony to the inexorable logic of cultural decline. In Bali, men fashioned a masterpiece out of such unlikely substance as fertile mud and flowing water, so difficult to control and to maintain. Taken together, the ricefield terraces constitute an exquisite work of art which permanently mirrors the essential harmony between the human mind and nature, a harmony forever created and recreated in a process of never-ending transformation (Forman, Mrazek, and Forman 1983, 107).

While Bali is a place of transformation, as will be discussed in the following sections, its evolution is far from static. There are comparisons which can be drawn between the Bali of today and the Bali of several thousand years ago, although: "Ancient things are not revered in Bali so much as things living, dying, and emerging again – for these are what represent the 'reality of the present' and 'the reality of the past' for the Balinese." (Forman, Mrazek, and Forman 1983, 31).

PRE-FOURTEENTH CENTURY

Up until the early part of the fourteenth century A.D., globalization was probably not a major factor driving the evolution of the Balinese culture. The Balinese did trade extensively with other cultures, but prior to the fourteenth century the Balinese were mostly free to choose what form their culture would take. Supporting this hypothesis is the fact that although the Balinese adopted aspects of Javanese Hinduism, they resisted pressures from pre-fourteenth century ruling Javanese kingdoms to change their political structure towards an aristocracy. Instead, the Balinese continued to elect their council of elders and maintain a political structure that was more socialistic (Vickers 1996, 47).

MAJAPAHIT AND GELGEL

Beginning in the fourteenth century A.D., globalization shifted towards being a major driving force in the evolution of Balinese culture. The Majapahit empire started tilting power away from the Balinese and was willing to directly back up its rule with military action (Forman, Mrazek, and Forman 1983, 20-22). As a result, the Balinese began a transition towards an aristocratic, state-centered society based upon the 4 castes of Hinduism. Village walls were removed and the unity of individual villages was broken into smaller units called "banjar". The council of elders was replaced, in part, by a king-appointed head for each banjar and the power to make decisions about the form of Balinese culture was taken over primarily by an aristocratic class to which very few Balinese could belong (Vickers 1996, 46-48). Balinese rulers began rewriting their family genealogies in an attempt to obtain higher positions within the Majapahit political structure and new stories were written which equated the creation of Bali with the arrival of Majapahit (Forman, Mrazek, and Forman 1983, 22-23). The resurgence of Hinduism, through the building of temples and royal courts, must have become a constant reminder to the Balinese that they not only existed within a much larger cosmological order, but they also existed within a much larger political order as well.

Although Majapahit had a strong influence on shaping Balinese culture, around A.D. 1520, Majapahit disappeared as an entity and was replaced by a new centralized Balinese kingdom called Gelgel. In terms of its influence on shaping Balinese culture, Gelgel was in many ways an extension of Majapahit (Vickers 1996, 46).

Today, most Balinese do not associate the kingdoms of Majapahit and Gelgel as having been suppressive to the further development of traditional Balinese culture.

Rather, these kingdoms are associated as having given rise to traditional Balinese culture (Forman, Mrazek, and Forman 1983, 23). One reason for this perception might be that there are very few living representatives of the Bali Aga (original indigenous Balinese) and maintenance of a culture lifestyle similar to that which had been prominent prior to the arrival of Majapahit (Lansing 1983, 113). Another reason why the Balinese might consider the kingdoms of Majapahit and Gelgel to be so important for having given rise to traditional Balinese culture has to do with art. Art has been an important part of Balinese culture dating to pre-Hindu times. Although Majapahit rule removed walls from around Balinese villages, the Balinese continued to gather and express their collective village identity through works of art. Majapahit facilitated this trend by introducing several new art styles to the Balinese (such as shadow play-puppets and gamelan music). In this sense: "The Javanese conquest was absorbed, and turned into a powerful manifestation of classical Balinese culture." (Forman, Mrazek, and Forman 1983, 23). Today, each Balinese village strives to have its own gamelan orchestra, dance troupe, painters, sculptors, and so on (Wheatley 1999, 12). Yet, another reason why the Balinese may consider Majapahit and Gelgel to be important for having given rise to traditional Balinese culture has to do with rice agriculture. Around the time Majapahit conquered Bali, there is a strong likelihood that traditional Balinese cultural systems (with their focus on maintaining village autonomy) were unable to cope with growing regional resource management problems. Under Majapahit state control, appointed representatives of the Majapahit kings (sedahan agung) supervised Balinese rice agriculture production. The duties of the sedahan agung (along with his deputies) included collecting taxes, keeping a constant watch over the subaks to make sure that they did not encroach upon one another, and acting as a final arbitrator (by passing down a ruling on behalf of the king) in cases where disputes did occur between subaks (Forman, Mrazek, and Forman 1983, 78-79). In this sense Majapahit, by changing the form of Balinese culture (see Figure 10), provided the Balinese with a system that allowed rice agriculture to expand. Today, the Majapahit cultural model still provides the Balinese with a central framework for handling both social and resource management problems.

The form that Balinese culture took, based upon Majapahit and Gelgel influences, was not without flaws. Majapahit and Gelgel allowed the Balinese to develop their rice agriculture system to new levels of complexity by bringing autonomous villages together. This increased complexity was built upon a foundation of lower caste Balinese who became removed from political power. This was not the case prior to the arrival of Majapahit since village members had a vote in electing their council of elders. With a large percentage of Balinese removed from political power, some form of rebellion was almost inevitable. During the 1500s, there were 2 rebellions. A third rebellion brought an end to the kingdom of Gelgel in 1651 (Vickers 1996, 52-53).

With the fall of Gelgel, the Balinese were left in a power vacuum. The Balinese had passed the point of being able to return to a strictly village level political system. Everything from when rice should be planted to how water should be allocated had become influenced by Majapahit and Gelgel cultural systems. What emerged from this power vacuum was a Bali divided between multiple kingdoms. Although each kingdom maintained a structure based upon Majapahit and Gelgel influences, Bali's political landscape was very unstable and feuds between kingdoms were common.

THE DUTCH

Conquering of Bali

The Dutch first arrived on Bali in 1597. By the early 1600s, Bali was part of a Dutch trading empire that stretched from the tip of South Africa to Japan. Initially, the Dutch wanted very little to do with Bali other than to capitalize on the Balinese supply of spices, slaves, and rice. Bali's many aspiring kings soon realized that Dutch power could either make or break the development of a new Balinese kingdom. By trading with the Dutch, an aspiring Balinese king could obtain enough funding to support the formation of a new kingdom. On the other hand, the Dutch could also cripple a Balinese kingdom by enforcing an embargo on anybody that did not want to trade (Vickers 1996, 12-17). Through the process of trade, the Dutch played a major role in the fall of Gelgel in 1651.

It was not long before the Dutch set out to destroy the many Balinese kingdoms that they had, in part, helped to build. In 1841, a Dutch ship wrecked on the coast of Bali. A Balinese king declared that the ship was a gift to him from the gods and refused salvage requests from the Dutch. The Dutch decided to punish the Balinese and, in 1846, they launched the first of thousands of troops to Bali. Between 1846 and 1908, the Dutch systematically subjugated Bali's 9 kingdoms (Forman, Mrazek, and Forman 1983, 28-30). In the end, Dutch military strength only played a minor role in the fall of Bali's kingdoms. Dutch attempts to expand their stronghold on Bali, beyond the northern coast of Bali, were met with stiff Balinese military resistance. Although many of the Dutch military campaigns against the Balinese ended in Dutch defeat, self-preservation on the part of individual Balinese kings ultimately prevented the formation of a state action against the Dutch. With wars constantly occurring between Bali's kingdoms, some kings decided that it would be in their best political interest to form an alliance with the Dutch. In return for signing a treaty, the Dutch supplied some of Bali's kings with technology, continued access to trade, and military aid against enemy Balinese kingdoms (Covarrubias 1937, 29, Vickers 1996, 73-74).

By 1906, there were only 2 remaining Balinese kingdoms that had not fallen under Dutch rule. In September of 1906, the Dutch launched a large military campaign against the Balinese kingdom of Badung. Instead of surrendering to the Dutch, the Balinese at the royal palace of Badung decided to commit puputan (fight to the death). More than 3,500 Balinese marched into Dutch gunfire and were massacred. In 1908, the Dutch launched another military campaign against the last remaining independent Balinese kingdom of Klungkung. The Balinese were defeated in a final puputan and the Dutch took complete control of Bali (Forman, Mrazek, and Forman 1983, 30-31). The Dutch would continue to rule Bali until the beginning of World War II when the Japanese invaded the island (Lyon and Wheeler 1997, 15).

Capitalism

After the 1908 puputan, the Dutch began to look at Bali as a place that was fragile and in need of protection/preservation from the outside world (Vickers 1996, 93). Ironically, the marketing of Bali, as a tourist destination, became one of the biggest legacies of Dutch rule over Bali. The Dutch first began transporting tourists to Bali on their Netherlands Packet Steam Ship Line (KPM line) in 1914 (Picard 1996, 23, Vickers 1996, 91). The number of tourists arriving on Bali, in 1924, was 213 (Picard 1996, 25). The development of Dutch policies that would further their own economic interests, under the auspices of preserving the Balinese culture, was a common theme throughout the 34 years the Dutch ruled Bali (Vickers 1996, 9).

Miguel Covarrubias, author of the book Island of Bali, first arrived as a tourist on Bali in 1930 (Covarrubias 1937, xvii). Today, Covarrubias's book is considered by many Balinese as providing one of the best-written accounts of traditional Balinese culture. However, Covarrubias was also very concerned about the influences Dutch rule appeared to be having on Balinese culture.

> Undoubtedly Bali will soon enough be "spoiled" for those fastidious travelers who abhor all that which they bring with them. . . . But even when all the Balinese will have learned to wear shirts, to beg, lie, steal, and prostitute themselves to satisfy new needs, the tourists will continue to come to Bali to see the sights, snapping pictures frantically, dashing from temple to temple, back to hotel for meals, and on to watch rites and dances staged for them. The Balinese will be, to the tourists, guides, chauffeurs, and bellboys to be tipped, dancers on salary, curio-dealers, and tropical beauties to be photographed blouseless for fee (Covarrubias 1937, 393-394).

Covarrubias's implication that prior to the arrival of tourism a form that created a greater degree of social stability was driving the Balinese culture is very interesting. In a later paragraph, Covarrubias appears to elaborate from where that traditional cultural form might stem:

> Perhaps of even greater importance than the fascinating artistic development, and, in all probability, the factor that motivated the artistic impulses of the population, is the unique manner in which they solved their social and economic problems. Bali presents the amazing spectacle of a compact nation of over one million hard-working, cultured people living in a deeply-rooted, well-co-

> ordinated form of agrarian socialism, that has, perhaps because of its elemental directness, until recently, minimized the social and economic evils that today afflict the less fortunate rest of the world. The primitive Balinese socialism flourished parallel to mediaeval feudalism despite five centuries of domination by an aristocracy that with all its ruthlessness could not break down the inherent unity and co-operativism of the Balinese communities (Covarrubias 1937, 400).

Covarubias's point of view appears to overlook the fact that Majapahit and Gelgel had a major influence and, according to many Balinese, a positive influence on shaping the Balinese culture. In historical retrospect, Covarrubias's point of view might also be considered inaccurate because it underestimated the potential of the Balinese to adapt tourism into their traditional cultural paradigms. In other words, just as the Balinese absorbed the Javanese conquest and turned it into a powerful manifestation of classical Balinese culture, Covarrubias failed to predict that the Balinese would absorb tourism and also turn it into a manifestation of classical Balinese culture. Nevertheless, Covarrubias's writings provide a unique framework for understanding issues and conflicts that surrounded the evolution of the Balinese culture as it entered into the modern phase of globalization.

Prior to the arrival of the Dutch, individual Balinese did accumulate wealth. Capitalizing on trade was, however, for the most part a birthright reserved for upper caste Balinese. King Dalam Baturenggong's palace of Gelgel was a prime example. The palace of Gelgel is said to have had Chinese porcelain plates, all kinds of animals, gold-covered doors, high outer walls, and plenty of slaves (Vickers 1996, 43). Through their exploitation of the Balinese, the Dutch introduced a new form of capitalism to the Balinese. That is, a form of capitalism that was open to all Balinese simply by taking part in Bali's tourism economy.

The Development of Anti-Dutch Sentiments

Sukarno founded the Indonesian Nationalist Association (which later became the anti-Dutch Indonesian Nationalist Party-PNI) in 1927 (Seekins 1983, 36). As the following quote points out, Sukarno founded the Indonesian Nationalist Party with tradition in mind:

> Sukarno argued that once what he termed the golden bridge of independence had been crossed, there were two possible roads: one would lead to the establishment of an Indonesian capitalism with its own brand of exploitation based upon selfish, individualistic interests; the other would lead to a classless Marhaenist society. The economic basis of the latter would be socialism, but socialism expressed through the traditional Indonesian concept of mutual aid, such as was traditionally found in Javanese villages. . . . Harmony, rather than the conflict of individuals and groups within a Western-style parliamentary context, would be emphasized (Seekins 1983, 37-38).

For Balinese PNI members, the PNI movement was a call for the return of a Bali that would once again be united under a central authority. In contrast to pro-Dutch Balinese (mostly rajas that wanted to maintain some form of the political power they had gained under Dutch rule), the nationalists wanted the Balinese caste system to be rebuilt so that it would once again facilitate social unity and not be abused by a few aristocrats. Under Dutch rule, rajas, especially those that had historically cooperated with the Dutch, were allowed to reclaim their political status (Covarrubias 1937, 37). However, the Dutch maintained tight control over the rajas and through the rajas imposed village work requirements that would further Dutch economic interests (Lyon and Wheeler 1997, 14-15).

Balinese PNI members were somewhat divided on the issue of how much the Balinese should look into the past in order to build a new future. Some nationalists called for the Balinese caste system to be totally abandoned and others simply wanted it to be toned down so that a greater degree of social and economic equality could be created (Penders 1974, 112, Vickers 1996, 157-158). Balinese PNI members that called for the total abandonment of the caste system, in light of Sukarno's vision for Indonesia's political future, probably adhered more strictly to the original or fundamental doctrines of the PNI movement. Given that socialism had never really flourished on Bali, beyond the level of individual villages, the call for Bali to become united under socialism was simultaneously both traditional and yet radical at the same time. Balinese PNI members that called for the Balinese caste system to be toned down might have been considered to be somewhat more pro-Dutch. However, given the historical importance of the Balinese caste system in maintaining social order on Bali, either PNI movement can equally be seen as being about political reform within a traditional Balinese cultural renaissance paradigm.

WORLD WAR II AND THE JAPANESE

World War II ushered in the modern phase of globalization. Nations were jockeying to find alliances that would bolster their economic and political future. The two major themes that emerged were East versus West and the Soviet Union versus the United States.

Bali, at the end of World War II, was a place of economic and social hardship. Bali's economy had been destroyed by years of natural disasters, Dutch abuse, and wartime deprivation. Circumstances dictated that the best course for the Balinese would be to find a way of moving forward collectively. However, the Balinese were deeply divided on the issue of what direction to take politically. The Japanese occupation of

Bali during World War II had done very little to quell Balinese political unrest. The Japanese torture of many Dutch sympathizers (mostly aristocratic Balinese) bolstered the sentiments of the PNI members on Bali (Vickers 1996, 156)

SUKARNO AND INDONESIAN INDEPENDENCE

On August 17, 1945, under the leadership of Sukarno, Indonesia declared itself an independent nation (Lyon and Wheeler 1997, 14-15). On June 1, 1945, prior to declaring Indonesia an independent nation, Sukarno gave an address in which he described his 5 principals (pancasila) that would guide Indonesia as an independent nation: belief in one god; humanitarianism; national unity; democracy; and social justice (Seekins 1983, 41-42). Within weeks after declaring Indonesia an independent nation, Sukarno's dream of a united Indonesia was already being tested.

In September of 1945, allied troops landed on Java to reclaim Indonesia from the Japanese. Many Indonesians saw the allied landing as the start of a plot to return Indonesia to the Dutch. Indonesian nationalists went to war with the allied forces and, in October of 1945, Sukarno was forced to step down as provisional president of Indonesia because both the allied forces and the Indonesian Nationalist Party members did not trust him. The allied forces distrusted Sukarno as a possible collaborator with the Indonesian Nationalists. The Indonesian Nationalists distrusted Sukarno for not doing more to prevent the landing of the allied forces on Java (Penders 1974, 102-106, Seekins 1983, 42-43).

Over the next 4 years, the Dutch instigated additional political instability throughout Indonesia in an attempt to regain their pre-World War II control (Worldmark

Encyclopedia of the Nations: Asia and Oceania 1995). The Dutch activities sparked many violent clashes between both pro-Dutch and anti-Dutch Indonesian political forces. In 1948, the Dutch launched a military action (the Second Police Action) that almost crushed Indonesia's republican government (Vickers 1996, 161). These Dutch efforts were quelled when, on January 1, 1949, the United Nations stepped in and demanded that the Dutch recognize a reinstatement of Indonesia's republican government. After a series of negotiations, Indonesia's republican government was officially declared to be sovereign on December 27, 1949 (Seekins 1983, 44-45).

In a provisional constitution adopted by Indonesia's legislature on August 14, 1950, Sukarno was declared president of the newly formed Republic of Indonesia (Seekins 1993, 47). Although the Balinese had officially broken away from decades of Dutch rule, most Balinese were left wondering what their freedom really meant. The Dutch policy of preserving Balinese culture taught the Balinese that they should try to look inward when attempting to solve problems. With the ether of Dutch rule finally beginning to lift off Bali, the Balinese were left staring into reality. Their attempts at solving growing economic and social problems through a renaissance of traditional Balinese cultural forms and practices had simply not worked. Every time the Balinese tried to revisit their cultural past to build a better economic and social future, the issue of caste would ultimately emerge as a reminder that the Balinese were divided along both economic and social lines. Pressures had been growing for many years and something had to give. By uniting with the rest of Indonesia and integrating into the main stream of globalization, the Balinese had much to gain. Trade could once again rejuvenate Bali's economy and bring back social harmony. In contrast, with Sukarno as the president of the Republic of Indonesia, it became obvious that the Balinese also had a lot that they could lose.

In Indonesia's first general election, held on September 29, 1955, 5 major parties took seats within the Republic of Indonesia's legislature. These parties included the Indonesian Nationalist Party (PNI), Masyumi, the Muslim Scholars League (NU), the Indonesian Communist Party (PKI), and the Indonesian Socialist Party (PSI) (Seekins 1983, 47). Political tensions were very high throughout the Indonesian archipelago. While two thirds of Indonesia's population was on the island of Java, much of Indonesia's wealth was located on outer islands. With Sukarno as president, large sums of government revenue began being spent on Java. Indonesian's living on outer islands resented this and started staging coup attempts (Worldmark Encyclopedia of the Nations: Asia and Oceania 1995). By 1956, Sukarno had decided that Indonesia's parliamentary system was no longer working and introduced the concept of Guided Democracy (Seekins 1993, 49).

Working under a coalition of central military command and the PKI, Sukarno was able to crush political opposition and establish himself as an authoritarian leader (Seekins 1983, 48). After a 1958 coup attempt by Permesta rebels on the island of Sulawesi (see Figure 4), Sukarno discovered that the United States had been supplying aid to Indonesia's rebels. After 1958, Sukarno began developing a closer relationship with the People's Republic of China and the Soviet Union (Seekins 1993, 50-51). In 1959, Sukarno dissolved the old House of Representatives and, in 1960, a new government-appointed House of Representatives was created. Both the Masyumi and

PSI political parties were banned for their failure to recognize Guided Democracy (Seekins 1983, 49).

During the 1960s, Indonesia's economy was in a shambles. Sukarno, however, continued to support the building of expensive monuments and public buildings on Java. In 1966, Indonesia's earnings from exports were exceeded by over $100 million (U.S.) in debt obligations (Seekins 1983, 55). Indonesia's total foreign debt, at this time, was $2.3 billion (U.S.). Almost one billion of that was owed to the Soviet Union and East European allies (mostly for arms purchases) (Seekins 1993, 60). Between 1961 and 1964, hyperinflation reached 100% (Seekins 1983, 50). On Bali, rajas and other power holders began taking control of Bali's economy. Only a few hundred Balinese controlled most of Bali's land. Upper caste Balinese built hotels, factories, and transportation routes, exploiting lower caste Balinese for labor. In 1964, a famine left 18,000 Balinese in poverty. Prior to 1960, the two main political parties on Bali, the Indonesian Socialist Party (PSI) and the Indonesian Nationalist Party (PNI) both supported some type of land reform. After 1960, with the banning of the PSI, the Indonesian Communist Party (PKI) became very popular throughout Indonesia (Vickers 1996, 162-169).

