ABSTRACT

Title: THE EVOLUTION, PHYLOGEOGRAPHY, AND CONSERVATION OF THE GOLDEN LANGUR (*Trachypithecus geei*) IN BHUTAN

Tashi Wangchuk, Doctor of Philosophy, 2005

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The golden langur (*Trachypithecus geei*) is an endangered endemic species of primate in Bhutan. Conservation of this species is addressed here through phylogeographic and habitat management tools.

I hypothesize that rivers and mountains in Bhutan isolated a population of capped langurs (*Trachypithecus pileatus*) and that this population later speciated into the morphologically distinct golden langur. *Trachypithecus,* the genus to which both capped and golden langurs belong, spread north from a paleo-refuge in south China and *Semnopithecus* (grey langurs) spread east and northward from a refuge in south India. My results show that these two genera both arrived in Bhutan but could not mix since the Sunkosh River and Pelela range form a biogeographic barrier. Likewise, a population of capped langurs isolated from parental populations by rivers speciated into the distinct golden langur.

I conducted field surveys covering the entire range of langurs in Bhutan, confirming the distribution and isolating barriers among the three langurs. Grey langurs and golden langurs are isolated from each other by the Sunkosh River and

Black Mountain range in west Bhutan. In the east, the Manas river system (Manas-Mangde-Chamkhar) served as a barrier between golden and capped langurs. However, this barrier has been broken in the last 30 years due to the construction of bridges over the Chamkhar river. A hybrid zone was found and the implications are discussed.

A *cyt b* phylogeny showed the grey langur of Bhutan grouping into a distinct clade with other congenerics of *Semnopithecus*. The south-Indian clade of grey langurs is more ancient, with the Bhutan and Nepal grey langurs having diverged later. The golden and capped langur from Bhutan grouped with *Trachypithecus* from South East Asia.

Finally, I explore conservation of golden langur habitat in Bhutan and estimate available habitat at 3,089 km^2 and an estimated population of about 6,000 individuals. I also find that the most viable strategy for conservation of langur habitat is to give ownership of the forests to local people, with monitoring by the Department of Forestry.

THE EVOLUTION, PHYLOGEOGRAPHY, AND CONSERVATION OF THE GOLDEN LANGUR (*Trachypithecus geei*) IN BHUTAN

By

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Dissertation submitted to the Faculty of the Graduate School of the
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Dedication

To the memory of my beloved grandmother *Angay* Thinley Bidha of *Wang-Simu*.

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Tashi Lham translocated half way across the world without complaint and bravely went to public school in America. Tashi Lham wasn't quite so sure about the big yellow bus on the first day of her kindergarten in 2001.

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Dissertation Summary

Solving the problem of how the golden langur (*Trachypithecus geei*) evolved into a distinct species in the heart of the Himalayas is the challenge addressed here. To answer this question I journey back into time to about 20 million years ago (MYA) when colobines first appeared in the fossil record and reconstruct events from there. This will show where and how the paleo-ancestors of the golden langurs first emerged and dispersed. The next great phenomenon of interest is when the Indian plate collided with the Eurasian plate some 40 MYA and gave birth to the highest mountains on earth, the Himalayas. This created the dramatic background or stage on which the langurs perform their evolutionary act. Another great event of consequence is the Pliocene and the last global Ice Age, the Pleistocene, stretching from 5 MYA to about 14,000 years before present (BP). Global cooling and warming during these epochs acted like a giant pump that either pushed langurs out of the Himalayas or sucked them back in. The cooling and warming phases also had a spectacular effect on Himalayan rivers, transforming them into barriers during warm periods and reducing them to mere trickles during cold periods. How the langurs responded to changing river conditions and their paleo-environment and dispersed across the Himalayan landscape is deciphered using field data and reconstructing phylogenies.

The golden langur is an “island” in a sea of grey langurs (*Semnopithecus entellus*) and capped langurs (*Trachypithecus pileatus*). Grey langurs are currently widespread and range from west Bhutan throughout India to Pakistan. Likewise, the capped langur extends from east Bhutan all the way through Assam, Bangladesh, and Burma. Golden langurs, by contrast, are found only in a small area of central Bhutan and in adjoining areas of Assam immediately bordering Bhutan (Ellerman and Morrison-Scott, 1966; Corbet and Hill, 1992; Wangchuk et al., 2003). Even as recently as 2000, information on the distribution of langurs in Bhutan was incomplete and one of the major efforts of field work for this dissertation has been to map accurately the distribution of langurs of Bhutan.