During the 1960s, Sukarno had called upon Indonesian Communist Party (PKI) members on Java, North Sumatra (see Figure 4), and Bali to become aggressive and re-distribute land to poor peasants (Seekins 1983, 50). Land redistribution created tensions between Bali's triwangsa (members of the 3 upper castes) and sudra (members of the commoner caste) (Vickers 1996, 169). Despite the widespread popularity of the PKI, there was also widespread opposition that was not associated with caste issues.

Members of the Masyumi political party, made up mostly of Islamic Indonesians who had headed many coup attempts against Sukarno's antiparliamentarianism, opposed the PKI because of its close ties to Sukarno (Seekins 1983, 49). By 1965, there were even many Indonesian Nationalist Party (PNI) members that opposed the Indonesian Communist Party (PKI).

In 1965, Balinese PKI members attempted to interfere with the cremation of a raja who had fought to preserve traditional Balinese culture. Regardless of its stance on land reform, the fact that the PKI had become so extreme in its anti-traditional cultural sentiments was more than even many lower caste Balinese could tolerate (Vickers 1996, 170). On September 30, 1965, pro-Communist rebels launched a coup attempt by taking over a radio station and killing 5 Indonesian military generals (claimed by the rebels to have been cooperatives with the U.S. Central Intelligence Agency) (Seekins 1993, 54-56). Although the coup attempt was quickly brought under control by military forces, under the leadership of Major General Suharto, the coup attempt sparked off widespread anti-Communist violence throughout Indonesia (Seekins 1983, 53-54). Between October 1965 and February 1966, the PNI formed village death squads, led primarily by PNI youth members, on Bali. The death squads traveled from village to village leading anybody suspected of being a communist sympathizer to graveyards to execute them. Decapitation with a samurai sword was the favored form of execution. The number of people executed is unknown, but one estimate is that approximately 100,000 Balinese were killed (Vickers 1996, 170-172). Bali's landscape was a place of: ". . .blackened areas where entire villages had been burnt to the ground, and the graveyards could not cope with the numbers of corpses." (Vickers 1996, 170).

Today, it would appear that many Balinese are comfortable talking about their culture in terms of both caste and class, however, capitalizing off of trade is no longer a right that is reserved primarily for upper caste Balinese. In this sense, the anti-communist killings were about reconciling differences between Dutch capitalism, the traditional Balinese caste system, and even traditional Balinese socialism. According to Adrian Vickers, the killings represented:

> . . . a sort of mystical cleansing of the island's problems and ills. . . . Specific aspects of that culture, such as 'caste' titles and rituals, were part of a continuing series of power struggles, going on in Bali even before the arrival of the Dutch. . . . The killings signaled the end of a period of overt social tension, since with the removal of a generation of leftist intellectuals and activists, they created an unchallengeable consensus about what Balinese culture should be (Vickers1996, 172-173).

SUHARTO

In the aftermath of the 1965 coup attempt, Sukarno was forced to step down as the president of the Republic of Indonesia and transfer his authority to Major General Suharto. In March of 1967, the Consultative Assembly-Provisional (MPR-S) officially declared Suharto president (Seekins 1983, 54).

Suharto's reign as president of the Republic of Indonesia lasted from 1967 to 1998. During his presidency, Suharto implemented a series 5 year development plans (Repelita) designed to re-build Indonesia's economy within 25 years. Repelita I (1969-1973) focused on increased production of staple foods and infrastructure development. Repelita II (1974-1978) focused on agriculture, employment, and regionally equitable development. Repelita III (1979-1983) focused on the development of agricultural-related industry. Repelita IV (1984-1988) focused on the development of basic industries. Repelita V (1989-1993) focused on the development of transportation and communications (Seekins 1993, 60). In general, the Repelita stressed fiscal and credit restraints, foreign investment (especially from Japan and western countries including the United States), and the rescheduling of international debts (Seekins 1993, 60, Worldmark Encyclopedia of the Nations: Asia and Oceania 1995). In addition to the Repelita, Suharto also revived Sukarno's pancasila. However, unlike Sukarno, Suharto recognized that cultural and ideological homogeneity could not be imposed upon the Indonesian people (Seekins 1993, 59).

In 1998, Suharto's regime collapsed and Abdurrahman Wahid was elected as the new president in Indonesia's first democratic election in over 40 years. In 2001, Abdurrahman Wahid lost his presidency to Megawati Soekarnoputri (daughter of Indonesia's former president Sukarno). Since 1998, major violence has once again erupted throughout Indonesia. Much of this violence is associated with policies that were initiated by Suharto (Dahlby 2001, 80-91). For now, the Balinese are mostly at peace. However, a historical inventory of the effects of Suharto's policies raises both hopes and concerns about their future.

CHAPTER VI

BALI'S UNCERTAIN FUTURE

POPULATION GROWTH

Population growth has been a major driving force behind social, economic, political, and environmental problems throughout Indonesia. In 1971, Indonesia's human population was estimated at 120,000,000 (Neill 1973, 367). Between 1975 and 1980, the overall annual growth rate was 2.2 % (Kuipers 1993, 82). By 1997, the population had grown to an estimated 209,774,138 and the average rate of natural increase was at 1.5 % (Information Please Almanac 1998). The decline in the annual growth rate percentage was due in large part to ambitious family planning initiatives instituted by the Indonesian government starting in the 1960s. The prevalence of contraceptive use among married couples increased from 10% in the 1960s to more than 45% in the late 1980s (The World Bank 1994, 10). Even if birth control programs continue to succeed beyond expectations and each Indonesian women has only 2 children, Indonesia's population is so young that large numbers of woman will reach their child bearing years in the first decades of the twenty-first century (Kuipers 1993, 83). Zero population growth may not be achieved until the end of the twenty-first century when the stationary population will have surpassed 300,000,000 (The World Bank 1994, 10).

Six thousand of Indonesia's 17,000 islands are inhabited (Dahlby 2001, 80, Wheatley 1999, 7). However, Indonesia's population is unequally distributed and a small number of islands have very high population densities. In 1980, the islands of

Java, Madura, and Bali (see Figure 4), with only 6.9 % of Indonesia's land area, contained an estimated 63.6 % of Indonesia's population (Kuipers 1993, 83). When Suharto became president, many of Bali's farmers were suffering because of pressures associated with growing population. Rice fields were being broken up into smaller sizes that would no longer support the farmers (Picard 1996, 13-14). One goal of Suharto's Repelita was to try and relieve pressures on Java, Madura, and Bali.

THE TRANSMIGRATION PROGRAM

In 1969, Suharto initiated a transmigration program. The transmigration program, through 1994, relocated almost 8.5 million people (at a cost $500 million (U.S.) in World Bank loans) from Java, Madura, and Bali to outer islands such as Sumatra, Kalimantan, the Moluccas, and Papua (see Figure 4) (Dahlby 2001, 87, Marshall 1993, 173). In the short term, the transmigration program appears to have had a positive influence on helping to stabilize Bali's social, political, economic, and environmental problems. It is still far too early to fully assess what the long term effects of the transmigration program will be for Bali.

Despite the transmigration program, Bali's population has continued to grow. During Repelita III (1979-1983), at the peak of the transmigration program, the number of people leaving Java and Bali was only one quarter the annual recruitment rate of people joining Bali's and Java's work force (Whitten, Soeriaatmadja, and Afiff 1996, 33). According to a 1980 census, Bali had a population density of 444 persons per square kilometer and Java had a population density of 700 people per square kilometer. At this time, most of Indonesia's other islands were estimated to have had a population density of less then 50 persons per square kilometer (Adiwoso-Suprapto 1983, 78). As of 1995, Java's estimated average population density was 862 people per square kilometer (with a population of 114,000,000) and Bali's estimated average population density was 520 people per square kilometer (with a population of 3,000,000) (Whitten, Soeriaatmadja, and Afiff 1996, 5). These figures indicate that, at best, the transmigration program has been responsible for only slightly delaying problems associated with population growth on Bali and Java.

Today, widespread violence remains throughout Indonesia between local native populations and immigrants. Papua's 1,200,000 native Papuans have had to contend with approximately 1,000,000 immigrants (Dahlby 2001, 87). Much of the violence has been associated with land disputes and environmental concerns (Marshall 1993, 174). Bali's relatively wealthy status makes it a destination of choice for emigrants, from Indonesia's devastated islands, who are seeking prosperity. Determining how many immigrants arrive annually on Bali is a difficult task since Bali has an extensive informal (small scale, largely unregulated) economic sector that is capable of providing immigrants the ability to make a living and at the same time blend in virtually undetectably with the Balinese. The Balinese point out to tourists that people begging on the streets are immigrants. However, if this is the case, the number of immigrants begging on Bali's streets appears to be relatively low and, at least for the moment, immigrants are not creating widespread problems on Bali. With poverty conditions rapidly increasing on many of Indonesia's islands, there is reason for concern that immigration might become a major problem for Bali in upcoming years.

ECONOMIC CONCERNS

Indonesia's Economy

Initially, Suharto's economic development plans helped bring Indonesia out of the economic slump that was created by Sukarno. From 1989 through 1993, Indonesia's industrial sector experienced an average economic growth rate of 8.5% per year. By 1993, some economic analysts were seeing the potential of Indonesia joining Hong Kong, Singapore, South Korea, and Taiwan as being an Asian economic tiger (Keum 1993, 170-171). However, Indonesia's economic reform has been plagued with problems.

Exports of natural resources (including petroleum, natural gas, tin, copper, coal, timber, and fish) and agriculture products (including rice and tree-crop cultivation) have remained the primary base of Indonesia's economy (Marshall 1993, 140, Wickman 1983, 121). Oil production, especially during the 1970s through the mid-1980s, played a significant role in Indonesia's economic development (Wickman 1983, 124). However, such reliance on natural resources and agricultural exports has tended to make Indonesia's economy more susceptible to large scale price swings and fewer employment opportunities in comparison to Asian countries with a larger percentage of economic base in manufactured goods. Indonesia's economy suffered terribly during the mid-1980s collapse of the global oil market (Marshall 1993, 140-141).

Because of the mid-1980s oil market collapse, new policies were adopted in an attempt to boost Indonesia's manufacturing sector. These policies included renewed encouragement of foreign investment, broader ownership rights in export-oriented manufacturing sectors, streamlining of investment processes, banking deregulation, elimination of major subsidies, privatization of the Jakarta Stock Exchange, and reductions in tariffs and non-tariff barriers (Marshall 1993, 141, Worldmark Encyclopedia of the Nations: Asia and Oceania 1995). As a result of these policies, Indonesia's manufacturing exports grew from less than $1 billion (U.S.) in 1982 to more than $9 billion (U.S.) in 1990 (Marshall 1993, 141). Despite these economic gains, Indonesia's economy remained troubled. Most of Indonesia's gross national product still came from agriculture (40% in 1993), most of Indonesia's national budget had to go towards making payments on the interest from loans (40% of the national budget in 1993), and average annual income per person remained low ($490, in 1993, with an 11% inflation rate). Construction projects, associated with the building of transportation and communication links between islands, were not cost effective. Most Indonesians remained illiterate or had not attended college (in 1993, only 6 people per 1,000 attended college). The costs associated with the extraction of natural resources continued to rise and require additional borrowing of money. Growth in the industrial sector created very few jobs (in 1989 the industrial sector employed 6,500,000 workers or only 9% of the work force) (Collinwood 1993, 54-55, Marshall 1993, 164-165).

In the 1970s and 1980s, tight government controls over Indonesia's economy led to widespread corruption. By the mid-1980s, approximately 1,500 items were imported by government licensed importers or controlled through a quota system. Selected firms became protected from foreign competition and were able to sell their products at higher prices. These price increases were passed along to Indonesian manufacturers and ultimately to Indonesian consumers. Widespread public resentment grew as Indonesia's economic gains increasingly benefited only a minority group of wealthy individuals.

Although Suharto's reforms in the 1980s were supposed to transition Indonesia's economy away from government control and towards a competitive market, Suharto granted several large conglomerates monopoly rights (probably for political favors) (Marshall 1993, 144-154).

In 1998, Indonesia's economy suffered a major crisis due to a combination of several factors. Economic output had declined to a point where hyperinflation was imminent, the burden of government debt depressed market sentiment, Indonesia's monetary exchange rate collapsed, Indonesia's banking system had almost completely stopped functioning, and Indonesia's corporate sectors were weighted down by recession, inflation, and debt (Singh 2000, 4). The 1998 economic collapse, along with the fact that Suharto's own family had been heavily profiting from his economic reforms, became focal points for political discontent throughout Indonesia and were major reasons why Suharto was forced to step down as president (Dahlby 2001, 80, Marshall 1993, 145-146).

Since 1998, signs of democratization and attempts by the central Indonesian government to eliminate corruption have been important in winning back the economic confidence of both Indonesians and western countries. However, economic analysts are waiting to see just how far the Indonesian government will go towards restructuring Indonesia's banking system and developing a true privatized competitive market economy (Dahlby 2001, 84-85, Pudjomartono 2000, 1, Singh 2000, 4). Even if sweeping economic reforms are put into place, widespread social instability and environmental degradation will probably remain a threat to Indonesia's economy for many years.

Bali's Economy

The per capita income of the Balinese, in 1997, was around $967 (U.S.) (Lyon and Wheeler 1997, 23). In comparison to other Indonesian islands, Bali is an economic success story. Because of Bali's physical geography and large population, Suharto targeted Bali under his Repelita for tourism and agricultural development rather then for industrialization or widespread exploitation of natural resources. Even though Balinese social unrest had almost completely eliminated Bali's tourist economy until the end of the 1960s, Sukarno had expanded Bali's Ngurah Rai airport and built a luxury hotel on Bali's Sanur beach (Picard 1996, 42). Under Suharto's Repelita I (1969-1974), Bali was singled out as being an especially important prospect for the development of tourism and government money was allocated for the building of hotels, infrastructure (including roads to prospective tourist sites), and for providing assistance to villages so that they could integrate tourism at the local level. The implementation of the first plan turned out to be so successful that tourist arrivals on Bali increased from 6,000 in 1968 to 1,032,000 in 1994 (Picard 1996, 43-52).

Because of historical events, it is difficult to assess Bali's tourism as being either positive or negative. Through the processes of globalization, Bali's social, economic, and environmental stability has become increasingly dependent upon the rest of Indonesia. Violence on almost any Indonesian island can cause a downturn in the number of tourists visiting Bali. Also, Bali is by far one of the richest islands in the Indonesian archipelago in terms of its contribution to national gross domestic product. While part of this productivity has to do with its large population, a major part has to do with its "parasitizing" of natural resources from other islands (Whitten, Soeriaatmadja, and Affif 1996, 33). As population pressures cause environmental damage throughout Indonesia, it remains to be seen if Bali's economic structure can remain intact. Finally, tourism can exacerbate Bali's environmental problems by creating additional demands on natural resources, by creating additional waste products, and by overwhelming traditional Balinese resource management systems.

ENVIRONMENTAL CONCERNS

Deforestation

Indonesia's forests are second only to those of Brazil in terms of size and represent 10% of the world's remaining tropical forest (The World Bank 1994, xiii). Discounting the effects of fire in the mid-1980s, Indonesia's deforestation rate was the highest in Southeast Asia at 700,000 to 1,000,000 hectares per year. In turn, deforestation has led to widespread soil erosion and, in some cases, desertification (Kuipers 1993, 78-80).

Energy Demands

Indonesia's domestic demand for energy is expected to increase by over fourteen-fold by the year 2020 (The World Bank 1994, xiv). While Indonesia has a large natural supply of energy resources, the burning of oil and coal has caused environmental problems such as deforestation and air pollution (Worldmark Encyclopedia of the Nations: Asia and Oceania 1995).

Agriculture

Initially, Suharto's integration of "Green Revolution" technology into Indonesia's agricultural sector had very positive results in expanding rice production. By the 1970s, Indonesia had become a major rice importer. By 1985, through the use of "Green Revolution" technology, Indonesia had achieved 6 years of rice production growth rates in excess of 7% and self-sufficiency. From 1968 to 1989, rice production increased from 12,000,000 to 29,000,000 tons and yields increased from 2.14 tons per hectare to 4.23 tons per hectare (Marshall 1993, 174-176). However, it did not take long before expansion of rice agriculture productivity began to be offset by problems. Green Revolution technology included a government policy promoting continuous cropping with new rice hybrids and the use of chemical fertilizers. In 1987, Indonesia used 3,100,000 tons of fertilizer (Worldmark Encyclopedia of the Nations: Asia and Oceania 1995). Both fertilizer and pesticide runoff has threatened the health of coral reefs and Indonesia's fisheries (Kuipers 1993, 79-80).

On Bali, continuous cropping interrupted Bali's traditional rice growing systems (associated with Balinese Hinduism and temples), which for many centuries had successfully dictated when, or if, farmers should grow rice so as to avoid widespread water shortages or pest outbreaks. With continuous cropping, Bali began to suffer water shortages and unprecedented outbreaks of rice pests and diseases (Lansing 1995, 75). Similar problems occurred throughout Indonesia's rice growing regions and poverty became largely a rural problem. Green Revolution technology's devastating effects on Bali's rice agricultural system is probably an indicator that Bali's rice agricultural system is very near the point of reaching Bali's carrying capacity. Future economic and environmental costs associated with trying to expand Bali's rice agricultural productivity will probably offset or eclipse any economic gains. While there is always the possibility that new technological advancements will overcome some of these diminishing returns, it is doubtful that these advancements will be made any time soon.

Urbanization

Urbanization is rapidly creating environmental problems associated with improper solid waste disposal, air pollution from vehicles, and the contamination of water sources from chemical and sewage runoff. One study has estimated that the 1990 economic cost associated with pollution, from the city of Jakarta (on the island of Java), was approximately $500,000,000 (U.S.). Part of this economic estimate was associated with shrimp production, on the north coast of Java, being threatened by toxic industrial runoff (The World Bank 1994, xiv-xvi).

Bali, through its rapidly growing human population, has for many centuries been heading in a direction of urbanization and the need to diversify its economy. The introduction and subsequent failure of Green Revolution technology only served to speed these trends. Workers who had traditionally been employed in agriculture found they needed some form of temporary work in the off-peak seasons. Many families, assisted by the increased availability of automobiles and other forms of transportation, began engaging in a circular migration between urban and rural areas for employment. Others, with no hope for employment in rural areas, permanently relocated to urban areas (Marshall 1993, 173-174, Sethuraman 1985, 719). In 1970, only 15% of Indonesia's population lived in urban areas. During the 1980s, the rate of urbanization exceeded 5% per annum. Today, the urban sector represents about 30% of the population. If this trend continues, half of the entire population may live in urban areas by the year 2040 (The World Bank 1994, 11).

Urban sprawl is a rapidly growing problem that is threatening Bali's forested and rice growing areas. There are ongoing concerns that children, growing up in urban areas, are no longer being taught traditional Balinese Hindu beliefs (such as the Tri-Hita Karana doctrine). Some children have only seen rice fields or forests because of school programs that bus them on day trips into highland areas. However, there are also signs of hope for the future. Crime, anonymity, pollution, and problems in finding a better way of life have disillusioned many Balinese who migrated to urban areas (Kuipers 1993, 85). Studies are showing that many urban Balinese are making frequent trips back to their villages as an extension of the need to be among friends and family (Mitchell 1995, 373).

While the majority of people who have turned towards urban areas for employment have been unable to find jobs within the formal economy, the informal sector, consisting chiefly of very small units engaged in the production and distribution of goods and services, has played a vital role in the Indonesian economy by absorbing labor (Sethuraman 1985, 719). Because Bali's economy diversified into tourism, with a wide range of informal economic opportunities, the Balinese have had a relatively smooth transition away from an agriculture dominated economy in comparison to other islands. Economic development strategies, for Bali, have placed considerable emphasis on the development of small-scale handicraft enterprises and tourism. Employment opportunities, in the handicraft economic sector, nearly doubled between the late 1970s and the mid-1980s. In 1990, handicraft items accounted for 19% of the total value of all exported goods from Bali. The value of these goods was more than $37,000,000 (U.S.) (Bater 1995, 78-84). With expanding markets for handicraft items, Balinese are slowly finding new rural opportunities. Village artisans can pool their resources into small-scale enterprises or even work alone out of their houses and still earn lucrative wages (Lansing 1995, 115-117). Currently, not all craft production is based upon the sustainable use of natural resources. Balinese wood carvers are still utilizing teak and mahogany hardwoods from islands that are experiencing rapid deforestation. However, there is a growing emphasis on trying to control environmental problems associated with tourism by developing and implementing eco-tourism strategies.

Finally, despite many historical setbacks associated with globalization, the Balinese remain open to working with foreigners and learning new approaches towards solving their economic, social, and environmental problems. The Balinese are committed to maintaining aspects of traditional Balinese culture, while recognizing that their culture must also continue to evolve.

CHAPTER VII

METHODOLOGY

INTRODUCTION

Until recently, the development and testing of landscape ecology models for long-tailed macaques has been hindered by several factors. First, very little remote sensing data existed for most of Southeast Asia. Second, very few detailed forestry maps existed for many parts of Southeast Asia. Third, very few in-depth ground surveys had been conducted for identifying the location of long-tailed macaque troops in Indonesia. Lastly, both Geographical Information System (GIS) and Global Positioning System (GPS) technologies were still being developed. Today, even though all of these factors have changed, a GIS landscape ecology model has not been developed and tested to determine if long-tailed macaques have broad habitat specificity.

Advances in both GPS and GIS technologies have been especially important for the further development of landscape ecology models for long-tailed macaques. Hand held GPS units are now widely available that are:

- Cost effective.
- Capable of tracking multiple satellites and determining the coordinate location for a survey point with high degree accuracy.
- Capable of storing multiple survey points and downloading survey data directly into a desk or lap top computer.

Advances in GIS technology include:

- Mapping software that can be run on most desk or lap top computers.
- Software that is relatively user-friendly.
- Software that will accept spatial data from a number of input devices including GPS units, digitizing tables, and scanners.

- The ability to develop maps containing multiple themes (such as geology, soil types, hydrology, and vegetation types).
- The ability to link spatial data with tabular data.
- The ability to run data queries based upon a single and/or multiple map themes.
- The ability to manipulate how map themes are displayed based upon attributes such as: whether or not a map theme is turned on or off; how themes are layered; color; and legend symbols.
- The ability to determine landscape changes by overlaying and comparing separate maps from multiple time periods.
- The ability to conveniently store and retrieve map data.
- The ability to conveniently develop and manipulate map layouts.
- The ability to output map layouts by printing them into hard copy format or by linking them into digital presentations.
- The ability to develop digital maps which feature projection and scale flexibility.

Scale flexibility is an especially important GIS attribute for the development of long-tailed macaque landscape ecology models. Utilizing GIS technology, a single digital map can now be developed that can display both large scale regional ranges for long-tailed macaques and small scale landscape features.

GIS DATABASE DEVELOPMENT

The Central Washington University (CWU) library obtained a 47-map set of 1:25000 Bakosurtanal (Indonesian military) maps. Combined, these maps formed a complete coverage for Bali, Indonesia. The map set was developed by Bakosurtanal based upon air photos (from 1981 and 1982) and a 1991 ground survey.

Each of the 47 maps was digitized utilizing Environmental Systems Research Institute, Inc.'s (ESRI's) ArcView® (version 3.2) GIS program. Initially, 4 reference or

"TIC" points were digitized and georeferenced for each map. The ArcView® GIS program was used to link coincident TIC points (TIC points on adjacent maps sharing the same latitude and longitude coordinate/georeference) and produce a TIC point mosaic (see Figure 11: TIC point mosaic and rectified maps).

After the TIC point mosaic was created, each map was scanned utilizing a large format engineering scanner and saved on to a compact disk (CD) as a Tagged Image File Format (TIFF) file. Utilizing Adobe Photoshop® (version 5.5) each map image was then opened, cropped around the edges, adjusted for visual quality, and resaved as a TIFF file.

Utilizing the ArcView® Image Analysis extension, each of the Adobe Photoshop® TIFF files were opened and rectified onto the TIC point mosaic (see Figure 11). The final product of the rectification process was a georeferenced map mosaic for the island of Bali (see Figure 12: Map mosaic of Bali).

The Bali map mosaic formed a primary database for the creation of several GIS map themes. Landscape features, that were chosen to be included within this thesis project's GIS database, were defined based upon 1:25000 Bakosurtanal map legend features. Selected 1:25000 Bakosurtanal map features were, in turn, transferred into this thesis project's GIS database utilizing the ArcView® onscreen digitizing option. Several GIS map themes were created including: Bali's coastline and lakes (see Figure 13: Bali's coastline and lakes); cities, villages, and roads (see Figure 14: Major cities, villages, and roads); and forested and rice agricultural areas (see Figure 15: Forested and rice agricultural areas).

Figure 11: TIC point mosaic and rectified maps.

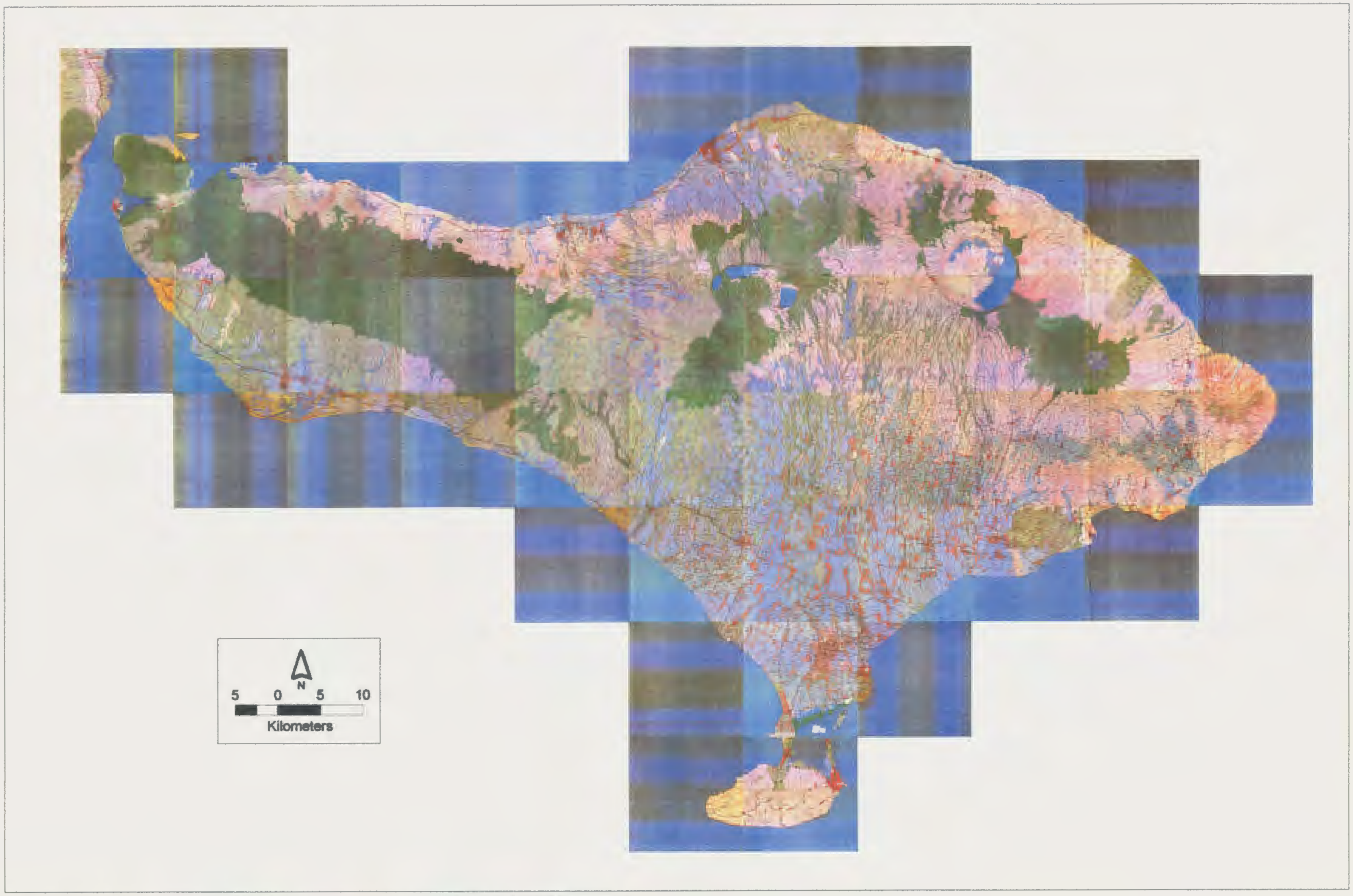

Figure 12: Map mosaic of Bali (Based upon modified 1:25000 maps).

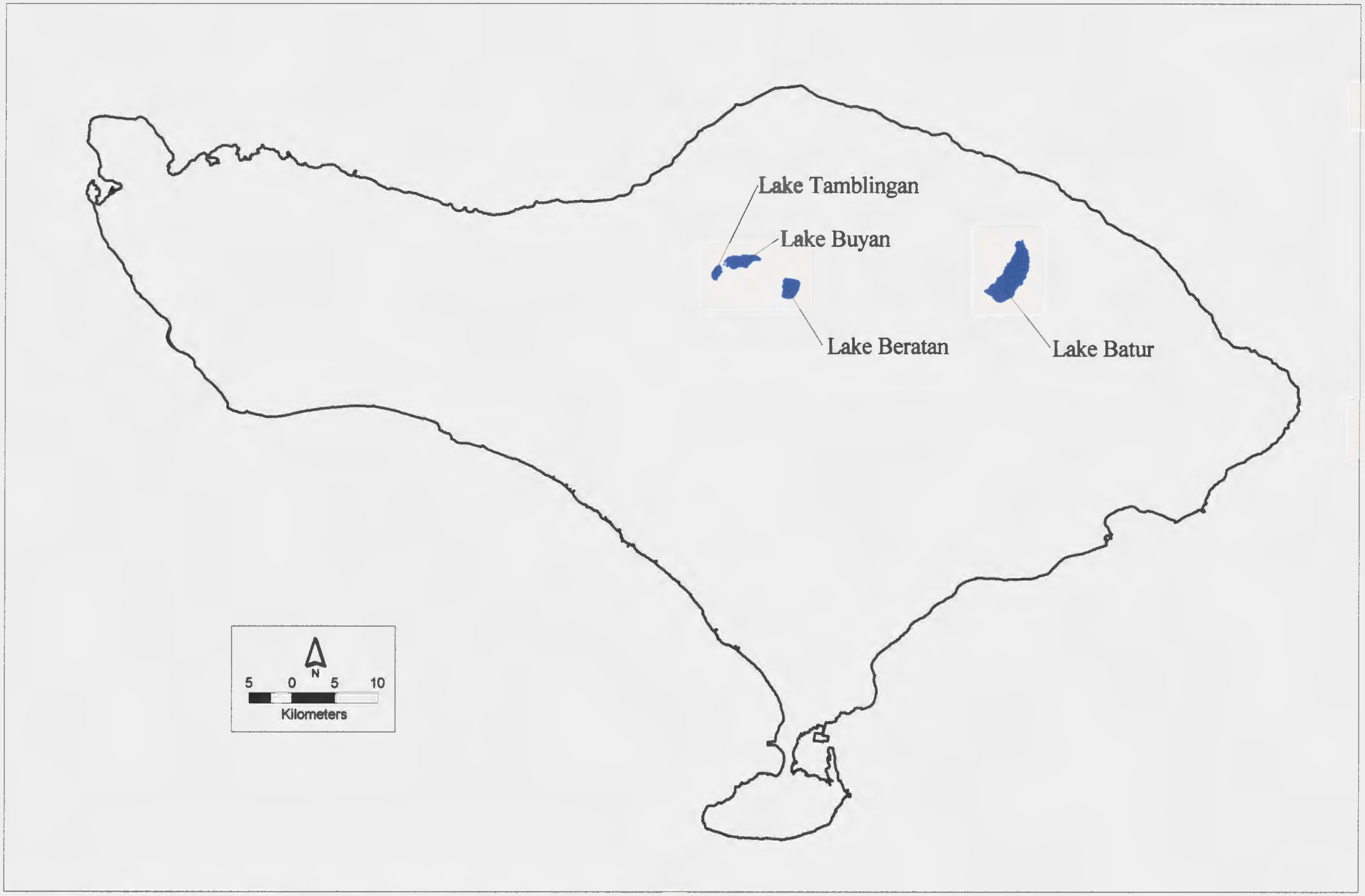

Figure 13: Bali's coastline and lakes (Based upon modified Bakosurtanal 1:25000 maps).

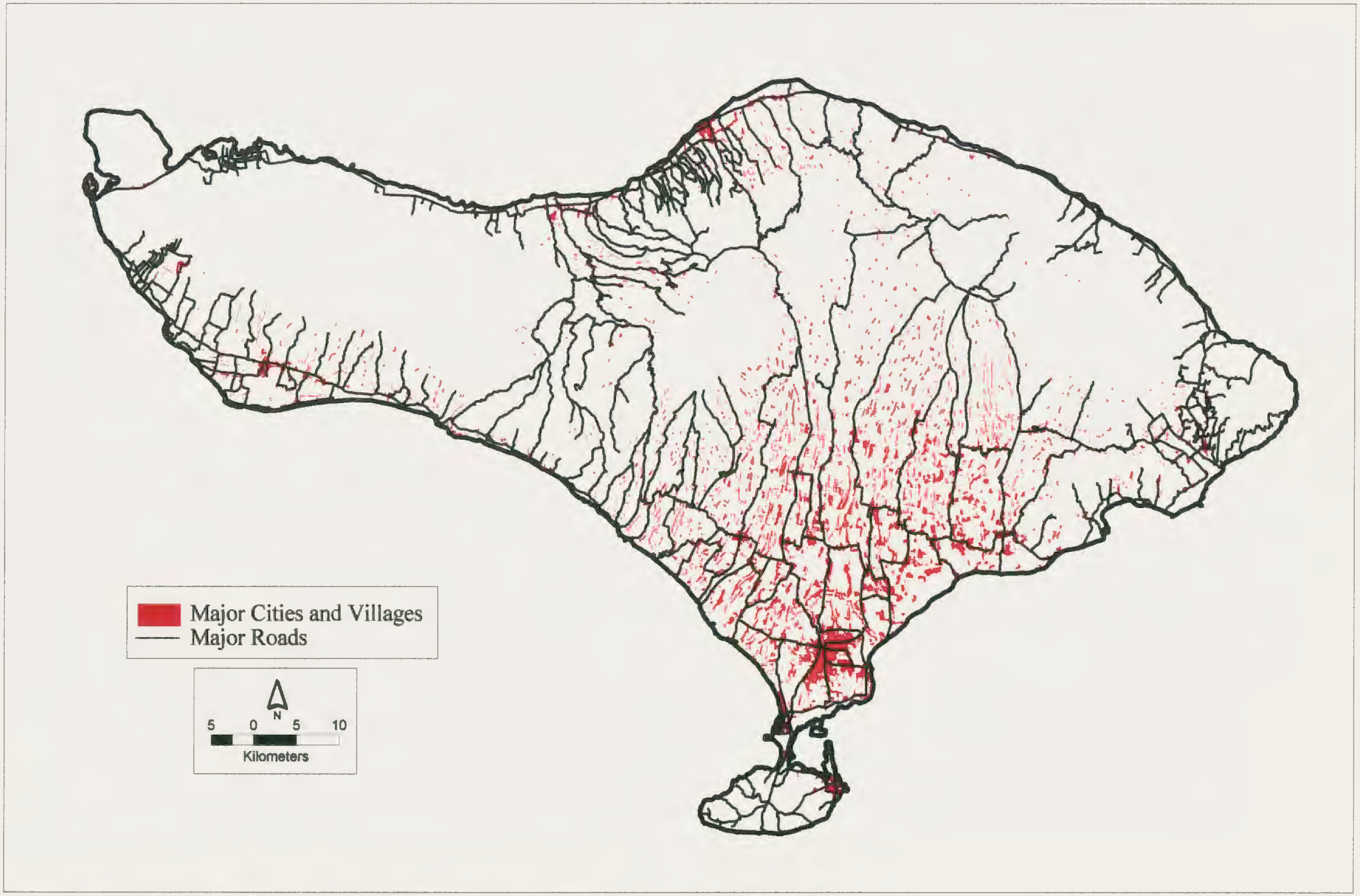

Figure 14: Major cities, villages, and roads (Based upon modified Bakosurtanal 1:25000 maps).

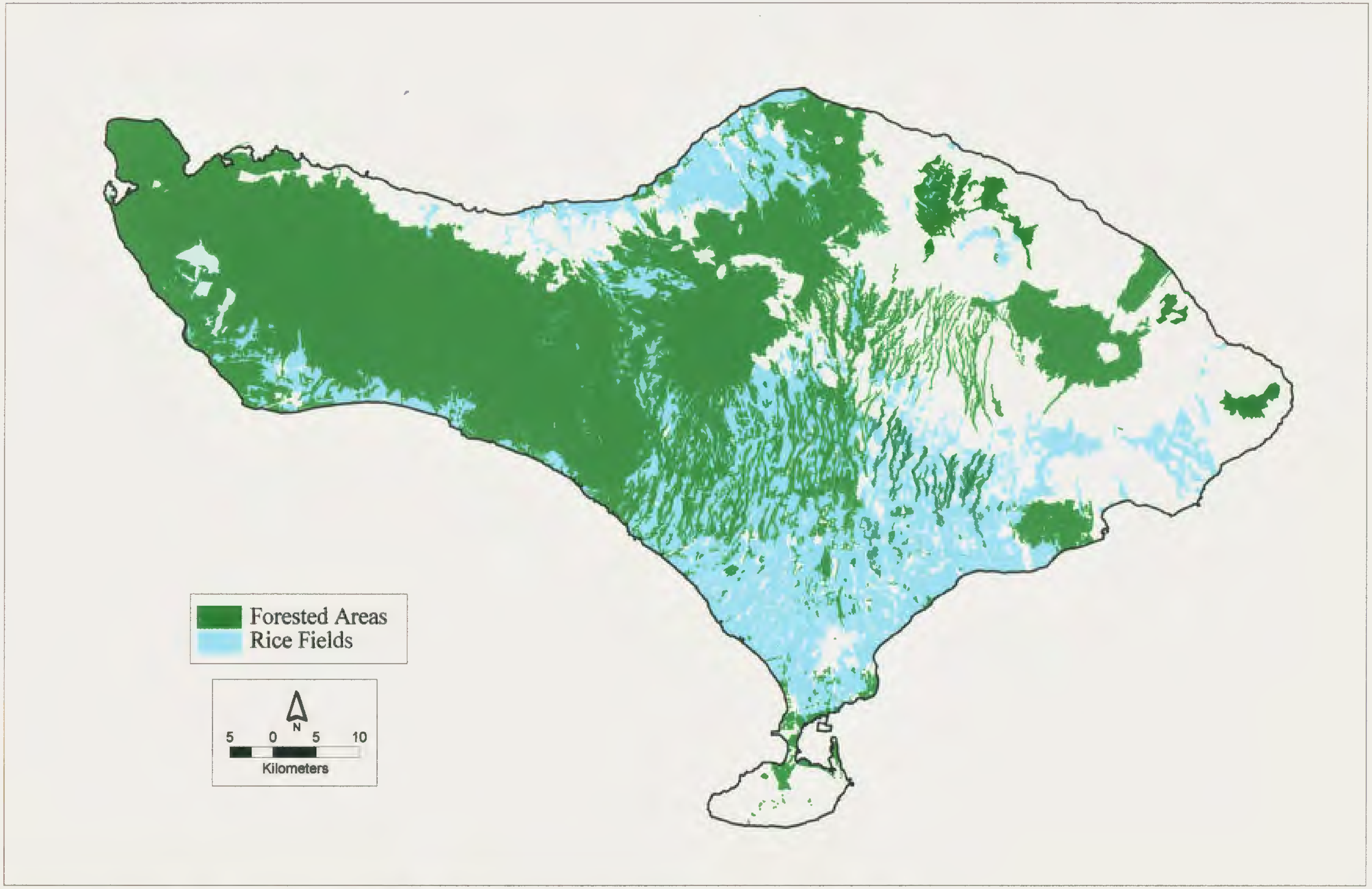

Figure 15: Forested and rice agricultural areas (Based upon modified Bakosurtanal 1:25000 maps).

The locations of Balinese long-tailed macaque troops were digitized into the GIS database utilizing the ArcView® onscreen digitizing option (see Figure 16: Balinese long-tailed macaque troop sites and 100 hectare buffer zones). Data on the location of Balinese long-tailed macaque troops was obtained from CWU's Balinese Macaque Project (directed by CWU Professor of Anthropology Dr. Agustin Fuentes). The troop location data were collected between 1998 and 2001 by staff members from the Universitas Udayana and as a part of research conducted by the Balinese Macaque Project. A total of 44 Balinese long-tailed macaque troop sites were identified. Each site was assigned a separate GIS identification number. Site 36 and site 37, although they were assigned GIS identification numbers, were not included in this thesis project's analysis because they were located on the neighboring island of Nusapenida.