The question arises as to how the golden langur arose as a distinct species. Firstly, the biogeographic situation of Bhutan, where all three species are found, offers a unique opportunity to study this event. I hypothesize that rivers and mountain systems in Bhutan isolated a population of capped langurs during a warming period in central Bhutan and this population later speciated into the morphologically distinct golden langur. Brandon-Jones (1996) writes that *Trachypithecus,* the genus to which both capped and golden langurs belong, spread westward from Pleistocene Ice Age refuge in south China and *Semnopithecus* spread east and northward from refuge in south India. I hypothesize that these two genera met in Bhutan but could not mix since the Sunkosh River and Pelela range form a biogeographic barrier. Also, likewise I predict that a population of capped langurs was isolated from the parental population by rivers, which substantially increased in size as the glacial ice melted during the inter-glacial warming period. This barrier allowed the isolated capped langur population to speciate into the morphologically distinct golden langur species.

To test these hypotheses a phylogeographic approach is used. First, I conducted extensive field surveys covering the entire range of golden langurs in Bhutan, about 3,500 km^2 over a period of ten years, to confirm the exact distribution noting the isolating barriers among the three langur species such as river systems and mountains. The extremely rugged terrain and impenetrable forests made this a difficult task. Due to this difficulty no one else had attempted to walk the range thus far. Maps of the exact distribution of the langurs of Bhutan were produced based on the survey data (using topographic sheets 1:50,000 scale, GPS locations and ArcGIS software). The distribution maps reveal that indeed grey langurs and golden langurs are isolated from each other by the Sunkosh River in west Bhutan. In the east, the Manas river system (Manas-Mangde-Chamkhar) serves as a barrier between golden and capped langurs. Second, the evolutionary history of the langurs of Bhutan was reconstructed using molecular phylogenetic tools. Third, the evolutionary history of the langurs of Bhutan was reconstructed using paleoclimatic and environmental reconstructions, and molecular phylogenetic tools. The cytochrome b region (*cyt b*) and control region of the mitochondrial DNA were sequenced to build a phylogeny. The *cyt b* phylogeny revealed the distinct evolutionary paths taken by the golden, capped, and grey langurs. As predicted, golden and capped langurs are closely related to each other and to other species in the *Trachypithecus* group from SE Asia. The grey langur of Bhutan grouped into a distinct clade with other conspecifics of *Semnopithecus* from South India and Nepal. The south Indian clade of grey langurs is more ancient with the Bhutan and Nepal grey langurs having diverged off later. This fits with the glacial models of ice sheet retreats and colonization of South Asia by grey langurs from south India north towards the Himalayas. Likewise, the golden and capped langur clade are the most derived and diverged off from the more older groups of *Trachypithecus* in south east Asia. This also fits with paleo-refuge models of recolonization by the *Trachypithecus* group into the rest of southeast Asia and north towards the Himalayas from paleo- refuges in south-east Asia.

As predicted, golden and capped langurs are closely related to each other and the grey langur is only distantly related to this golden-capped clade. The divergence between capped and golden langurs is more recent while the split between *Trachypithecus* and *Semnopithecus* is more ancient and took place prior to the Pliocene.

An emerging issue, related to these speciation events, has been the construction of five permanent suspension bridges in the last 30 years over the Chamkhar river, a tributary of the Mangde river. Prior to this people had used seasonal and temporary cane twine ropeways to climb across the rivers. The construction of bridges has dissolved the geographical barrier between capped and golden langurs. A hybrid zone was found in February 2000 and the exact boundaries of the hybrid zone were mapped by October 2003. The hybrids are fertile and this gives rise to a new set of questions. Are the capped and golden langurs actually distinct species since the hybrids are viable? What species concept should be applied to this problem to manage the hybrids from a conservation perspective? What are some management options available to solve the problem of the bridges? My research has shown that the hybrids have arisen due to human activities and that they are not natural hybrids. Also, if humans had not interfered, golden and capped langurs would perhaps have eventually developed complete reproductive isolation. Since human actions disrupted an evolutionary process, it is fair to assume that golden and capped langurs are distinct species from both a phylogenetic species as well as biological species perspective. Conservation management is currently being applied to maintain this distinction. The hybrids are under observation and it is hoped that without the introduction of additional capped langur genes, the hybrids will backcross with parental goldens and over many generations will have more golden langur representative genes. The other option is to euthanize the hybrids, of which there are about 700 individuals in 39 groups. This would be unacceptable socially given the Buddhist value for life and also from a conservation stand since the hybrids form about 15 % of the total population of golden langurs and are a valuable and diverse gene pool.

Finally, an assessment of threats and land use pressures in golden langur habitat is done. Almost all of golden langur habitat, both in and out of protected areas parks, is used by the local people of Zhemgang, Trongsa, Sarpang, and Tsirang districts. Land use types include subsistence farming, forest grazing, and forest product use such as timber, firewood, and a variety of non-timber forest products by local communities. Commercial timber harvesting operations are also conducted by the Forestry Development Corporation. Other large impact activities include vehicle road construction, mega-electric power line grids passing through langur habitat, and urban growth and development along the border towns with India.

To understand clearly the pressures of these land use activities, firstly habitat available to golden langurs was surveyed and quantified. Surveys in golden langur habitat show that all broadleaf forests below 2,400 m are regularly used by the langurs (Wangchuk 1995). In summer langurs have been seen at higher elevations, close to 2,600 m in Chendebji. However, this may only represent a short seasonal visit. Core habitat therefore consists of forests classified as warm broad leaved forests, between 1,000 m to 2,400 m, and subtropical forests between 200 m and 1,000 m (Grierson and Long, 1983) between the Puna Tsang Chu (Sunkosh river) and Chamkhar / Mangde / Manas rivers. In this area north-facing slopes and shady areas such as ravines and gorges are dominated by mixed broad leaved forests. South-facing slopes that receive more sunlight are dominated by Chir pine (*Pinus roxburghii*) stands.

Next, the types of land use in langur habitat and impacts of each land use types were assessed. Several towns and villages under the districts of Zhemgang, Trongsa, Sarpang, and Tsirang fall within this prime golden langur habitat. Agriculture is the most prevalent land use along with forest grazing of cattle. Other activities such as commercial logging, road building, and urban development have commenced since the start of planned socio-economic development in the 1960s. During the surveys in 2002, a 37 km road (called the Dakpai-Buli Road) passing through prime langur habitat was under construction. The road connects the villages of Tali, Kikhar, and Buli with the Zhemgang – Gelephu highway. This provided an opportunity to measure the impact of the road on the golden langur population in the area and its habitat.

It was generally found that although relatively good quality habitat amounting to about 3,400 km^2 is available, pressures are also increasing. The biggest challenge is over enforcement of existing legislation and management of golden langur habitat. The Department of Forestry (DOF) is mandated with both enforcement and management of all forests in Bhutan, including langur habitat. However, shortage of resources largely to do with the lack of professional staff to field equipment hinders the DOF in implementing its mandate. Also, until 1961 villagers themselves had managed their forests as village community forests. Bhutan’s opening up to the outside world in the early 1960s resulted in changes from a traditional society to a developing country with influxes of donor aid and new ideas. Motor vehicles were introduced, a road network was built and an emerging market economy replaced the traditional barter economy. Forests became an import source of revenue for the nation. All forests, including village community forests, were nationalized and a new system of management put in place by the mid 1960s. However, currently there are efforts underway to return certain forests to villages. Village forests can be better managed and protected if proper user guidelines are instituted. Endangered species such as the golden langur will benefit from such protected forests.

Chapter 1: Evolution and Phylogeography of the langurs of Bhutan

Introduction: Non-human Primates of Bhutan

In Bhutan there are six species of non-human primates. These can be grouped into three distinct groups, the arboreal large-bodied langurs (Colobinae, Cercopithecidae) with long tails, the smaller terrestrial macaques (Cercopithecinae, Cercopithecidae) with relatively shorter tails, and the nocturnal and small-bodied loris (Loridae). Macaques are found in Africa and Asia while langurs and lorises are found only in southern Asia.