Utilizing the ArcView® X-Tool extension, a circular buffer zone was created around each of the digitized Balinese long-tailed macaque troop locations (see Figure 16 and Figure 17: Individual monkey sites and buffer zones (on compact disk)). The buffer zone represented a troop home range of 100 hectares (based upon total land area). A study conducted by Crockett and Wilson concluded that the core range for long-tailed macaques typically does not exceed 100 hectares (Crockett and Wilson 1980, 168).

The buffer zones provided bases for querying the GIS database to determine the proximity of Balinese long-tailed macaque troops to forested areas, rivers and streams, and cities and villages. Each Balinese long-tailed macaque troop site was assessed as either having or not having a 100 hectare buffer zone that overlapped with a river or stream, city or village, and forested area. Assessment was based upon a visual comparison between 1:25000 Bakosurtanal map features, which were included with this

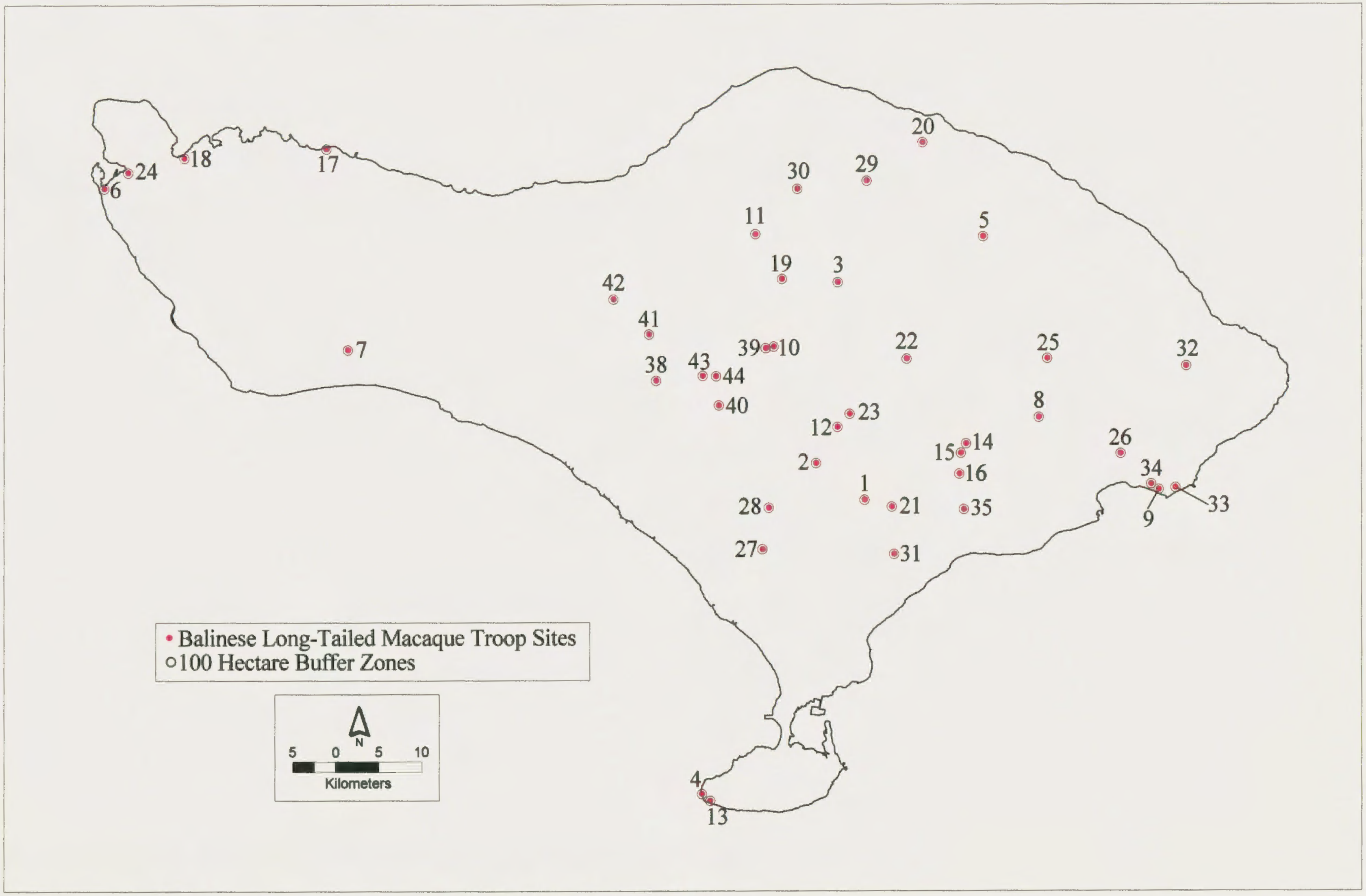

Figure 16: Balinese long-tailed macaque troop sites and 100 hectare buffer zones.

thesis project's GIS database, and each of the 100 hectare buffer zones that were created through the use of the ArcView® X-Tool extension.

Querying of the GIS database was carried out to determine if potential Balinese long-tailed macaque habitat/forest corridors existed between each of the digitized Balinese long-tailed macaque home range sites. A potential Balinese long-tailed macaque habitat/forest corridor was assessed as existing between Balinese long-tailed macaque home range sites where a GIS line could be digitized that:

- Overlapped with the 100-hectare home range buffer zones, for separate Balinese long-tailed macaque home range sites.
- Was contiguous.
- Overlapped with forest throughout its entire length.

Lines were predominantly digitized along the most visually direct route(s) between Balinese long-tailed macaque home range sites.

Additional querying of the GIS database was carried out to determine if potential Balinese long-tailed macaque habitat/forest corridors could be identified based upon analysis of both the GIS forest and river or stream themes. A potential Balinese long-tailed macaque habitat/forest corridor was assessed as existing between Balinese long-tailed macaque home range sites where a GIS line could be digitized that:

- Overlapped with the 100-hectare home range buffer zones, for separate Balinese long-tailed macaque home range sites.
- Was contiguous.
- Overlapped with forest, a river, or a stream throughout its entire length.

Lines were digitized predominantly along the most visually direct route(s) between Balinese long-tailed macaque home range sites. In addition, all river or stream segments, regardless of whether or not they were indicated within the GIS database as overlapping with forest, were considered for querying purposes as overlapping with forest.

AIR PHOTO INTERPRETATION

A set of 1:50000 Bakosurtanal air photos for the south central portion of Bali were obtained from the Indonesian government. Because of their date (1982) and their large scale (1:50000), the air photos were not chosen (over the Bakosurtanal maps) as the primary data source for the development of this thesis project's GIS database. However, an air photo showing the Ubud Monkey Forest of Padangtegal was rectified (utilizing the ArcView® Image Analysis extension) onto a corresponding Bakosurtanal map image contained within the GIS database. The rectified air photo, along with ground verification, provided data that was utilized to determine the relative accuracy of the Bakosurtanal maps.

GROUND VERIFICATION

Ground verification for the GIS database was conducted during the summers of 2000 and 2001. Balinese long-tailed macaque home range sites initially were randomly selected for ground verification by drawing site numbers. However, after arriving on Bali, the author was advised by Balinese Macaque Project researchers not to visit a number of the sites that had been randomly chosen because of travel costs and time constraints. The author ultimately opted not to ground verify Balinese long-tailed macaque home range sites based upon random drawings and instead the author opted to ground verify Balinese long-tailed macaque home range sites that that were selected by

Balinese Macaque Project researchers (without input from the author). In addition, although the author personally ground verified 18 Balinese long-tailed macaque home range sites, the author was advised to, and agreed to, accept ground verification results that were independently collected by Balinese Macaque Project researchers.

The author was assisted by Balinese Macaque Project researchers (primarily from the Universitas Udayana) in: traversing and visually verifying selected potential habitat corridors that had been identified within the GIS database; taking GPS coordinates for selected long-tailed macaque home range sites; visually verifying whether or not selected Balinese long-tailed macaque home range sites overlapped with forest, a river or stream, and a city or village within a core area of 100 hectares; and photographing both home range and potential habitat corridor areas for Balinese long-tailed macaques. The author also conducted several informal interviews in order to gather information regarding cultural variables that may play a role in the destruction or conservation of Balinese long-tailed macaque habitat.

CHAPTER VIII

RESULTS

GIS HOME RANGE ANALYSIS RESULTS

Forest

Thirty one (73.8%) of the Balinese long-tailed macaque 100-hectare home range sites were indicated within the GIS database as overlapping with forest (see Table 1: Home range analysis results). Sites that were not shown within the GIS database as overlapping with forest include site 4 (Ulu Watu), site 8 (Muncan), site 9 (Candidasa), site 13 (Ungasan), site 26 (Selumbung), site 27 (Alas Nenggan), site 31 (Tengenungan), site 32 (Batunmadeg), site 33 (Bukit Gumang), site 34 (Tenganan), and site 35 (Bakas) (see Table 2: Site list and individual home range analysis results).

River and Stream

Forty (95.2%) of the Balinese long-tailed macaque 100 hectare home range sites were indicated within the GIS database as overlapping with a river and or stream (see Table 1). Sites that were not shown within the GIS database as overlapping with a river and or stream include site 6 (Cekik) and site 9 (Candidasa) (see Table 2).

City and Village

Thirty five (83.3%) of the Balinese long-tailed macaque 100-hectare home range sites were indicated within the GIS database as overlapping with a city and or village (see Table 1). Sites that were not shown within the GIS database as overlapping with a

Table 1: Home range analysis results.

	GIS Results				Combined GIS and Ground Verification Results				
	Number Sites (Yes)	**Number Sites (No)**	**Percent Sites (Yes)**	**Percent Sites (No)**	**Number Sites (Yes)**	**Number Sites (No)**	**Percent Sites (Yes)**	**Percent Sites (No)**	**GIS versus Combined Results (Percent Change Yes)**
Forest	31	11	73.8%	26.2%	41	1	97.6%	2.4%	+23.8%
River or Stream	40	2	95.2%	4.8%	37	5	88%	12%	-7.2%
City or Village	35	7	83.3%	16.7%	34	8	81%	19%	-2.3%

Table 2: Site list and individual home range analysis results.

Y = (Yes) **N = (No)** **ND = (No Data)**		GIS	Ground Verification	GIS	Ground Verfication	GIS	Ground Verification	Author	Balinese Macaque Project
Site	**Name**	**Forest**		**River or Stream**		**City or Village**		**Ground Verification**	
1	Padangtegal	Y	Y	Y	Y	Y	Y	Y	
2	Sangeh	Y	Y	Y	Y	Y	N	Y	Y
3	Pelaga	Y		Y		Y			
4	Ulu Watu	N	Y	Y	N	Y	N	Y	Y
5	Batur	Y	Y	Y	N	N	N	Y	Y
6	Cekik	Y	Y	N	N	N	Y	Y	Y
7	Penyaringan	Y		Y		Y			
8	Muncan	N	Y	Y	ND	Y	ND		Y
9	Candidasa	N	Y	N	ND	Y	Y	Y	Y
10	Angseri	Y	Y	Y	Y	Y	Y	Y	
11	Bedugal	Y		Y		Y			
12	Carangsari	Y	Y	Y	Y	Y	Y	Y	
13	Ungasan	N	Y	Y	N	Y	Y		Y
14	Tambahen	Y		Y		Y			
15	Kuning	Y		Y		Y			
16	Tegal	Y		Y		Y			
17	Pulaki	Y		Y		Y			
18	Telukterima	Y	Y	Y	Y	Y	Y	Y	
19	Batunya	Y	Y	Y	ND	Y	ND	Y	
20	Tajakula	Y		Y		N			
21	Tengkulak	Y		Y		Y			
22	Tegalalang	Y	Y	Y	Y	Y	Y	Y	
23	Payangan	Y		Y		Y			
24	Gilimanuk	Y	Y	Y	Y	N	N	Y	Y
25	Besakih	Y	Y	Y	Y	Y	Y	Y	Y
26	Selumbung	N	Y	Y	ND	N	ND		Y
27	Alas Nenggan	N	Y	Y	Y	Y	Y	Y	
28	Alas Kedatan	Y		Y		Y			
29	Mesahan	Y		Y		Y			
30	Lemukih	Y		Y		Y			
31	Tegenungan	N	Y	Y	Y	Y	Y	Y	
32	Batunmadeg	N	N	Y	ND	Y	ND		Y
33	Bukit Gumang	N	Y	Y	Y	N	N	Y	
34	Tenganan	N	Y	Y	ND	Y	ND		Y
35	Bakas	N	Y	Y	ND	N	ND		Y
36	Not Included In Results: Located On Nusa Penida								
37	Not Included In Results: Located On Nusa Penida								
38	Belimbing (Mekori)	Y	Y	Y	Y	Y	Y	Y	Y
39	Bugbugan	Y	Y	Y	Y	Y	Y	Y	
40	Sangketan	Y		Y		Y			
41	Batungsel	Y		Y		Y			
42	Pejuritan	Y		Y		Y			
43	Puncasari	Y		Y		Y			
44	Wangaya Gede	Y		Y		Y		Y	

city and or village include site 5 (Batur), site 6 (Cekik), site 20 (Tejakula), site 24 (Gilimanuk), site 26 (Selumbung), site 33 (Bukit Gumang), and site 35 (Bakas).

HOME RANGE GROUND VERIFICATION RESULTS

An attempt was made to ground verify 24 (57%) of the 42 sites (see Table 2). Sites that were included for ground verification were site 1 (Padangtegal), site 2 (Sangeh), site 4 (Ulu Watu), site 5 (Batur), site 6 (Cekik), site 8 (Muncan), site 9 (Candidasa), site 10 (Angseri), site 12 (Carangsari), site 13 (Ungasan), site 18 (Telukterima), site 19 (Batunya), site 22 (Tegalalang), site 24 (Gilimanuk), site 25 (Besakih), site 26 (Selumbung), site 27 (Alas Nenggan), site 31 (Tegenungan), site 32 (Batunmadeg), site 33 (Bukit Gumang), site 34 (Tenganan), site 35 (Bakas), site 38 (Belimbing or Mekori), and site 39 (Bugbugan).

Forest

All 11 of the sites that were indicated within the GIS database as having a 100-hectare home range that did not overlap with forest were ground verified. Ground verification results contradicted what was indicated within the GIS database for all but 1 of these sites. Only site 32 (Batunmadeg) could not be confirmed as having a 100-hectare home range that overlapped with forest (see Table 2).

All 13 of the remaining sites, that were ground verified, were indicated within the GIS database as having a 100 hectare home range that overlapped with forest. Corresponding to what was indicated within the GIS database, all 13 of these sites were confirmed as having a 100-hectare home range that overlapped with forest (see Table 2).

River and Stream

Both of the sites that were indicated within the GIS database as having a 100-hectare home range that did not overlap with a river or stream were ground verified (see Table 2). Corresponding to what was indicated within the GIS database, a river or stream could not be confirmed as overlapping with the 100-hectare home range for site 6 (Cekik). At the time of ground verification for site 9 (Candidasa), a significant proportion of the site was not accessible and the ground verification was inconclusive.

All 22 of the remaining sites, that were ground verified, were indicated within the GIS database as having a 100-hectare home range that overlapped with a river or stream. Ground verification results contradicted what was indicated within the GIS database for 3 of these sites. These sites include site 4 (Ulu Watu), site 5 (Batur), and site 13 (Ungasan) (see Table 2). Balinese Macaque Project members, who assisted the author in conducting ground verifications, did not return river or stream data for site 8 (Muncan), site 19 (Batunya), site 26 (Selumbung), site 32 (Batunmadeg), site 34 (Tenganan), and site 35 (Bakas) (see Table 2). Corresponding to what was indicated within the GIS database, a river or stream was confirmed as overlapping with the 100-hectare home range for the remaining 13 sites (see Table 2).

City and Village

An attempt was made to ground verify 6 of the 7 sites that were shown within the GIS database as having a 100-hectare home range that did not overlap with a city or village. Site 20 (Tejakula) was omitted from ground verification because of its remote location. Of the 6 sites, for which an attempt was made to ground verify, Balinese

Macaque Project members did not return city or village data for site 26 (Selumbung) and site 35 (Bakas) (see Table 2). Of the remaining 4 sites, ground verification results corresponded with what was indicated within the GIS database for 3 of them. A city or village could not be confirmed as overlapping with the 100-hectare home range for site 5 (Batur), site 24 (Gilimanuk), and site 33 (Bukit Gumang) (see Table 2). Contrary to what was indicated within the GIS database, site 6 (Cekik) was determined to have a 100-hectare home range that overlapped with a city or village (see Table 2).

All 18 of the remaining sites that were ground verified were indicated within the GIS database as having a 100-hectare home range that overlapped with a city or village. Ground verification results contradicted what was indicated within the GIS database for 2 of these sites. These sites include site 2 (Sangeh) and site 4 (Ulu Watu) (see Table 2). A city or village could not be confirmed as overlapping with their 100-hectare home ranges. Balinese Macaque Project members did not return city and or village data for site 8 (Muncan), site 19 (Batunya), site 32 (Batunmadeg), and site 34 (Tenganan) (see Table 2). Corresponding to what was indicated within the GIS database, a city or village was confirmed as overlapping with the 100-hectare home ranges for the remaining 12 sites (see Table 2).

COMBINED GIS HOME RANGE AND GROUND VERIFICATION RESULTS

The combined results of the GIS home range analysis and the home range ground verification results indicate that 97.6% of the Balinese long-tailed macaque 100-hectare home range sites overlap with forest, 88% of the sites overlap with a river or stream, and 81% of the sites overlap with a city and or village (see Table 1). These percentages were calculated based upon: 1) the use of initial GIS analysis results in cases where ground verification results were recorded as being either inconclusive or as having no data obtained; 2) the use of ground verification results in instances where GIS and ground verification results were found to be conflicting; and 3) the use of initial GIS results for sites that were not ground verified.

GIS FOREST CORRIDOR ANALYSIS RESULTS

A tract of contiguous non-forested land was identified that divides Bali approximately into eastern and western halves. This tract of non-forested land starts on the southwest coast of Bali, winds its way through the central region of Bali, and ends on the northeast coast of Bali (see Figure 18: Bali's eastern and western forest patterns)

Bali's Western Region

A total of 20 Balinese long-tailed macaque sites are located in the western region of Bali. In addition, site 10 (Angseri) and site 19 (Batunya) are almost completely surrounded by the non-forested tract and for analysis purposes were considered to be located within the western region of Bali. Of these 22 sites, 18 (81.8%) were found to be connected to one another by a contiguous tract of forest (which extends from the east-west Bali dividing line, to the west coast of Bali) (see Figure 19: GIS forest corridor analysis results for the western region of Bali). The 4 sites that were found to be isolated from the contiguous tract of forest were site 23 (Payangan), site 10 (Angseri), site 17 (Pulaki), and site 19 (Batunya).

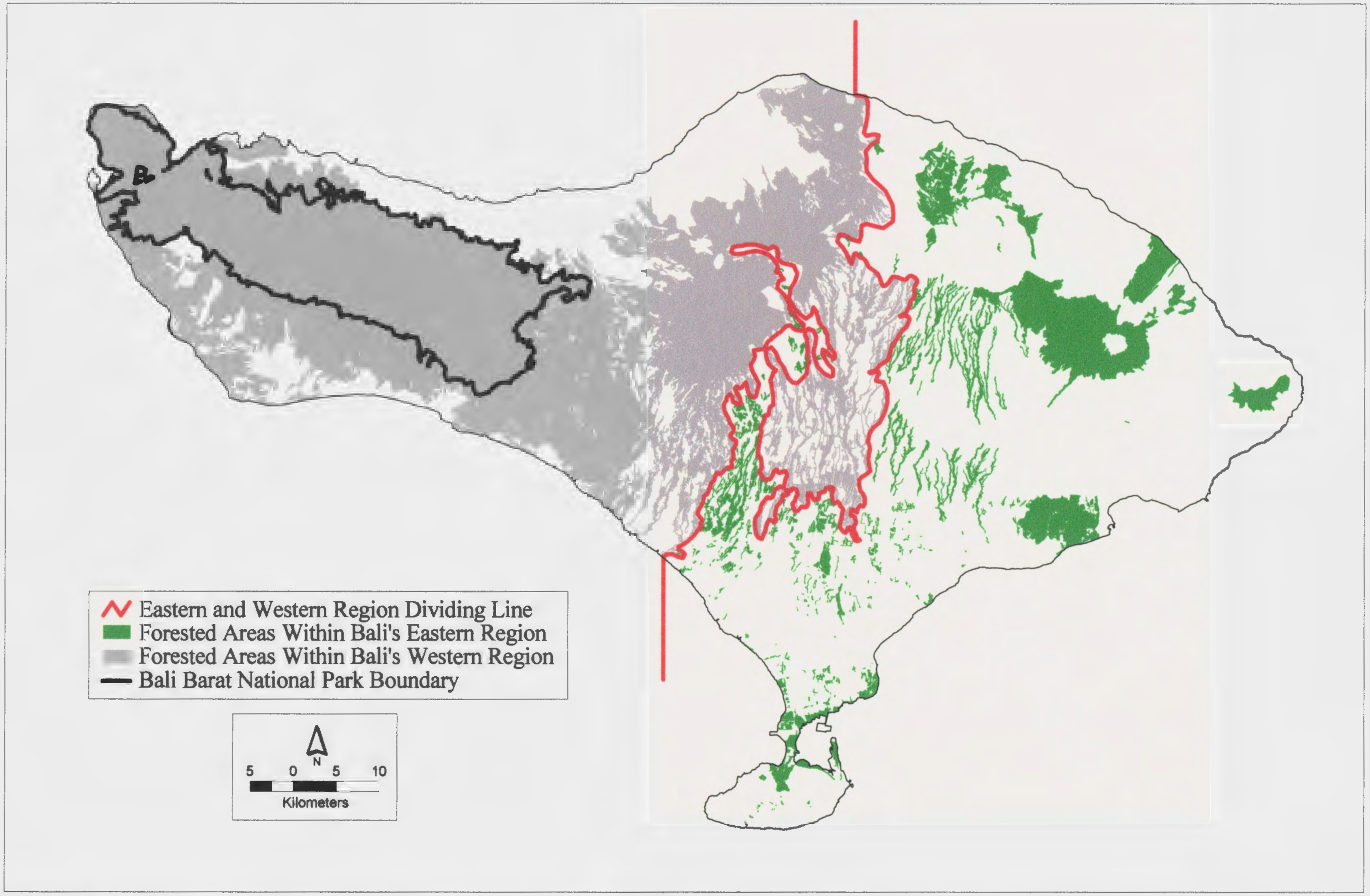

Figure: 18: Bali's eastern and western forest patterns (Based upon Bakosurtanal 1:25000 maps).

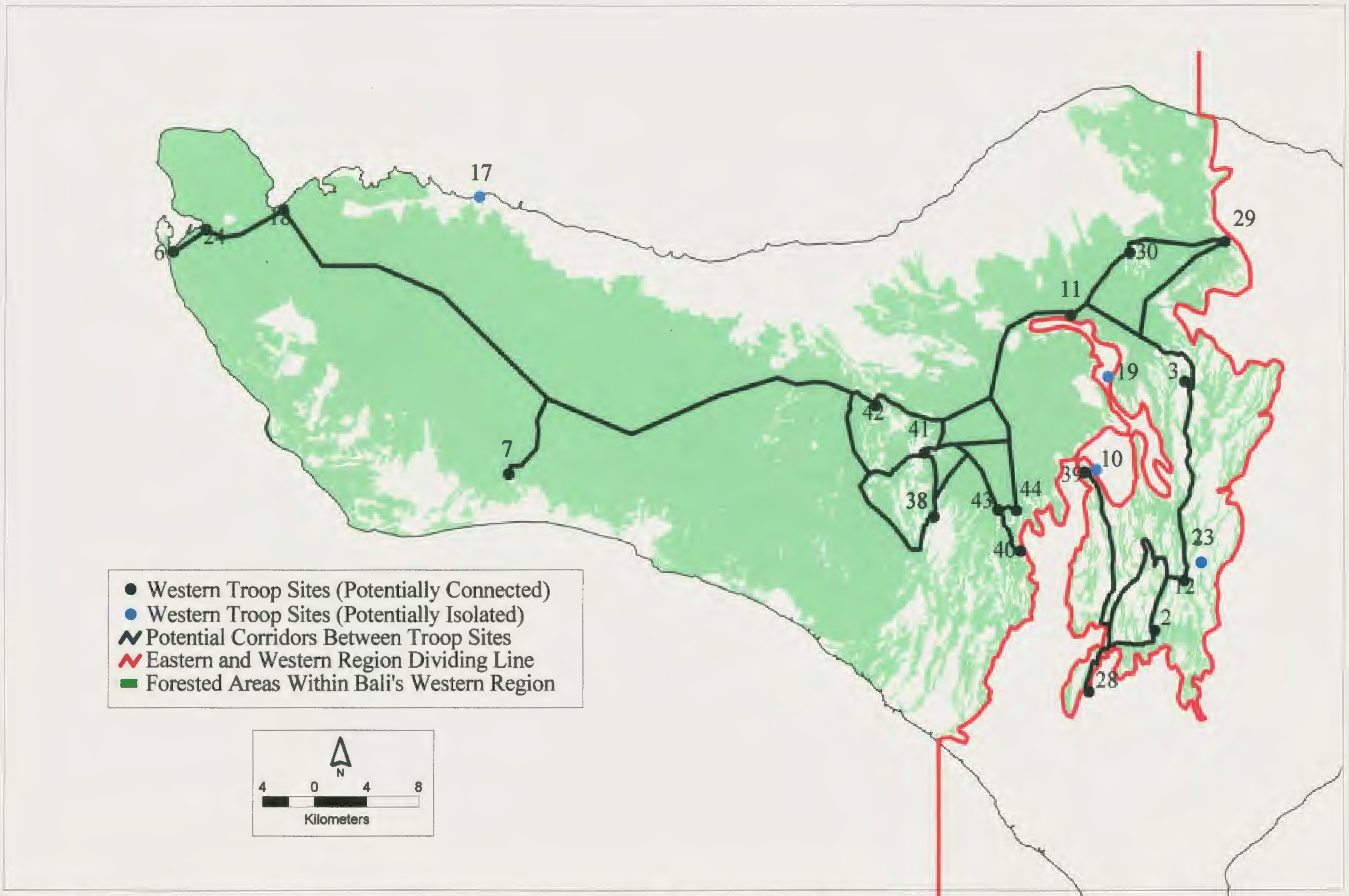

Figure 19: GIS forest corridor analysis results for the western region of Bali (Forest areas are based upon Bakosurtanal 1:25000 maps).

Bali's Eastern Region

Of the 20 sites located in Bali's eastern region, only 3 sites (15%) were found to be connected to one another by a contiguous tract of forest. These 3 sites are site 14 (Tambahen), site 15 (Kuning), and site 16 (Tegal) (see Figure 20: GIS forest corridor analysis results for the eastern region of Bali).

COMBINED RIVER, STREAM, AND FOREST CORRIDOR ANALYSIS RESULTS

A GIS comparison between forest and drainage patterns indicated that a large number of the eastern region's forest tracts are riverine (see Figure 21: A comparison between forest and drainage patterns within the eastern region of Bali). Based upon this initial comparison, additional GIS analyses were conducted to determine how many of the 42 Balinese long-tailed macaque sites were connected along forest, river, and or stream tracts.

Bali's Western Region

All (100%) of the sites located within Bali's western region were found to be connected by a contiguous corridor consisting of forest, rivers, and/or streams (see Figure 22: Combined river, stream, and forest corridor analysis results). Three sites within Bali's eastern region were also found to be connected to the sites within Bali's western region. These sites include site 1 (Padangtegal), site 20 (Tejakula), and site 27 (Alas Nenggan) (see Figure 22).

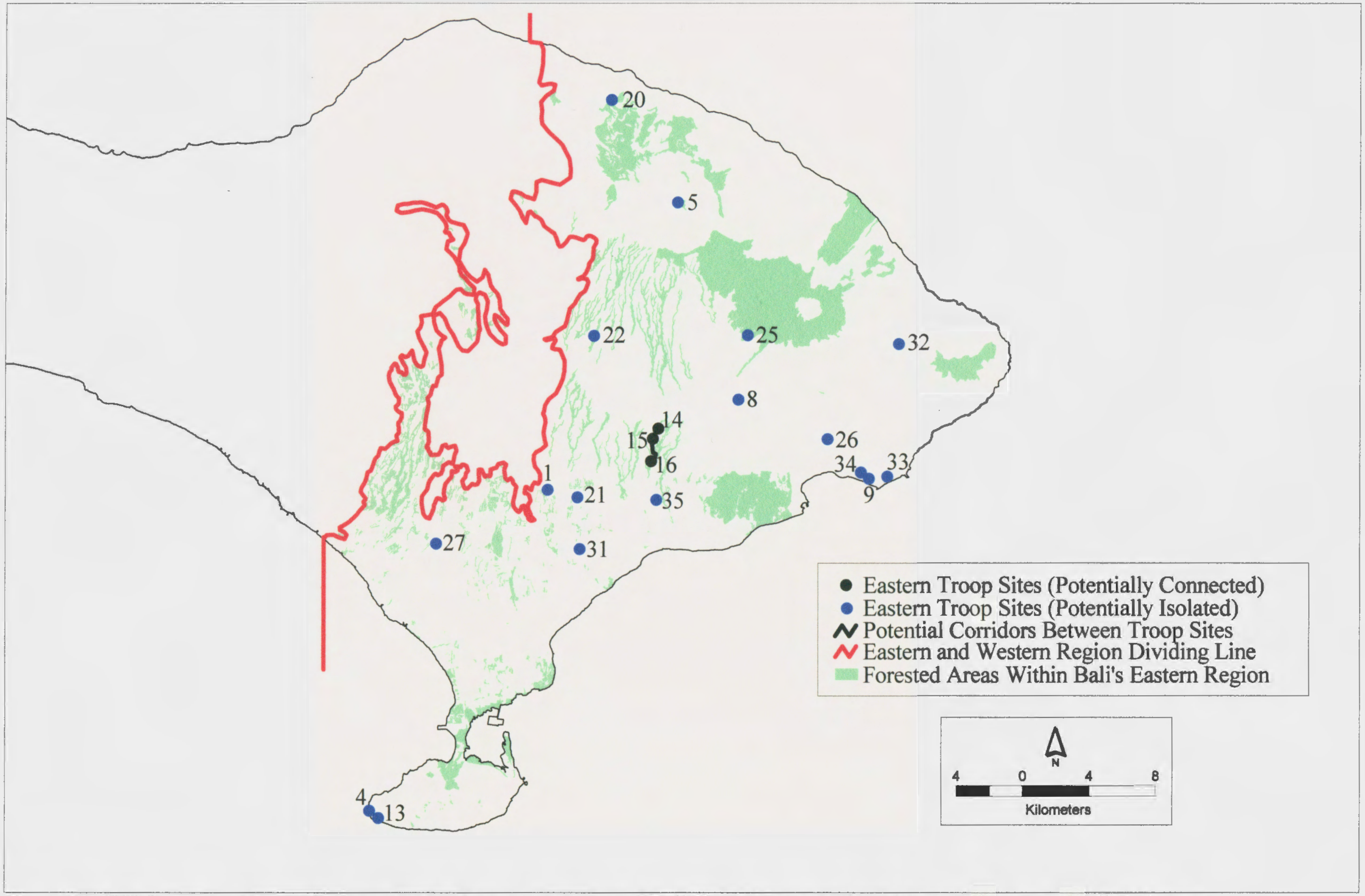

Figure 20: GIS forest corridor analysis results for the eastern region of Bali (Forest areas are based upon Bakosurtanal 1:25000 maps).

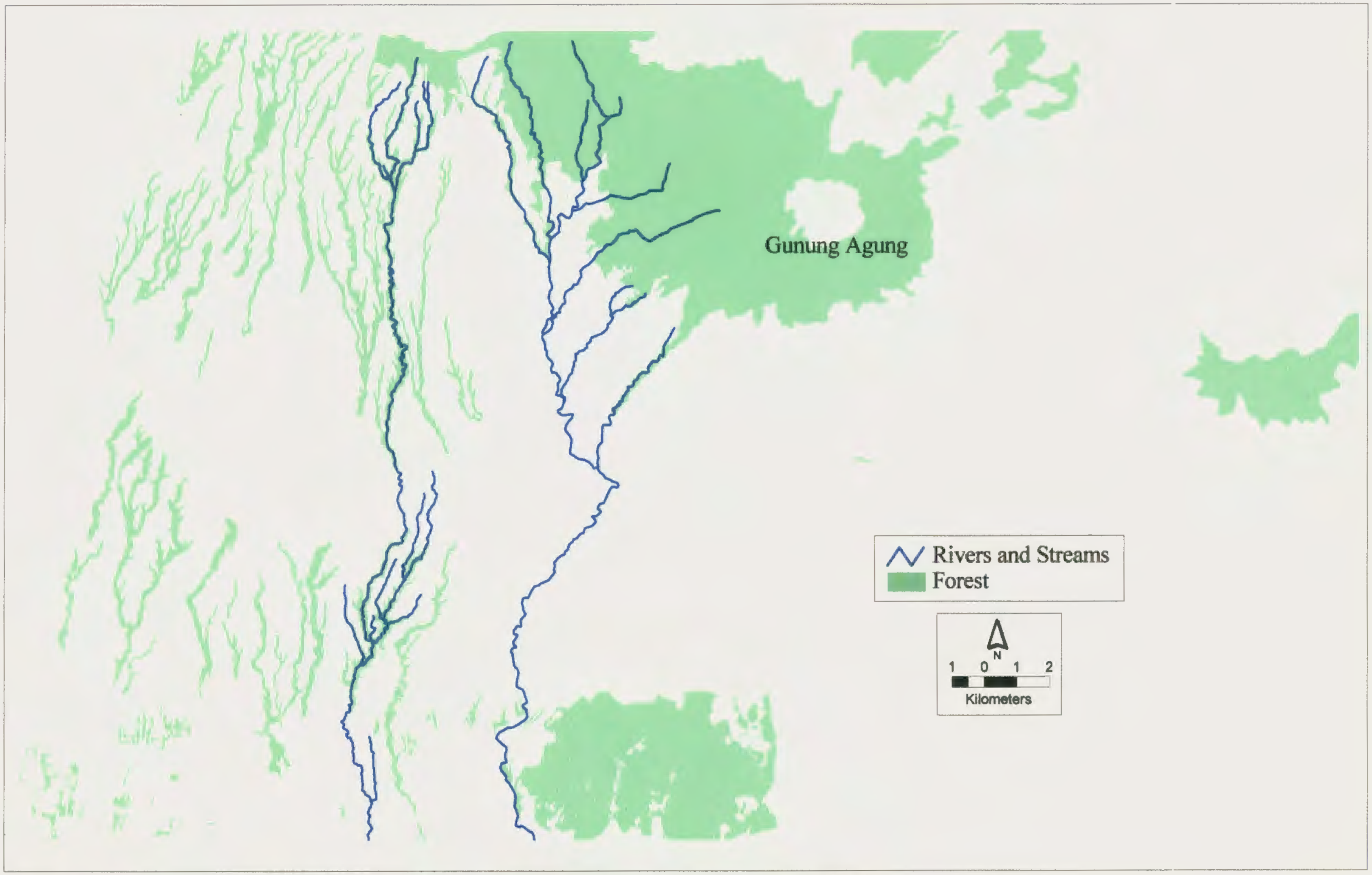

Figure 21: A comparison between forest and drainage patterns within the eastern region of Bali (Forest and drainage patterns are based upon Bakosurtanal 1:25000 maps).

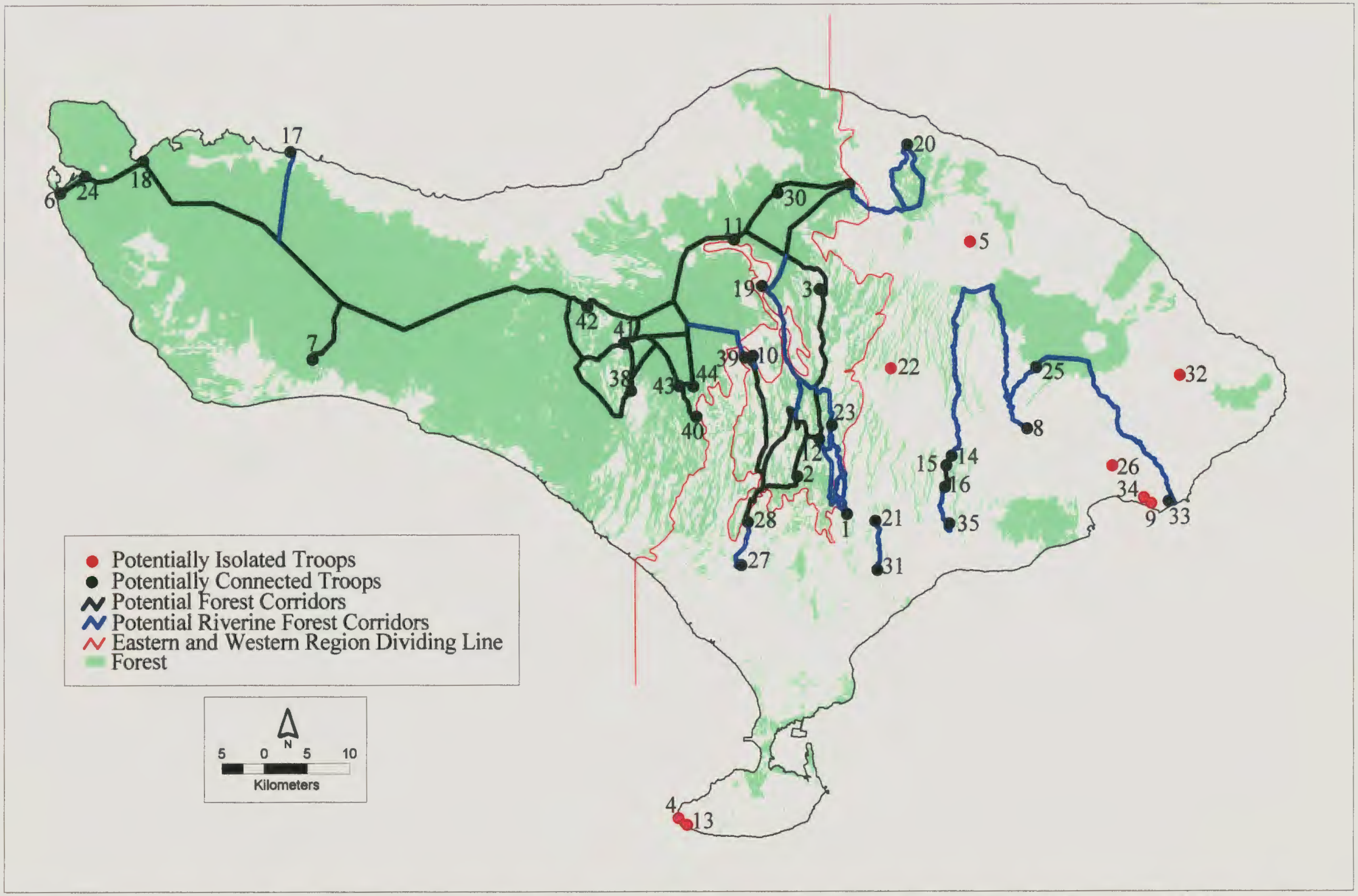

Figure 22: Combined river, stream, and forest corridor analysis results (Rivers, streams, and forest are based upon Bakosurtanal 1:25000 maps).

Bali's Eastern Region

Eight out of the 20 sites (40%) located in Bali's eastern region remained completely isolated. These sites include site 4 (Ulu Watu), site 5 (Batur), site 9 (Candidasa), site 13 (Ungasan), site 22 (Tegalalang), site 26 (Selumbung), site 32 (Batunmadeg), and site 34 (Tenganan) (see Figure 22).

Site 21 (Tengkulak) and site 31 (Tegenungan) were found to be connected along a single river corridor (see Figure 22). Site 8 (Muncan), site 14 (Tambahen), site 15 (Kuning), site 16 (Tegal), site 25 (Besakih), site 33 (Bukit Gumang), and site 35 (Bakas) were found to be connected along a corridor consisting of forest, river, and stream tracts (see Figure 22).

FOREST CORRIDOR GROUND VERIFICATION RESULTS

In order to verify the GIS analysis results the author drove along a stretch of highway that extends almost the entire length of the southwestern and western coasts of Bali. As a part of an overnight stay within the Bali Barat National Park, the author also traveled by boat from a point just northeast of site 18 to a point on Bali's western peninsula. In addition, the author both hiked and drove to locations throughout the south-central, eastern, and southern peninsular regions of Bali.

Bali's Western Region

In comparison to Bali's eastern region, the author found Bali's western region to be substantially more forested. In accordance with what is indicated within this thesis project's GIS data, a large tract of contiguous forest appeared to stretch along the entire length of the western region's central mountain chain (see Photo 1: A section of forest located within the central mountain chain of western Bali).