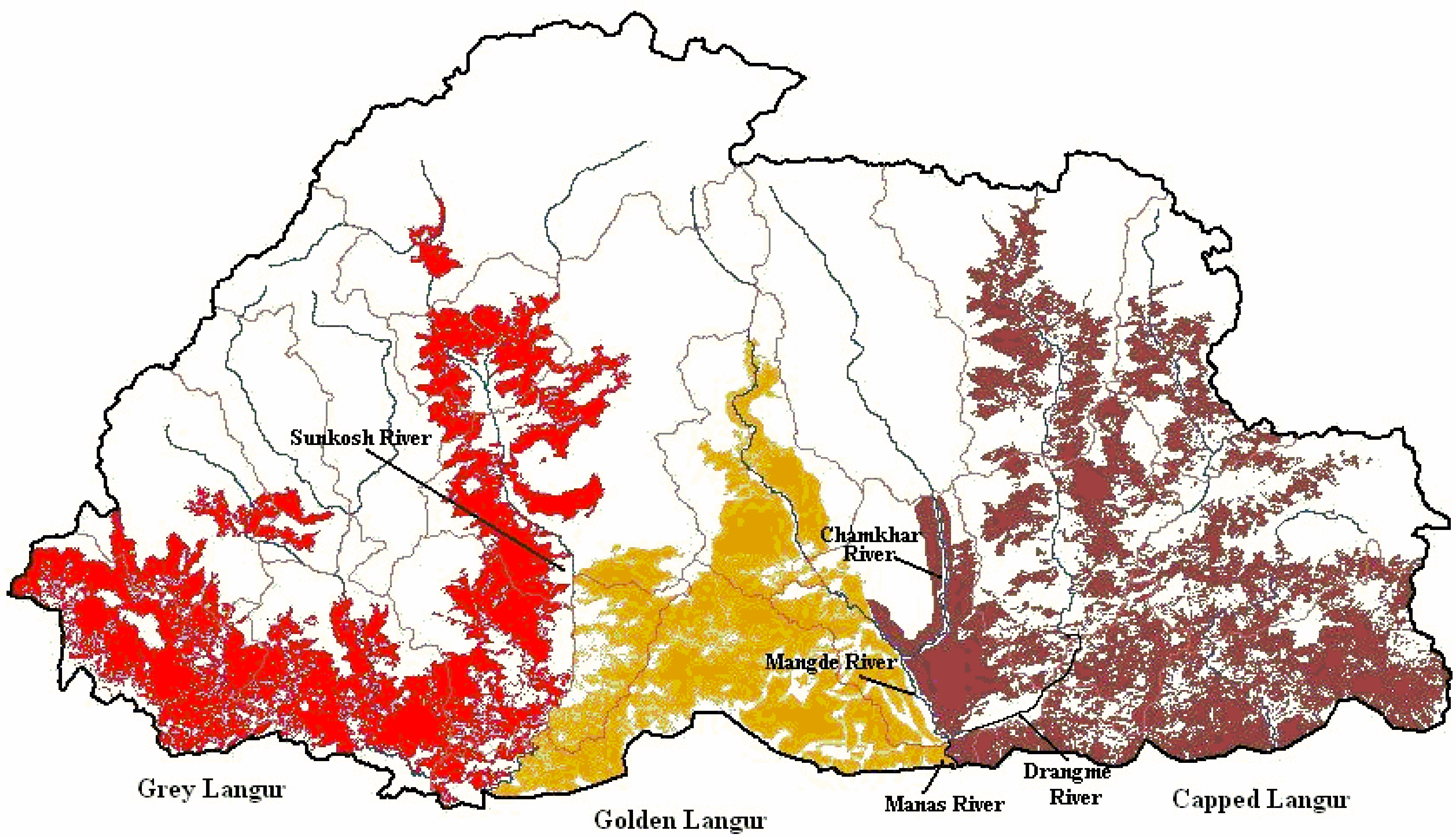
The three species of langurs or leaf monkeys are the grey langur (*Semnopithecus entellus*), the golden langur (*Trachypithecus geei*), and the capped langur (*Trachypithecus pileatus*) (Figure 1.1). Due to the general isolation of the country, information on the existence, distribution, and population status of the langurs of Bhutan is limited. A major effort of this dissertation is to shed light on the primates of Bhutan. Even relatively recent guides, field reports, encyclopedias, and dissertations on primates are usually uncertain about the status of primates in Bhutan (Roonwal and Mohnot, 1977; Srivastava, 1999; Karanth, 2000, Groves, 2001, Brandon-Jones *et al*. 2004).