Bali's Eastern Region

In comparison to Bali's western region, forest tracts within Bali's eastern region appeared to be generally sparser. However, forest tracts were not as sparse as indicated within this thesis project's GIS database. Substantial tracts of dry deciduous forest, which were not indicated on the 1:25000 Bakosurtanal maps, were encountered in the southeastern coastal and southern peninsular regions of Bali (see Photo 2: Forest at site 4 (Ulu Watu) and see Photo 3: Forest at site 33 (Bukit Gumang)).

Bali's South-Central Region

The south-central region of Bali was found to be extensively developed with rice fields, cities, and villages. In general, hiking along river and stream corridors was difficult. Many drainages cut through cities, villages, and or rice field areas. In addition, many drainages had no maintained trails or trails that went for only short distances, dense foliage, and/or dangerous slopes. In accordance with the GIS data, many smaller riverine forested corridors were encountered which originated and/or terminated in rice fields (see Photo 4: Rice field and small drainage patterns within the south-central region of Bali). Many larger river and stream corridors, which appeared to be more contiguously forested than what is indicated on the 1:25000 Bakosurtanal maps, were also encountered. The author rafted down several kilometers of the Ayung River

Photo 1: A section of forest located within the central mountain chain of western Bali.

Photo 2: Forest at site 4 (Ulu Watu) (Adapted from Photo by Rio Helm. Periplus Editions: Impact Postcards).


Photo 3: Forest at site 33 (Bukit Gumang).

Photo 4: Rice field and small drainage patterns within the south-central region of Bali.

and noted riverine forest along the majority of the route (see Photo 5: Forest within the Ayung River valley of south-central Bali).

The interfluves throughout the south-central region of Bali represented some of the most extensively developed land that the author visited. However, a large number of garden-variety fruit, nut, and shade trees are grown by the Balinese in rice fields and in and around cities and villages. Groves of these trees were generally not indicated on the 1:25000 Bakosurtanal maps. Although some of the villages within the south-central region of Bali are very densely populated, the large number of garden-variety trees growing in and around some of these villages provided the appearance that these areas were not nearly as populated or developed as they actually were. While the 1:25000 Bakosurtanal maps indicated the location of larger fruit and nut tree plantations, the author noticed many regions on Bali that had extensive tracts of such plantations that were not indicated on the 1:25000 Bakosurtanal maps.

The south-central region of Bali was found to have many temple sites that are forested. Not all of the temple sites indicated on the 1:25000 Bakosurtanal maps, were indicated as being forested. For example, Balinese long-tailed macaque site 1 (Padangtegal), a temple site with 11 hectares of forest, is not indicated as being forested on its corresponding 1:25000 Bakosurtanal map.

Photo 5: Forest within the Ayung River Valley of south-central Bali.

CHAPTER IX

RESULTS DISCUSSION

POTENTIAL HABITAT CORRIDOR ANALYSIS

The results of the home range analysis supported this thesis' hypothesis that forest would represent the landscape type with the greatest percentage of overlap with known Balinese long-tailed macaque home range sites. The results of the habitat corridor analysis supported this thesis project's hypotheses that forest corridors would exist between known Balinese long-tailed home range sites, although the results did not support this hypothesis for all of the know Balinese long-tailed home range sites.

Bali's Western Region

Results for the western region of Bali indicated that potential uninterrupted gene flow might be occurring between all of the Balinese long-tailed macaque troops located in the western region of Bali (which were studied as a part of this thesis project). The potential habitat corridors that were digitized for the western region of Bali were chosen based upon potential direct routes between Balinese long-tailed macaque troop sites. However, the forest patterns for the western region of Bali suggest that there are numerous possibilities for alternative habitat corridor routes.

Bali's Eastern Region

Unlike Bali's western region, most of the potential habitat corridors for Bali's eastern region emerged only after the GIS analysis was expanded. Additional querying of the GIS database conducted based upon upon ground verification results, indicated that many of Bali's drainages, which were not indicated within the GIS database as overlapping with forest, may in fact be riverine forest corridors. Despite the expansion of the GIS analysis to incorporate potential connectivity along river and stream areas not shown within the initial GIS database as being forested, 40% of the troops located in Bali's eastern region remained isolated.

Most of the rivers that flow through the south-central region of Bali originate at the caldera rim of Gunung Batur. Gunung Batur's caldera rim represented a particularly challenging area for conducting potential habitat corridor analysis. Although the fluvial areas along the caldera rim are located in relatively close proximity to one another, the interfluvial areas along Gunung Batur's caldera rim are generally not indicated within the GIS database as being forested. The author made several trips to various areas along Gunung Batur's caldera rim and found that the area appeared to be generally more forested than what is indicated within the GIS data. However, the author was never able to find an adequate vantage point to document that forested interfluves exist radiating outward from Gunung Batur's caldera rim that are not indicated within the GIS data.

For GIS analysis purposes, a conservative approach was utilized and potential habitat corridors were not digitized into areas other then those that were indicated within the GIS data as having forest, a river, or a stream. Had data been obtained indicating that fluvial areas along Gunung Batur's caldera rim are connected by forest, the potential connectivity between Balinese long-tailed macaque troops located throughout Bali's eastern region would have been greater. Despite this, 7 (35%) of the Balinese long-tailed macaque troop sites, located in Bali's eastern region, most likely would have still remained isolated. These sites include site 4 (Ulu Watu), site 5 (Batur), site 9

(Candidasa), site 13 (Ungasan), site 26 (Selumbung), site 32 (Batunmadeg), and site 34 (Tenganan).

The results indicate that the potential for interruption of gene flow between troops is probably significantly higher for the eastern region of Bali versus the western region of Bali. In addition, once gene flow, between Balinese long-tailed macaque troops, is interrupted along a particular habitat corridor troops in the eastern region of Bali are probably more likely to remain isolated than troops within Bali's western region.

HOME RANGE ANALYSIS

Forest

The difference between the percentages of home range sites that were found to overlap with forest, based upon combined GIS and ground verification results (97.6%) versus GIS analysis results alone (73.8%), represents an increase of 23.8% (see Table 1). This increase is due entirely to 10 Balinese long-tailed macaque home range sites that were not indicated within the GIS data as overlapping with forest, but based upon ground verification were found to overlap with forest (see Table 2). Site 4 (Ulu Watu), site 13 (Ungasan), site 33 (Bukit Gumang), and site 34 (Tenganan) were found to overlap with dry deciduous forest. Site 8 (Muncan), site 9 (Candidasa), site 26 (Selumbung), site 27 (Alas Nenggan), site 31 (Tegenungan), and site 35 (Bakas) were all found to overlap with riverine forest.

Site 32 (Batunmadeg) represented the only site that could not be considered as overlapping with forest based upon both GIS analysis and ground verification.

However, interpreting the results for Batunmadeg was complicated by several factors. The GIS data indicates that Batunmadeg has a small outer portion of its 100-hectare home range that overlaps with a river or stream. In addition, the author noted many plantations and small garden patches in the region just south of Batunmadeg. This data indicates that there is a strong likelihood that Batunmadeg has a 100-hectare home range that overlaps with riverine, garden-variety, and/or plantation forest. Although a member of the Balinese Macaque Project provided the ground verification data for Batunmadeg, the author suspects this individual may not have noticed some forested areas that overlap with Batunmadeg or chose to conservatively interpret certain tracts of garden and plantation forest as not being potential habitat for Balinese long-tailed macaques. Difficulties associated with traversing terrain represented the major reason why ground verification data was not returned for some sites or ground verification data was interpreted as being inconclusive. In addition, all of the assisting Balinese Macaque Project members were instructed by the author to take a conservative approach when interpreting site overlap and only record site overlap with a city and or village, river and or stream, or forest based upon visual confirmation. A return visit to Batunmadeg was not possible and the author decided to take a conservative approach and record Batunmadeg as not having a 100-hectare home range that overlapped with forest.

City and Village

The difference between the percentages of home range sites that were found to overlap with a city or village, based upon combined GIS and ground verification results (81%) versus GIS analysis results alone (83.3%), represents a decrease of 2.3% (see

Table 1). Site 2 (Sangeh) and site 4 (Ulu Watu), despite being indicated as overlapping with a city or village within the GIS data, were found based upon ground verification to not have a 100-hectare home range that overlapped with a city and or village (see Table 2). Had both of these sites represented the only data changes, the combined results would have indicated a percentage decrease of 4.8%. However, site 6 (Cekik) was indicated within the GIS data as not overlapping with a village but, based upon ground verification, was found to overlap with a village.

The discrepancies between what was indicated within the GIS data and what was found based upon ground verification appeared to center around temple complexes and sparsely distributed buildings. Despite what was sometimes indicated on the 1:25000 Bakosurtanal maps, temple complexes as defined in this thesis project were not interpreted as village areas. Many of Bali's temple complexes are associated with city or village areas, but, because they represent sacred sites, temple complexes can provide Balinese long-tailed macaques with a high degree of protected status in comparison to more typical city or village areas. This accounts for the discrepancy at site 4 (Ulu Watu). In general, interpreting some of the sparse buildings that were included on the 1:25000 Bakosurtanal maps was difficult. For example, site 2 (Sangeh) is shown on its corresponding 1:25000 Bakosurtanal map as overlapping with a village. However, based upon ground verification, the only thing that could be found at site 2 (Sangeh) that resembled a village was a bus stop complex. Site 6 (Cekik) is shown on its corresponding 1:25000 Bakosurtanal map as having sparse buildings. However, at the time of ground verification site 6 (Cekik) was found to overlap with a row of houses and the author's Balinese guide indicated that the area did indeed have a village. It is possible that in the case of site 6 (Cekik), the discrepancy between the GIS and ground verification data was due to landscape changes that had occurred since 1991 (the most recent draft date for the 1:25000 Bakosurtanal maps utilized for this thesis project).

The results of the home range city and village analysis would appear to challenge the conclusion of this thesis project that Balinese long-tailed macaques have a habitat specificity which is primarily limited to forested areas. However, data that have been collected as a part of this thesis project and the Balinese Macaque Project would appear to indicate that most Balinese long-tailed macaque troops do not range into village areas. On limited occasions when a troop ranges into a village area it is only for very short distances and time periods away from a forested area. For example, the 11 hectare patch of forest that is known to represent the core range for the Balinese long-tailed macaque troops at site 1 (Padangtegal) is located just south and across the street from the main village area of Padangtegal. Conjoining Padangtegal, to the north, is a village called Ubud. Both Padangtegal and Ubud are densely populated. An area across the street from site 1 has tourist shops, hotels, and restaurants. Troops from site 1, as a part of ongoing behavioral research being conducted by the Balinese Macaque Project, have been documented ranging into the main village area of Padangtegal on a regular basis. However, these troops: almost always stay on or around a retaining wall that is directly across the street from the 11 hectare patch of forest; have never been documented ranging into the main village area of Padangtegal more than approximately 50 meters from the 11 hectare patch of forest; often times frequent the main village area of Padangtegal in the morning hours when human activity is limited; and tend to retreat very quickly into the 11 hectare patch of forest when they are challenged by humans.

Evidence further suggests that the pattern of ranging behavior for Balinese long-tailed macaque troops at site 1 (Padangtegal) most likely also holds true for Balinese long-tailed macaque troops that have a home range that overlaps with a city or village at other sites located throughout Bali. Dr. Agustin Fuentes, Dr. Komang Gde Suryana, and Arta Putra (members of the Balinese Macaque Project) derive this evidence from approximately 20 years of combined experience in locating Balinese long-tailed macaque troops and studying their behavior. None of these researchers have documented a Balinese long-tailed macaque troop ranging for any significant time period or distance from a forested area that is at least several hectares in size.

The author also collected anecdotal evidence, based upon informal interviews conducted with 2 Balinese, suggesting that Balinese long-tailed macaque troops have historically been documented as moving out of areas that have become extensively developed by humans and subsequently deforested. One of the Balinese indicated that she grew up in an area of Bali that traditionally had Balinese long-tailed macaques. Today, that same area no longer has macaques and she remembers that the macaques seemed to begin moving away at a time when her home village started a growth surge. The second Balinese told the author about a temple site in the village that he grew up in. The Pura (temple) Dalem Penunggekan is located in Bali's Bangli regency (an area in the highlands of Bali's south-central region). Elders from local villages have indicated that macaques once lived in and around the temple until the 1950s. Village elders believe that these Balinese long-tailed macaques were caretakers of the temple. In addition, village elders also believe that the macaques were forced to move away from the temple site because the area became developed with village. The author visited Pura

Dalem Penunggekan and found that the area surrounding the temple had been developed with village that a paved road passes close to one of the outer walls of the temple complex. The author was taken to the last confirmed location of Balinese long-tailed macaques within the area, which were spotted by a Balinese Macaque Project member in the year 2000, and found the site to be a riverine forested area located approximately 1 kilometer from the temple.

River and Stream

The difference between the percentage of home range sites that were found to overlap with a river or stream based upon combined GIS and ground verification results (88%) versus GIS analysis result alone (95.2%), represents a decrease of 7.2% (see Table 1). This decrease is due entirely to 3 Balinese long-tailed macaque home range sites that were indicated within the GIS data as overlapping with a river or stream, but based upon ground verification were found to not overlap with a river and or stream. These 3 sites are site 4 (Ulu Watu), site 5 (Batur), and site 13 (Ungasan) (see Table 2).

Site 5 (Batur) is located within Gunung Batur's caldera. The only place that the site 5 troop has been documented ranging is on Gunung Batur's lava dome. This area receives approximately 2,000 to 3,000 millimeters of annual rainfall, however, the surface of Gunung Batur's lava dome is comprised of porous rock and surface water is most likely limited predominantly to very small pools (Whitten, Soeriaatmadja, and Afiff 1996, 122-123). Evidence collected by the Balinese Macaque Project indicates that the Balinese long-tailed macaques at site 5 (Batur) are obtaining some of their water requirements from food provisions brought by tourists who hike out on to the lava dome.

It is also possible that the site 5 troop is obtaining water by ranging down to the bottom of Gunung Batur's lava dome and drinking from Lake Batur or by consuming some of the vegetation that has managed to grow on the lava dome.

Site 6 (Cekik) represents the only site that was found, based upon both GIS and ground verification, to not have a 100-hectare home range that overlaps with a river or stream. Site 6 overlaps with mangrove forest and there are large amounts of seawater located throughout the area. Because of its salinity, this water is probably unpotable for the Balinese long-tailed macaques.

SIGNIFICANCE

Potential Habitat Corridor Analysis Results

The identification of potential Balinese long-tailed macaque habitat corridors provides bases for the conducting of additional research. The author recommends that genetic analysis and the tracking of Balinese long-tailed macaques be conducted to further test whether or not gene flow is occurring along potential habitat corridors that were identified as a part of this thesis project. Should research evidence support the maintenance of gene flow between Balinese long-tailed macaque troops along forest corridors, the author recommends this evidence be utilized as a foundation for the conducting of additional ongoing research which will:

- Identify the location of Balinese long-tailed macaque troops throughout Bali.
- Monitor the fitness of Balinese long-tailed macaque troops located throughout Bali to determine if gene flow is potentially being interrupted between troops.
- Determine how and if the fitness of troops is being impacted once a troop becomes isolated from gene flow with other troops.

- Identify changes in Bali's forest configurations to determine if gene flow is potentially being interrupted between Balinese long-tailed macaque troops.
- Identify Balinese land uses that may potentially cause deforestation and subsequent interruption of gene flow between Balinese long-tailed macaque troops.
- Identify changes within the Balinese culture that may promote existing land uses or create land uses that will cause deforestation and subsequent interruption of gene flow between Balinese long-tailed macaque troops.
- Identify natural disturbances that may cause deforestation and subsequent interruption of gene flow between Balinese long-tailed macaque troops.
- Promote the development of resource management projects and support existing resource management projects that will facilitate the conservation of Balinese long-tailed macaques.

Home Range Forest Analysis Results

The results of the home range forest analysis further support the results of the forest corridor ground verification indicating that the GIS database under-represented Bali's dry deciduous and riverine forest (some of Bali's dry-deciduous and riverine forested areas, were indicated on the Bakosurtanal maps as <u>not</u> being forested). These results also support the incorporation of GIS data within the combined GIS and ground verification results for sites that were not ground verified for forest. Of the sites that were not ground verified for forest, none were indicated within the GIS data as not overlapping with forest. The combined results, which concluded that 97.6% of the home range sites overlap with forest, is important because it indicates that forested areas most likely represent the primary habitat of Balinese long-tailed macaques. In turn, this provides some evidence that the Balinese long-tailed macaques may be relying on the corridors identified as a part of this thesis project to support gene flow between troops.

The author recommends that site 32 (Batunmadeg) be revisited as a part of future research on Balinese long-tailed macaque habitat preferences. If the Balinese long-tailed macaque troop(s) at Batunmadeg can be confirmed to be thriving, despite limited to no use of forested areas, such results would challenge the conclusion of this thesis project that Balinese long-tailed macaques have a habitat specificity which is primarily limited to forested areas. Alternatively, if the fitness of these Balinese long-tailed macaques were found to be compromised, such results would also be significant for several reasons. They would support the conclusion of this thesis project's home range analysis that indicates the habitat specificity of Balinese long-tailed macaques is primarily limited to forested areas. Such results would also indicate that the Balinese long-tailed macaques at Batunmadeg are potentially genetically isolated from other troops, which would in turn support the conclusion of this thesis project's potential habitat corridor analysis results for Batunmadeg. In either event, Batunmadeg should be promoted as a site for conducting additional research on genetic and environmental factors that contribute to the potential genetic isolation between Balinese long-tailed macaque troops. Finally, such results would provide data on what types of landscape configurations can be promoted as part Balinese long-tailed macaque conservation projects.

Home Range City and Village Analysis Results

The home range city and village analysis results would appear to challenge the premise of this thesis' hypothesis that Balinese long-tailed macaques have a habitat specificity that is primarily limited to forested areas. However, there is evidence indicating that Balinese long-tailed macaque troops do not tend to range into village areas or on limited occasions when they do range into village areas it is only for very short distances and for short time periods away from a forested area. Such evidence is important because it not only supports results suggesting that Balinese long-tailed macaques have a habitat specificity that is primarily limited to forested areas, but it also supports the possibility that Balinese long-tailed macaques are utilizing the habitat corridors that were identified as a part of this thesis project to maintain gene flow between troops. However, the author recommends that ongoing research be conducted which will:

- Track the movements of Balinese long-tailed macaques to determine the home range patterns of troops located throughout Bali and develop a GIS database that can facilitate the determination of how home range patterns are changing or not changing over time.
- Collect data on environmental factors that may play a role in limiting or promoting Balinese long-tailed macaque troop movements within city and village.
- Collect data, from sources such as documents and interviews with village members, to determine the historical extent of Balinese long-tailed macaque troops throughout Bali.
- Compare data on the historical extent of Balinese long-tailed macaques, for selected sites and from multiple time periods, to determine what regions of Bali may have exhibited factors that have historically caused Balinese long-tailed macaque troops to go extinct or move their home range.
- Try to determine what factors may have historically contributed to some Balinese long-tailed macaque troops going extinct or moving their home ranges.
- Facilitate resource management projects to focus their efforts on promoting land use practices and landscape patterns on Bali, which will in turn promote the conservation of Balinese long-tailed macaques.

Home Range River and Stream Analysis Results

The home range river and stream analysis results indicate that Balinese long-tailed macaques may be capable of thriving without having a home range that overlaps with riverine forest. In turn, this supports the possibility that Balinese long-tailed macaque troops that appear to be exclusively exploiting Bali's riverine forested areas are not necessarily doing so by choice. Some troops may have had their traditional broader forested home ranges limited to riverine forest areas because of changes within Bali's landscape.

The ground verification results for site 4 (Ulu Watu) and site 13 (Ungasan), which indicate that these 2 sites do not overlap with a river or stream, are supported by the fact that the southern peninsular region of Bali receives an annual rainfall of less then 1,500 millimeters (Whitten, Soeriaatmadja, and Afiff 1996, 122-123). In addition, vegetation throughout this region consists predominantly of dry deciduous forest. However, the results of the home range river and stream analysis did not rule out the possibility that site 4 (Ulu Watu), site 5 (Batur), site 6 (Cekik), and site 13 (Ungasan) overlap with an intermittent river or stream. Therefore, the author recommends that additional research be conducted to:

- Determine whether or not these sites overlap with an intermittent river or stream.
- Determine what sources are being utilized by the Balinese long-tailed macaques to obtain water.
- Determine if the fitness of troops at a significant number of these sites has been or are becoming compromised.

Should the fitness of troops at a significant number of these sites turn out to be compromised and these sites are found not to overlap with a river or stream, then such results would provide some evidence that Balinese long-tailed macaques have a strong habitat preference for riverine forested areas. However, the author cautions that interpretation of such results should also take into consideration the possibility that troops at some of these sites are genetically isolated. Because of extensive development around the southern isthmus of Bali, there is a high probability that site 4 (Ulu Watu) and site 13 (Ungasan) are genetically isolated from troops located in areas outside of Bali's southern peninsular region. The results of this thesis project's potential habitat corridor analysis for site 5 (Batur) concluded that this site is most likely genetically isolated. The results of this thesis project's potential habitat corridor analysis for site 6 (Cekik) concluded that this site is most likely not genetically isolated.

GIS versus Ground Verification Results

The Indonesian government generally maintains tight controls over its maps and remote sensing data for Bali. It took the author approximately 1 year, with assistance from both Balinese Macaque Project members and the Central Washington University library, to obtain the 1:25000 Bakosurtanal map set that was utilized for the development of this thesis project's GIS database.

Variations between landscape patterns documented as a part of this thesis project's ground verifications and Bali's landscape patterns as represented on the 1:25000 Bakosurtanal maps were noted. The author suspects that some of these landscape discrepancies, especially associated with the location of village and city areas, is due to landscape changes that have occurred between when the 1:25000 Bakosurtanal maps were last revised (1991) and when ground verifications were conducted as a part of this thesis project. Other discrepancies, such as riverine forest areas that were documented as a part of this thesis project's ground verifications not being indicated on the 1:25000 Bakosurtanal maps, the author suspects can be attributed to factors such as: the scale of the maps (1:25000), inherent limitations in the remote sensing and ground verification data that was utilized in the making of the maps; or decisions that were made about how much detail should be included in drafting of map features.

Within this thesis project, discrepancies between ground verification and map data did not pose a significant problem. One reason for this is that the majority of the data contained on the 1:25000 Bakosurtanal maps were found to be a fairly accurate representation of Bali's landscape. Another reason is that most discrepancies were not so much based upon landscape data contained on the 1:25000 Bakosurtanal maps, but landscape data that was not contained on the 1:25000 Bakosurtanal maps. In these cases, ground verification data could be utilized to supplement the 1:25000 Bakosurtanal map data. Finally, in the few instances where discrepancies between ground verification and GIS data could not be resolved (e.g., the contradiction over whether or not a stream is located in the area of Ulu Watu) this thesis project was able to utilize those discrepancies as a foundation for making recommendations for future research. The author recommends that future landscape ecology research projects with a focus on Bali:

- Establish standards for map and remote sensing data, which will be utilized in the development of a GIS database, prior to attempting to obtain map and remote sensing data for Bali.
- Plan on the possibility that map and remote sensing data may be difficult to obtain for Bali.
- Scrutinize map and remote sensing data that is obtained for Bali, prior to utilizing it for the development of a GIS database, for accuracy and to make sure that it suitable for project use based upon pre-established standards.

- Plan on the possibility that, even after map and remote sensing data is pre-scrutinized, landscape discrepancies will still be encountered between the map, remote sensing data, and results obtained from subsequent ground verification.
- Establish methodologies in anticipation of the possibility that ground verification results may have to be utilized in lieu of those obtained from GIS analysis, but also take into account potential difficulties associated with conducting ground surveys on Bali.

CHAPTER X

BALINESE LONG-TAILED MACAQUE CONSERVATION CONCERNS

INTRODUCTION

The Tri-Hita Karana doctrine represents a model of "ideal" cultural form for the Balinese. An ideal culture is one that promotes people living in harmony with each other, god, and nature. Because of the Tri-Hita Karana doctrine, there is a foundation for the development of conservation programs for Balinese long-tailed macaques. However, if Balinese long-tailed macaques are going to be conserved well into the future, the Tri-Hita Karana doctrine must result in land use practices that promote the conservation of Bali's remaining forests.

The results of this thesis indicate that deforestation may represent a significant threat to the viability of Balinese long-tailed macaque populations. There are currently an estimated 10,000 Balinese long-tailed macaques on Bali and a large number of Balinese long-tailed macaque troops appear to be thriving. However, traditional Balinese land use systems have promoted widespread deforestation on Bali. In addition, there is reason for concern that ongoing human population growth combined with changes in Balinese land use will continue to cause deforestation.

This chapter's section on resource management systems, examines whether or not a resource management system is currently in place that can adequately promote the future conservation of Bali's natural resources. The pros and cons associated with local (Balinese) versus central Indonesian government control over the management of Bali's natural resources will be the focus of this discussion. In the third section of this chapter, the author will make recommendations for conflict resolution.

BALINESE LAND USE AND DEFORESTATION

Traditional Land Use Systems

Today, most of Bali's forests appear to be located in areas that have historically not been suitable for the development of rice agriculture and villages. This indicates that traditional Balinese land use systems have primarily promoted the exploitation of Bali's natural resources for the expansion of villages and rice agriculture. In addition, Balinese land use systems have traditionally not promoted the conservation of Bali's forests.

The majority of Bali's western peninsular, southern peninsular, eastern peninsular and southeastern coastal regions have not been suitable for rice agriculture because of low annual precipitation. Extending irrigation into these regions from neighboring low-lying areas has historically not been a cost-effective option.

The upper slopes of Bali's central volcanic mountain chain comprise a region that receives high annual precipitation and yet, historically, has also not been utilized extensively for rice agriculture. One possible explanation for why this region has not been utilized extensively for rice agriculture is that this region may be composed of highly permeable pyroclastic fall deposits. These deposits represent groundwater recharge areas and, therefore, surface water for rice agriculture may be limited (Tanaka and Sunarta 1994, 182-190). Tanaka and Sunarta indicate that on the southern slopes of Gunung Batur these pyroclastic fall deposits appear to be located above 500 meters in elevation, which appears to explain why rice fields on the southern slopes of Gunung

Batur are located primarily below 500 meters in elevation. However, Tanaka and Sunarta further indicated that the elevation at which pyroclastic fall deposits transition into pyroclastic flow deposits may be related to a slope factor (Tanaka and Sunarta 1994, 182-190). The author conducted an informal GIS analysis and determined that most of Bali's rice fields appear to be located on slopes of less then 20%. The author recommends that additional research be conducted to further test this hypothesis. Another reason why the upper slopes of Bali's central mountain chain may not be suitable for rice agriculture has do with Bali's radial drainage patterns. As rivers and streams flow down Bali's steep mountain slopes they expend energy down-cutting into soft volcanic rock. As a result, drainage patterns towards the top Bali's mountains tend to consist of deep gorges separated by interfluves with precipitous slopes. These interfluves are often unstable and have historically not been suitable for the development of rice agriculture and villages.

The south-central region of Bali has been the most suitable region for the development of rice agriculture because it has relatively fine-textured soils that can hold water on the surface of the ground. This region also exhibits a large number of rivers, streams, and springs that provide a convenient and ample supply of irrigation water. Further more, drainages in this region tend to not be as deeply down cut in comparison to those found on the steeper mountain slopes and exhibit interfluves that are relatively wide, flat, and stable. Throughout this region, most of the interfluves have been extensively developed for rice agriculture, cities, and villages. Forested areas are mostly limited to drainage bottoms, small groves in rice fields, around temple sites, and gardens that are grown in and around cities and villages.

Recent Land Use Changes

Starting in the 1970s, the Balinese economy began to rapidly transition away from an exclusive agricultural base. The primary stimuli for this transition were human population growth and the inability of the rice agricultural sector to create new jobs. In 1983, tourism was estimated as representing only 10% of Bali's total gross domestic product. By 1994, tourism represented an estimated 42% and agriculture was estimated as representing barely 28% of Bali's total gross domestic product (Picard 1996, 57). As of 1996, it was estimated that 1,082 square kilometers of Bali's total land area of 5,560 square kilometers was being utilized for rice agriculture (Whitten, Soeriaatmadja, and Afiff 1996, 5-11).

The development of land for tourist-related purposes is creating a loss of approximately 1,000 hectares (10 square kilometers) of Bali's rice fields per year (Whitten, Soeriaatmadja, and Afiff 1996, 60). Business developers are building everything from theaters, hotels, golf courses, amusement parks, shopping malls, art shops, restaurants, fast food chains, and convenience stores with the hopes of profiting from Bali's existing tourists and luring additional tourists to Bali. Urban sprawl is compounded by the growing numbers of Balinese who are moving into urban areas in search of jobs in the tourist economy and immigrants who are moving to Bali in order to take advantage of its relatively successful economy. Urban sprawl is a growing trend throughout Bali, but is probably most noticeable in the area of Denpasar (Bali's capital city, population 700,000 people) (see Figure 5) (Lyon and Wheeler 1997, 168). Today, it is possible to drive across the southern isthmus of Bali, through the streets of Denpasar, and almost 30 kilometers to the north of Denpasar and not see a landscape that is dominated by either forest or rice fields. Because of urban development within Bali's southern isthmus region, Balinese long-tailed macaque troops on Bali's southern peninsula, such as sites 4 and 13 (see Figure 16), are most likely isolated from gene flow with troops located north of Denpasar.

The transition of Bali's economy is also creating new demands for forest products. Bali's growing human population is creating demands for basic necessities such as wood for housing construction. In addition, there are also a growing number of Balinese who have the purchasing power to consume a greater quantity and a wider variety of goods and services. Tourists contribute directly to the growing demand for forest products in a wide variety of ways. Tourists require basic necessities such as food and housing. Tourists also purchase a large number of luxury items (that are made from wood) such as Balinese art products. Currently, the Balinese are importing most of the wood for art products from other Indonesian islands.

Because urban sprawl has primarily been limited to rice field areas and because the Balinese import a large number of forest products from other Indonesian islands, deforestation is currently not a major factor on Bali. Of concern is Bali's human population which will most likely continue to grow for many years and the general lack of forest conservation programs on Bali.

Balinese Long-Tailed Macaque Conservation Implications

There are several potential impacts of deforestation on Balinese long-tailed macaques. Troops that experience a significant amount of deforestation within their home range can either become extinct or be forced to establish a new home range.

Troops that are displaced from their home range may experience competition with other troops (inter-troop competition). Deforestation within a troop's home range may also cause individuals within the same troop to compete (intra-troop competition). Competition leading to violent inter-troop or intra-troop clashes can generate stress that can lead to a reduction in fitness and in some cases the death of individuals. While provisioning by humans may reduce intra-troop or inter-troop competition, provisioning can also lead to increased fitness within troops. If the population of a troop receiving provisioning levels off above the natural carrying capacity of its home range, significant decreases in provisioning may cause extreme stress or mortality within that troop. Stress and mortality might be ameliorated by gradually weaning troops off of provisioning or by restoring lost habitat. In such cases the question must be examined as to why provisioning or habitat loss was allowed to occur in the first place.

There are several potential conservation ramifications of habitat or forest corridor fragmentation. Troops that cannot disperse along forest corridors may have a higher potential of going extinct than troops that can disperse along forest corridors in instances where home range habitat is undergoing severe degradation. The ability of Balinese long-tailed macaques to disperse throughout Bali may also play a role in the viability of the Balinese long-tailed macaque metapopulation. Morphological variability within the Balinese long-tailed macaque metapopulation may insure that at least some Balinese long-tailed macaque troops will survive an event of widespread and dramatic shift in Bali's environment. However, morphological variability within the Balinese long-tailed macaque metapopulation may be a function of either the ability of Balinese long-tailed macaques to disperse throughout Bali's landscape and/or localized selective pressures. Forest corridors may also promote the out-migration of males from troops. Out-migration of males may act to reduce the potential for intra-troop competition in circumstances where home range habitat is degraded. Additional evidence indicates that male Balinese long-tailed macaques act as the units of gene flow between troops (Kawamoto, Ischak, and Supriatna 1984, 131-159).

There are circumstances in which variable migration may reduce the viability of specific Balinese long-tailed macaque troops. Within smaller populations out-breeding tends to promote greater genetic variability and inbreeding tends to reduce genetic variability. Therefore, the viability of a population may depend on the traits favored by natural selection in any given situation. In this sense, forest management strategies that promote both the fragmentation and restoration of Balinese long-tailed macaque habitat corridors, variable throughout both space and time, may ultimately be the best strategies for promoting the conservation of the Balinese long-tailed macaque metapopulation. Trends indicate that Bali is becoming increasingly deforested. Given the wide range of potential negative impacts that deforestation can have on the conservation of Balinese long-tailed macaques, until additional research is conducted, conservation programs should adopt strategies that promote a reduction in the potential for future deforestation to occur on Bali.

RESOURCE MANAGEMENT SYSTEMS

Central Government Control

According to Indonesia's Constitution and 1960 Agrarian Act, the central Indonesian government has the sole authority to regulate and implement the allocation, use, supply, and care of all resources. In addition, national interest is placed above that of individuals and all rights to land imply a social function (Whitten, Soeriaatmadja, and Afiff 1996, 70).

Beyond the legal authority to manage Bali's natural resources, within the central Indonesian government there is also a framework to design and implement resource management projects that will promote the conservation of Bali's natural resources. The central Indonesian government has:

- Technologies, such as GIS and remote sensing, to monitor Bali's natural resources.
- Scholars that are capable of overseeing the development and implementation of natural resource management projects.
- A large police force.
- The ability to organize labor for conducting conservation projects.
- Means for communicating with potential resource management project stakeholders.

Despite this framework, there appears to be a large discrepancy between what the central Indonesian government has historically been capable of doing and what it has historically done to promote the conservation of Bali's natural resources.

An attempt to define why the central Indonesian government appears to have a poor track record for promoting the conservation of Bali's natural resources is difficult. One possibility is that the central Indonesian government does not have a large enough tax base to adequately fund projects that will promote the conservation of Bali's natural resources. As previously discussed, a large percentage of the central Indonesian government's tax revenues go towards making payments on its foreign debt. The central Indonesian government must also balance the utilization of tax revenues for promoting the conservation of Indonesia's natural resources with the utilization of tax revenues to promote the development of Indonesia's economy and the creation of jobs for Indonesia's rapidly growing work force. However, many of the Balinese that the author talked to did not necessarily buy into this argument. Instead, the author was repeatedly reminded that the central Indonesian government appears to be utilizing tax revenues to fund frivolous projects (e.g., the building of elaborately designed government office buildings on Bali).

Corruption may be another reason why the central Indonesian government has a poor track record of promoting the conservation of Bali's natural resources. Several research projects have documented instances in which corruption within the central Indonesian government has, or may be, undermining the conservation of Indonesia's natural resources. For example, Bali's textile dye businesses are supposed to obtain an operating permit from the central Indonesian government. These permits contain an environmental management plan and a monitoring plan that is approved by government officials. Still, according to one study, it is not uncommon for textile dye businesses to operate without having obtained a permit. When visited by regulatory officials, textile dye businesses often pay regulatory officials a small bribe in order to continue operating (Haight and Ratha 1995, 233). Another study cited corruption within the central Indonesian government as a major reason why the number of Sumatran orangutans has rapidly declined (Robertson and Van Schaik 2001, 26-34).

In addition to funding and corruption problems, other factors that may have played a role in the central Indonesian government developing a poor track record for promoting the conservation of Bali's natural resources include: lack of oversight and communication within the central Indonesian government; difficulties associated with balancing human rights, given that many Balinese support themselves by directly exploiting Bali's natural resources, with the conservation of Bali's natural resources; Bali's rapidly growing human population; and failure on the part of the central Indonesian government to include the Balinese as stakeholders within the design and implementation of planning projects for Bali.

Many Balinese are leery of any central Indonesian government control over Bali's natural resources because the Dutch, Japanese, and the central Indonesian government have all historically utilized their rule to exploit these resources. The Suharto administration developed its master plan for tourism on Bali not so much to benefit the Balinese as to capitalize off of Bali and balance Indonesia's national debt (Picard 1996, 118). By the end of the 1980s, the fact that the central Indonesian government and foreign investors appeared to be profiting the most from Bali's tourism, while the Balinese were having their environment increasingly degraded, became the focus for Balinese protests against the central Indonesian government (Picard 1996, 164-186). Today, any attempt by the central Indonesian government to sponsor development projects on Bali will typically raise Balinese protests. Another Balinese criticism of the Suharto administration's master plan to develop tourism on Bali was that the master plan called for a concentration of resorts in the south of Bali and did not take into account balanced regional development (Picard 1996, 118). As a result, attempts by the central Indonesian government to limit where development can occur on Bali have historically drawn equal protests from the Balinese.

Trying to define why the central Indonesian government has a poor track record of promoting the conservation of Bali's natural resources is also made difficult because social, political, and economic factors can merge in varying ways to undermine individual resource management projects. This complexity is illustrated in the case of the Bali Barat National Park.

The central Indonesian government, in one of its most ambitious attempts to conserve Bali's natural resources, established the Bali Barat National Park. The Bali Barat National Park was originally designed to conserve 60,000 hectares of Bali's relatively undisturbed natural areas. The park that was declared in 1982 was only 19,000 hectares in size and contained large areas of land that had been extensively degraded by human activities (Whitten, Soeriaatmadja, and Afiff 1996, 827). Efforts to expand the park back to its original planned size have been hindered by breakdowns in negotiations between the provincial forest service and the national park authorities (Whitten, Soeriaatmadja, and Afiff 1996, 827). Poaching is a rapidly growing problem within the park and in the past several years an immigrant village has been built within the park boundaries. The immigrant village was built by transmigration Balinese who have returned to Bali. Village members have been attempting to earn a living by cutting teak wood out of the park. Park rangers have been successful in catching some of the poachers and in confiscating wood that has been cut within the park, however, the number of park rangers is relatively low, funding for the rangers is relatively low, and human rights issues associated with people such as immigrants who are settling within the Bali Barat National Park sometimes override the authority of the park rangers to enforce laws. Even when park rangers catch poachers or other law violators, many judges within the central Indonesian government court system are sympathetic to the argument that humans are more important then nature and are reluctant to pass down convictions against violators of laws involving the exploitation of natural resources (Whitten, Soeriaatmadja, and Afiff 1996, 68-69).

Local Level Control

Many Balinese would like the central Indonesian government to relinquish or limit its authority to make resource management decisions for Bali. This would include the central Indonesian government limiting its taxation and allowing Balinese cities and villages more equity in tourism.

There are cases in which local oversight has promoted the conservation of Bali's natural resources. One example is the Ubud Monkey Forest of Padangtegal. The village of Padangtegal, owns the Ubud Monkey Forest of Padangtegal. Village members serve on the governing council for the sacred monkey forest. In turn, the governing council oversees a forest manager (who is hired by the governing council). The forest manager makes management recommendations to the governing council, hires and supervises forest caretakers, and along with his staff members is responsible for the care of the forest. In 1998, the monkey forest underwent a management change. Prior to 1998, the monkey forest had a manager that did a poor job of controlling environmental damage. Plastic trash was allowed to accumulate (up to 1 foot thick) in areas of the forest choking out large areas of vegetation and leading to soil erosion becoming a major problem. There were very few programs to promote the health of the Balinese long-tailed macaques or the marketing of the monkey forest to tourists.

Since 1998, I Wayan Selamet (manager of the Ubud Monkey Forest), working in collaboration with the monkey forest's governing council and the Balinese Macaque Project, has developed new management strategies for the monkey forest. As a result of the implementation of these management strategies the monkey forest currently has very little trash on the ground, lush vegetation, very little soil erosion, and a multi-faceted provisioning and veterinarian care program for the Balinese long-tailed macaques. The monkey forest also has a professional staff trained in aspects of tourism and forestry, programs that educate local village members on the importance of the monkey forest, and increased tourism.

It is estimated that on average 120,000 visitors pass through the monkey forest annually. The current entrance fee for the monkey forest is nominal (3,000 Rupiah or approximately 35 cents U.S.). The governing committee has resisted increasing the entrance fee because they would like to share the monkey forest with as many people as possible. I Wayan Selamet currently uses 40% of the monkey forest's entrance fee revenues to pay central Indonesian government taxes. If the central Indonesian government allowed the village of Padangtegal greater equity in its monkey forest revenues, the village of Padangtegal could utilize those revenues to further expand their efforts to conserve natural resources and to promote local tourism.

Although additional village level control would most likely directly benefit the conservation of Balinese long-tailed macaques within the Ubud Monkey Forest, circumstances surrounding the management of the forest are somewhat unique on Bali. The village of Ubud has long been a very popular tourist destination, in large part because Ubud represents a major center for Balinese arts. While the Ubud Monkey

Forest is a popular tourist destination, it is the attraction of the village of Ubud that has historically facilitated popularity of the Ubud Monkey Forest of Padangtegal. In turn, without revenues from tourism it is doubtful that the Ubud Monkey Forest's governing committee would have developed or would maintain the existing monkey forest management structure. The situation at the Ubud Monkey Forest might have turned out differently had the governing committee not selected I Wayan Selamet, to manage the monkey forest, and had the Balinese Macaque Project chosen not to focus its research on the Ubud Monkey Forest of Padangtegal. Both I Wayan Selamet and the Balinese Macaque Project have been instrumental in developing new monkey forest management strategies. As a result of those strategies the Ubud Monkey Forest of Padangtegal has expanded and is continuing to expand its marketability as a tourist destination.