The golden langur is found in central Bhutan ranging between the Sunkosh river and the Chamkhar, Mangde, Manas river complex (Wangchuk et al., 2003). In the language of central Bhutan, Khengkha, the golden langur is called *Raksha*. The golden langur is an endangered species and is listed in Appendix I of CITES. The latest listing by the IUCN/SSC in their report “Primates in Peril” (2002) the Golden Langur is shown as an endangered species endemic to Bhutan. A few populations exists in Assam, India in areas immediately bordering Bhutan but due to severe habitat loss and ongoing armed conflict between insurgents and security forces, the langurs there face extraordinary challenges (Srivastava, 2001). Bhutan, with more than 72% of its area under forest cover, may harbor the last viable populations of golden langurs.

Of the 16 subspecies of grey langur (*S. entellus*), there are two found in Bhutan. The subspecies in northern Bhutan is *S. e. achilles* according to the key developed by Pocock (1928). They are found only west of the Puna Tsang Chu or Sankosh river up to altitudes of 4,000 m in western Bhutan and called *Pcha Kar* in Dzongkha, the national language of Bhutan. In the higher altitudes, the langurs are larger in body size, the head is completely white, the body hair is thick and wooly. This contrasts with the hanuman langurs in the foothills along the Indian border, which resemble *S. e. hector*. The coat is thinner and the head is almost as grey as the body.

Figure 1.1. Grey Langur, Golden Langur, and Capped Langur from Bhutan. Shown here respectively in that order from left to right (From Wangchuk *et al*., 2004).

Figure 1.2. Distribution of the Grey / Hanuman Langur, Golden Langur, and Capped Langur in Bhutan (From Wangchuk *et al*., 2004).



The capped langur subspecies in Bhutan, based on field observations and using descriptions in Gee (1961) and Pocock's (1928) key, is *T. p. tenebricus*. The head and back are ashy grey, which contrasts with the almost reddish gold of the throat and chest that fades away on the abdomen. In terms of distribution, capped langurs are found in the Chamkhar river valley and areas east of the Mangde, Manas river complex. Recently completed field surveys determined this river complex as the boundary between Golden and Capped and a contact zone adjacent to the Chamkhar river valley (Wangchuk et al. 2001). Previously, the Drangme, Manas *Chu* or river complex was thought to be the geographic barrier between the two species, however the most recent field surveys (Feb 2000) show that *T. p. tenebricus* occur in the area previously thought to be occupied by *T. geei* (Wangchuk, 1995). Figure 1.2 shows the latest distribution map of the langurs of Bhutan (Wangchuk *et al*., 2004). In the language of eastern Bhutan, Sharchopkha, these monkeys are called *Roksha*.

Two species of macaques are also found in Bhutan, the Rhesus (*Macaca mulatta*) and the Assamese (*Macaca assamensis*). Unlike the allopatric leaf monkeys, the macaques are sympatric. Assamese macaques are more common than rhesus and can be found all over Bhutan in warmer areas up to altitudes of 2000 m; rhesus macaques are restricted to the foothills. It is possible that the recently discovered *Macaca munzala* (Sinha *et al*. 2004) from areas in Arunachal Pradesh in India, immediately bordering eastern Bhutan, may also be found in east Bhutan. However, they resemble *M. assamensis* and field surveys in east Bhutan are needed to clarify the situation.

Previously classified in the genus *Presbytis*, the golden langur was reclassified in the genus *Trachypithecus* based largely on the neonatal coloration (Pocock, 1935) and skull and tooth morphology (Aimi, pers. comm. 2000). Table 1. 1 shows the main morphological differences between the Asian Colobine genera *Trachypithecus*, *Presbytis*, and *Semnopithecus* used for classification purposes.