There are a large number of Balinese long-tailed macaque home range sites that are located next to cities and villages that receive very little to no tourists. There are some Balinese cities and villages that receive support from non-government organizations (NGOs) or the central Indonesian government for establishing tourism and conservation projects, but these cities and villages tend to be an exception on Bali. In cases where Balinese long-tailed macaques do not directly benefit the local economy, there tends to be little to no impetus for village members to take any special sort of management initiatives to conserve Balinese long-tailed macaques. This is cause for concern given that many cities and villages are experiencing increased pressure to exploit natural resources and there are indications that Balinese long-tailed macaques have historically been pushed out of some areas because of development projects.

Even if a large number of villages had the monetary and technical support to develop tourism centered on their Balinese long-tailed macaque troops many of these tourism ventures would probably fail. There are a large number of Bali's tourists that have never seen Balinese long-tailed macaques and are willing to travel to tourist sites that primarily feature Balinese long-tailed macaques. The author observed tourists within the Ubud Monkey Forest of Padangtegal and noted that many of the tourists spent little to no time looking at the monkey forest's 3 temple sites. Instead, they spent a large percentage of their time observing the Balinese long-tailed macaques. Still, there are no indications that a significant number of tourists will travel outside of routes between popular tourist destinations or outside of areas that feature a wide assortment of tourism opportunities exclusively to see Balinese long-tailed macaque home range sites. In addition, even if a significant number of tourists were willing to travel long distances just to see sites that primarily feature Balinese long-tailed macaques, the potential for the Balinese long-tailed macaque tourist market to become rapidly saturated is high.

RECOMMENDATIONS

Ideally, the central Indonesian government and the Balinese should both share in the responsibility of managing Bali's natural resources. Because pollution and wildlife can move across city and village boundaries, there must be some form of governing system that provides resource management oversight for all of Bali. However, the central Indonesian government will continue to fail in its attempts to manage Bali's natural resources unless it can gain the support of the Balinese. This will require that the central Indonesian government develop a resource management system for Bali that allows the Balinese to have input within all phases of resource management projects. These resource management project phases include: the monitoring of Bali's natural resources; the development of resource management goals, objectives, and activities; the implementation of resource management activities; monitoring or policing of resource management activities; and project re-evaluations.

The author recommends that the first step the central Indonesian government should take in an attempt to develop a comprehensive resource management system for Bali is forming a resource management committee for Bali. This committee should consist of representatives of the central Indonesian government (such as from the Ministry of Forestry) and the Balinese. A salary should be granted to committee members and serving as a committee member should represent a full time job. Funding for a resource management committee could be raised through Bali's airport tax on tourists. Initially, the primary responsibility of the resource management committee should be to establish guidelines for the conservation of Bali's natural resources. Included within those guidelines should be a mission statement and operation protocols for the resource management committee.

The author further recommends that a second oversight committee be formed. The oversight committee should consist of Balinese, representatives of the central Indonesian government, and foreign consultants. The role of the oversight committee should be to provide oversight during the formation of the resource management committee, facilitate communications between resource management committee members, review protocols adopted by the resource management committee, provide technical support, and make sure that the resource management committee fulfills its obligation to establish guidelines for the conservation of Bali's natural resources. An obligation of both committees should be to establish protocols for phasing out foreign oversight in favor of additional central Indonesian government and Balinese cooperative control.

As an interim measure, until a cooperative resource management system can be developed between the Balinese and the central Indonesian government, the author recommends that the Balinese rice agricultural system be adapted to help control pollution and loss of biodiversity on Bali. The Balinese rice agricultural system has persisted and worked well as a resource management system because:

- It has promoted reciprocity between individuals within the Balinese society.
- It has been capable of monitoring resource use at both the local and regional levels.
- It has promoted upward communication within the water temple system allowing individual farmers the opportunity to have input in the development of resource management goals, objectives, and activities.
- It has promoted top-down implementation since resource management goals, objectives, and activities are developed and implemented starting at the top of the water temple system.
- It has promoted system uniformity and the ability to troubleshoot problems.
- It has been capable of passing down punishments against individuals that are not doing their part to conserve resources.
- It has provided farmers a forum to work out disputes without resorting to violence and/or creating widespread disruption within the rice agricultural system.
- It is based upon water and soil conservation techniques that have been tested over many generations.
- It is also capable of integrating new technologies.

The author further recommends that the adaptation of the Balinese rice agricultural system be carried out as a joint project between university staff and students from Bali and the United States of America (U.S.). In Phase I, of the project, university staff and students from Bali and the U.S. would cooperate to develop a detailed GIS database for Bali. The development of a detailed GIS database for Bali would include collection of data on water temple system configurations, forest configurations, and water quality. Modeling would be conducted on the GIS database to determine how potential management boundaries can be established within the framework of the existing water temple system and to rank landscape areas according to how critical they are for management purposes.

In Phase II of the project, university staff and students will present the project to, and gather comments from, Balinese Hindu priests, city and village representatives, Non-Government Organization (NGO) representatives, and representatives from the central Indonesian government. Depending on the types of comments collected during the second project phase, the project would pass into additional phases that would require university staff and students to: conduct additional resource management system test trials and further public education; implement project activities that are designed to facilitate the adaptation of Bali's water temple system (to manage pollution and loss of biodiversity); monitor project results; and adapt project goals, objectives, and activities in response to monitoring feedback. Such a project would:

- Develop an environmental database for Bali that could be utilized as a foundation for conducting future research and resource management projects.
- Potentially adapt Bali's water temple system so that it can facilitate the management of pollution and loss of biodiversity on Bali.
- Provide an opportunity to create goodwill between Balinese and U.S. university staff and student members.
- Provide a framework for Balinese and U.S. university staff members to conduct additional joint research and resource management projects.

- Provide an opportunity for university students and staff members from both the U.S. and Bali to learn about each other's cultures and landscapes.
- Provide an opportunity for staff and students from Bali's universities to become acquainted with technologies, such as GIS and GPS, which are currently not readily available on Bali.
- Potentially develop goodwill between the Balinese, the central Indonesian government, NGOs, and universities.

CHAPTER XI

CONCLUSIONS

It is estimated that humans are causing the extinction of 5% to 11% of the world's existing species per decade (nearly 30,000 times the background rate of extinctions for the past 65 million years). By the end of the twenty-first century, a quarter of the world's biodiversity will have been lost exclusively to the clearing of tropical rain forests (Raven and McNeely 1998, 19-20).

The importance of long-tailed macaques *(Macaca fascicularis)* has generally been overlooked in the context of understanding and developing global biodiversity management strategies. Comparisons of home range locations have historically been interpreted as indicating that long-tailed macaques have a broad habitat specificity. In past studies, the regional population size and geographic range of long-tailed macaques has been assessed as being large.

Research suggests that long-tailed macaques may not have broad habitat specificity. Although long-tailed macaques are found throughout Southeast Asia, if the primary habitat of long-tailed macaques is forested areas, the potential for long-tailed macaque troops to become genetically isolated might be relatively high. One reason for this is that deforestation represents a major problem throughout much of southeast-Asia. As forested areas become increasingly fragmented, long-tailed macaque metapopulations will most likely also become increasingly fragmented. Such fragmentation can ultimately lead to the loss of viability of long-tailed macaque metapopulations. Because long-tailed macaques represent a core species for the examination of metapopulation pressures, long-tailed macaques are emerging as an important species in the development of global biodiverisity management strategies. According to Meffe and Carroll:

> A single population or metapopulation exists somewhere along a spectrum of isolation and gene flow, from an extreme of complete isolation and no genetic exchange with other populations, to the opposite extreme of free genetic exchange among populations. These natural biogeographic structures have important implications for genetic management because they are often altered by human actions, which may seriously affect fitness and local adaptation (Meffe and Carroll 1997, 189).

Balinese long-tailed macaques provide a unique opportunity to further test how molecular techniques can be combined with GIS and GPS technologies both to establish a better understanding of the history and distribution of primates and to establish biodiversity conservation strategies.

The Balinese have had a sustainable sympatric relationship with long-tailed macaques for at least 2 millennia. The results of this thesis indicate that the primary habitat of Balinese long-tailed macaques is forested areas. The results of this thesis also indicate that several Balinese long-tailed macaque troops are probably genetically isolated. Over the past several decades the Balinese economy has made a transition away from an exclusive agricultural base and it is quite likely that over the next couple of decades, unless conservation measures are put into place, human population growth and urban development will cause widespread deforestation on Bali. In turn, deforestation may cause many Balinese long-tailed macaque troops to go extinct and cause the Balinese long-tailed macaque metapopulation to suffer reduced viability.

WORKS CITED

Access Bali Online. 1998. "Religion and Customs" 7 March 2002 <http://baliwww.com/bali/info/religion_costums.htm>

Adiwoso-Suprapto, Riga. The Society and Its Environment. In *Indonesia: A Country Study.* 4th ed. Frederica M. Bunge, 63-117. Washington, D.C.: Federal Research Division, Library of Congress, 1983.

Bartlett, John. 1963. *The Shorter Bartlett's Familiar Quotations.* Edited by Kathleen Sproul. New York: Pocket Books, Inc. Original edition, United States of America: Little, Brown and Company, 1937.

Bater, James. 1995. Bali: Economic Development and Industry. In Bali: *Balancing Environment, Economy and Culture.* eds. Sugeng Martopo and Bruce Mitchell, 75-91. Waterloo, Canada: Department of Geography University of Waterloo.

Bellwood, Peter. 1985. *Prehistory of the Indo-Malaysian Archipelago.* Orlando, Florida: Academic Press, Inc.

Blij, H.J. de. 1996. *Human Geography: Culture, Society, and Space.* 5th ed. New York: John Wiley and Sons, Inc.

Clarke, Keith C. 1999. *Getting Started with Geographic Information Systems.* 2d ed. Prentice Hall Series in Geographic Information Science. Upper Saddle River, New Jersey: Prentice-Hall, Inc.

Collinwood, Dr. Dean W., ed. 1993. *Global Studies: Japan and the Pacific Rim.* 2d ed. Guilford, Connecticut: The Dushkin Publishing Group, Inc.

Covarrubias, Miguel. 1937. *Island of Bali.* New York: Alfred A. Knopf, Inc.

Crockett, Carolyn M., and Wendell L. Wilson. 1980. The Ecological Separation of Macaca nemestrina and M. fascicularis in Sumatra. In *The Macaques: Studies in Ecology, Behavior, and Evolution,* ed. Donald G. Lindburg, Ph.D., 148-181. San Francisco: Van Nostrand Reinhold Company.

Dahlby, Tracy. 2001. Indonesia. *National Geographic Magazine,* March, 80-87.

Delson, Eric. 1980. Fossil Macaques, Phyletic Relationships and a Scenario of Deployment. In *The Macaques: Studies in Ecology, Behavior, and Evolution,* ed. Donald G. Lindburg, Ph.D., 10-30. San Francisco: Van Nostrand Reinhold Company.

Eudey, Ardith A. 1980. Pleistocene Glacial Phenomena and the Evolution of Asian Macaques. In *The Macaques: Studies in Ecology, Behavior, and Evolution,* ed. Donald G. Lindburg, Ph.D., 52-83. San Francisco: Van Nostrand Reinhold Company.

Eudey, Ardith A. 1996/1997. Asian Primate Conservation-The Species and The IUCN/SSC Primate Specialist Group Network. *Primate Conservation* 17: 101-110.

Fooden, Jack. 1995. Systematic Review of Southeast Asian Longtail Macaques, Macaca fascicularis (Raffles, [1821]). *Fieldiana: Zoology,* n.s., 81: 186-206.

Forman, Werner, Rudolf Mrazek, and Bedrich Forman. 1983. *Bali: The Split Gate To Heaven.* London: Orbis Publishing Limited.

Griffiths, Michael. 1990. *Indonesia Eden: Aceh's Rainforest.* Baton Rouge, Louisiana: Louisiana State University Press.

Haight, Murray E., and Dr. Dra. Mardani Ratha. 1995. Wastes: Issues and Opportunities. In *Bali: Balancing Environment, Economy and Culture.* eds. Sugeng Martopo and Bruce Mitchell, 215-236. Waterloo, Canada: Department of Geography University of Waterloo.

Harries, Keith D. and Robert E. Norris. 1986. *Human Geography: Culture, Interaction, and Economy.* Columbus, Ohio: Merrill Publishing Company.

Hickman, Cleveland P. Jr., Larry S. Roberts, and Frances M. Hickman. 1984. *Integrated Principles of Zoology.* 7th ed. St. Louis, Missouri: Times Mirror/Mosby College Publishing.

Hiebert, Paul G. 1982. India: Politicization of a Sacred Society. In *Religions and Societies: Asia and the Middle East.* ed. Carlo Caldarola, 289-331. New York: Mouton Publishers.

Huxley, Sir Julian., ed. 1968. *The Illustrated Libraries Of Human Knowledge.* Vol. III, *Search For Truth.* London: Aldus Books Ltd.

Information Please Almanac, 1998 ed. S.v. "Countries of the World: Indonesia".

Jablonski, Nina G. 1998. The Response of Catarrhine Primates to Pleistocene Environmental Fluctuations in East Asia. *Primates* 39(1): 29-37.

Kawamoto, Y., T.B.M., Ischak, and J. Supriatna. 1984. Genetic variation within and between troops of Crab-eating (*Macaca fascicularis*) on Sumatra, Java, Bali, Lombok and Sumbawa, Indonesia. Primates 25(2): 131-159.

Keum, Peter. 1993. New Cub in the Pack: Indonesia Prepares to Join the Four Tigers. In *Global Studies: Japan and the Pacific Rim.* 2d. ed. ed. Dr. Dean W. Collinwood. Guilford, Connecticut: The Dushkin Publishing Group, Inc.

Kuipers, Joel C. The Society and Its Environment. In *Indonesia: A Country Study.* 5th ed. eds. William H. Frederick and Robert L. Worden, 69-135. Washington, D.C.: Federal Research Division, Library of Congress, 1993.

Lansing, Stephen J. 1983. *The Three Worlds of Bali.* New York: Praeger Publishers.

Lansing, Stephen J. 1995. *The Balinese.* Case Studies in Cultural Anthropology. ed. George and Louise Spindler. Orlando, Florida: Hardcourt Brace College Publishers.

Lyon, James, and Tony Wheeler. 1997. *Lonely Planet Travel Survival Kit: Bali and Lombok.* 6th ed. Australia: Lonely Planet Publications.

Marshall, Kathryn G. The Economy. In *Indonesia: A Country Study.* 5th ed. eds. William H. Frederick and Robert L. Worden, 137-206. Washington D.C.: Federal Research Division, Library of Congress, 1993.

McKnight, Tom. 1996. *Physical Geography: A Landscape Appreciation.* 5th ed. Upper Saddle River, New Jersey: Prentice-Hall, Inc.

Means, Gordon P. 1982. Malaysia: Islam in a Pluralistic Society. In *Religions and Societies: Asia and the Middle East.* ed. Carlo Caldarola, 445-496. New York: Mouton Publishers.

Meffe, Gary K., and Ronald C. Carroll. 1997. Genetics: Conservation of Diversity within Species. In *Principles of Conservation Biology.* 2d ed. Gary K. Meffe, Ronald C. Carroll, and Contributors, 161-201. Sunderland, Massachusetts: Sinauer Associates, Inc.

Mitchell, Bruce. 1995. DESA Sustainability in Bali. In *Bali: Balancing Environment, Economy and Culture.* eds. Sugeng Martopo and Bruce Mitchell, 373-388. Waterloo, Canada: Department of Geography University of Waterloo.

Narayan, R.K. 1977. *The Ramayana: A Shortened Modern Prose Version of the Indian Epic.* New York: Penguin Books. Original edition, United States of America: Viking Penguin Inc., 1972.

Naveh, Zev, and Arthur S. Lieberman. 1984. *Landscape Ecology: Theory and Application.* New York: Springer-Verlag New York.

Neill, Wilfred T. 1973. *Twentieth-Century Indonesia.* New York: Columbia University Press.

Padangtegal Wanara Wana Foundation. 1999. *Welcome to the Mandala Wisata Wanara Wana: Sacred Monkey Forest Sanctuary Padangtegal, Ubud, Bali.* Padangtegal, Bali: privately printed.

Penders, C.L.M. 1974. *The Life and Times of Sukarno.* London: Sidgwick and Jackson.

Phalgunadi, Dr. I. Gusti Putu. 1991. *Evolution of Hindu Culture in Bali (From the Earliest Period to the Present Time).* New Delhi: Sundeep Prakashan.

Picard, Michel. 1996. *Bali: Cultural Tourism and Touristic Culture.* Translated by Diana Darling. Republic of Singapore: Archipelago Press.

Poirier, Frank, and Jeffrey K. McKee. 1999. *Understanding Human Evolution.* 4th ed. Upper Saddle River, New Jersey: Prentice Hall.

Pudjomartono, Susanto, ed. "Govt to proceed with Soeharto graft charges" *The Jakarta Post* 7 October 2000, 1.

Pulliam, Ronald, H., and John B. Dunning. 1997. Demographic Processes: Population Dynamics on Heterogeneous Landscapes. In *Principles of Conservation Biology.* 2d ed. Gary K. Meffe, Ronald C. Carroll, and Contributors, 203-232. Sunderland, Massachusetts: Sinauer Associates, Inc.

Raven, Peter H., and Jeffrey A. McNeely. 1998. Biological Extinction: Its Scope and Meaning for Us. In *Protection of Global Biodiversity: Converging Strategies,* ed. Lakshman D. Guruswamy and Jeffrey A. McNeely, 13-32. Durham, North Carolina: Duke University Press.

Robertson, Yarrow J.M., and Carel P. Van Schaik. 2001. Causal factors underlying the dramatic decline of the Sumatran orang-utan. *Oryx 35*: 26-38.

Rowntree, Les, Martin Lewis, Marie Price, and William Wyckoff. 2000. *Diversity Amid Globalization: World Regions, Environment, Development.* Upper Saddle River, New Jersey: Prentice Hall.

Seekins, Donald M. Historical Setting. In *Indonesia: A Country Study.* 4th ed. ed. Frederica M. Bunge, 1-61. Washington, D.C.: Federal Research Division, Library of Congress, 1983.

Seekins, Donald M. Historical Setting. In *Indonesia: A Country Study.* 5th ed. eds. William H. Frederick and Robert L. Worden, 1-67. Washington, D.C.: Federal Research Division: Library of Congress, 1993.

Sethuraman, S.V. 1985. The informal Sector in Indonesia: Policies and Prospects. *International Labour Review* 124(6): 719-735

Singh, Anoop. "Challenge of sustaining recovery" *The Jakarta Post* 7 October 2000, 4.

Slattum, Judy. 1992. *Masks of Bali.* San Francisco: Chronicle Books.

Tanaka T., and N. Sunarta. 1994. Relationship between regional changes of soil physical properties and volcanic stratigraphy on the southern slope of Batur volcano in the island of Bali, Indonesia. *Environmental Geology* 23: 182-191.

Tantrayana, Nyoman. 1997. *Bali Storylines: The Guide to Balinese Arts and Culture Through the Stories That Inspire Them.* Privately printed.

Thorton, Ian. 1996. *Krakatau: The Destruction and Reassembly of an Island Ecosystem.* Cambridge, Massachusetts: Harvard University Press.

Tuan, Yi-Fu. 1990. Realism and Fantasy in Art, History, and Geography. *Annals of the Association of American Geographers* 80(3): 435-446.

Vickers, Adrian. 1996. *Bali: A Paradise Created.* Republic of Singapore: Periplus Editions (HK) Ltd. Original edition, Australia: Penguin Books, 1989.

Wheatley, Bruce. 1999. *The Sacred Monkeys of Bali.* Prospect Heights, Illinois: Waveland Press, Inc.

Whitten, Tony, Roehayat Emon Soeriaatmadja, and Suraya A. Afiff. 1996. *The Ecology of Java and Bali.* Vol II, The Ecology of Indonesia Series. Republic of Singapore: Periplus Editions (HK) Ltd.

Wickman, Stephen B. The Economy. In *Indonesia: A Country Study.* 4th ed. ed. Frederica M. Bunge, 119-174. Washington, D.C.: Federal Research Division, Library of Congress, 1983.

The World Bank. *Indonesia: Environment and Development.* Washington D.C.: The World Bank, 1994.

Worldmark Encyclopedia of the Nations: Asia and Oceania, 1995 ed. S.v. "Indonesia".