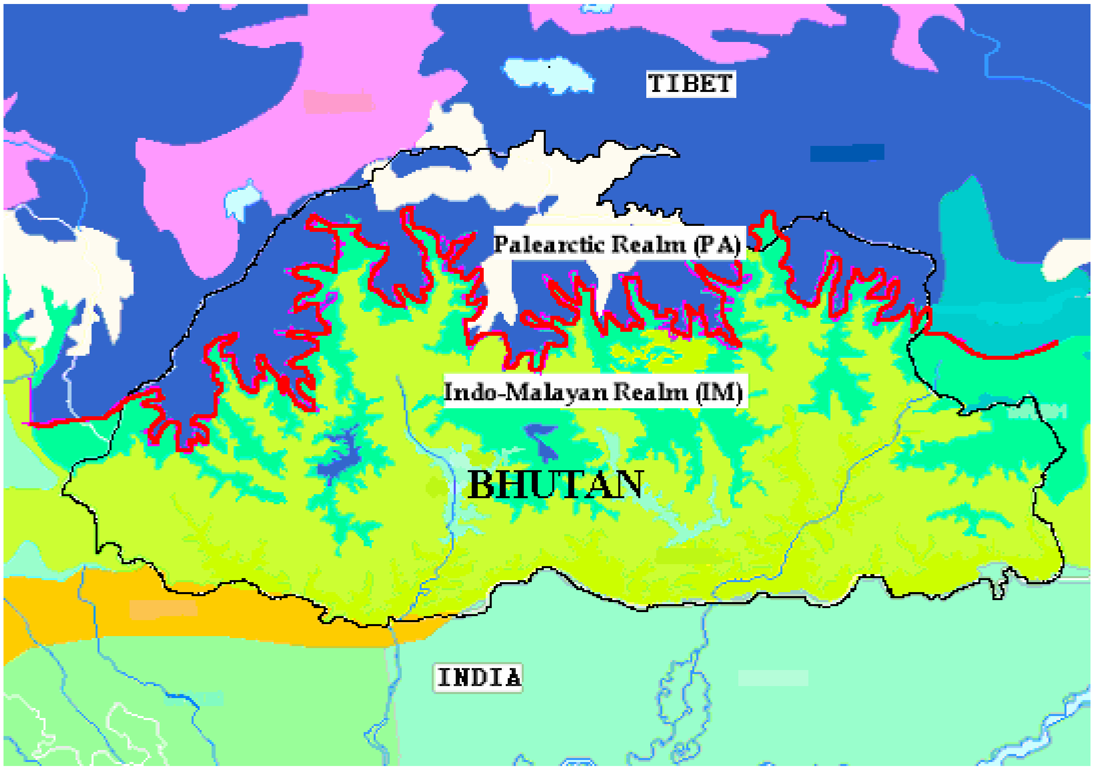
Table 1.1. Some morphological differences between *Trachypithecus*, *Presbytis*, and *Semnopithecus.*

Genus	Skull Morphology	Tooth	Natal Color
Trachypithecus	Brow ridge prominent, rounded and continuous across forehead. Rounded eyesockets. Long nasal bone.	3^{rd} molar with prominent 5^{th} cusp.	Orange to creamy white.
Semnopithecus	Brow ridge absent, sloping forehead Longer muzzle.	3^{rd} molar with prominent 5^{th} cusp.	Black
Presbytis	Brow ridge present but not heavy as in *Trachypithecus*, straight across forehead. Short nasal bone.	3^{rd} molar has inconspicuous 5^{th} cusp.	White

Ecological and Geophysical Background of Study Area

Bhutan, located in the Eastern Himalayas, features extremely diverse ecosystems and geophysical elements - from tropical rainforests in the south to rugged alpine mountains in the north. The abrupt rise of the Himalayas from sea level to over 8,000 meters within a short span of 150 km is a major factor for the geological, climatic, and ecosystem variations. Another reason is Bhutan's location at the juncture of the Palearctic zoogeographic realm of temperate Eurasia and the tropical Indo-Malayan realm of south Asia (Figure 1. 3). Because of this richness of diversity, the Eastern Himalayas are considered a Biodiversity Hotspot by Conservation International (Mittermeier, Mittermeier, and Myers, 2001), and a Global 200 ecoregion for priority conservation by the World Wildlife Fund (Olson and Dinerstein, 1998).

Figure 1.3. Zoogeographic realms meeting in Bhutan



Ecological Zones and Species Distribution

Species distributions in the Himalayas generally follow ecological zones shaped by altitude, temperature, terrain, and rainfall. Broadly, these ecological zones can be grouped into the Alpine, Temperate, and Subtropical Zones. Above 4,000m, consisting of alpine shrub, meadows, and permanent snow caps is the Alpine Zone. The Temperate Zone, between 1,500 to 4,000m, includes conifer and broadleaf forests and the Subtropical Zone, 150 to 2,000m is characterized by tropical and subtropical vegetation (Grierson and Long, 1983).

Biogeographically, Bhutan lies at the crossroads of three important biological regions: the Indo Malayan region consisting of lowland rain forests of South and South-East Asia, the Paleartic region consisting of rhododendron / conifer forests and alpine meadows of northern Asia and Europe, and the Himalayan Front, a unique and diverse assemblage of species found only in the Himalayas. It is this unique biological region that provides much of the ecological context and factors contributing to the evolution of langurs that is explored in this dissertation.

In general, Palearctic species are distributed in the alpine zone while Indomalayan species are found in the temperate and subtropical zone. However, some species are found in all three zones while some are more restricted in their range. For instance, Langur monkeys can be found in both the Subtropical Zones and Temperate Zones ranging from 150 m to 4,000 m (Bishop, 1979) and tigers are found in all three zones (McDougal and Tshering, 1998). Other representative megafauna of each zone are summarized below (NCD, 1991; 1995) in Table 1.2. Fauna unique to the Himalayan front consist of the red panda, takin, and the golden langur, the subject of this dissertation.

Table 1.2. Representative megafauna by ecological zone

Alpine Zone	Temperate Zone	Subtropical Zone
Snow Leopard (*Uncia uncia*) Blue Sheep (*Pseudouis nayaur*), Takin (*Budorcas taxicolor*), Marmot (*Marmota himalayana*) Musk Deer (*Moshcus chrysogaster*). Goral (*Nemorhedus goral*) Red Panda (*Ailurus fulgens*) Tiger (*Panthera tigris*)	Leopard (*Panthera pardus*), Serow (*Capricornis sumatraensi*), Wild Pig (*Sus scrofa*) Himalayan Black Bear (*Selenarctos thibetanus*), Sambar (*Cervus unicolor*), Barking Deer (*Muntiacus muntjak*) Goral (*Nemorhedus goral*) Red Panda (*Ailurus fulgens*) Tiger (*Panthera tigris*) Clouded Leopard (*Neofelis nebulosa* Golden Langur (*Trachypithecus geei*), Capped Langur (*Trachypithecus pileatus*) Gray Langur (*Semnopithecus entellus*) Assamese macaques (*Macaca assamensis* Rhesus Macaques *Macaca mullata*) Three species of hornbills (Rufousnecked, Pied and Great Indian).	Elephant (*Elephas maximus*), Greater One-Horned Rhinoceros (*Rhinoceros unicornis*), Water Buffalo (*Bubalus bubalis*), Gaur (*Bos gaurus*), Swamp Deer (*Cervus duvauceli*), Hog Deer (*Cervus porcinus*), Pygmy Hog (*Sus salvanius*), Sloth Bear (*Melurus ursinus*) Tiger (*Panthera tigris*) Clouded Leopard (*Neofelis nebulosa* Golden Langur (*Trachypithecus geei*), Capped Langur (*Trachypithecus pileatus*) Gray Langur (*Semnopithecus entellus*) Assamese macaques (*Macaca assamensis* Rhesus Macaques *Macaca mullata*) Four species of hornbills (Rufousnecked, Wreathed, Pied and Great Indian).

Hypotheses about the phylogeny of the langurs

To understand the evolution of the golden langur in the Himalayas it is necessary to understand the evolutionary relationship of the three langur species of Bhutan. The first objective therefore is to test the relationship between the genus *Semnopithecus* and *Trachypithecus*. This will reveal the evolutionary history of the three langur species currently found in Bhutan and thereby answer the question of how the golden langur evolved into a distinct species. Did the golden langur emerge as the result of an ancient hybridization event between females of *Semnopithecus* and males of *Trachypithecus* as posited by Karanth (2000)? Or does "climatic change…supply a consistent" explanation (Brandon Jones, 1996) for the emergence of the golden langur?

Karanth (2000), in building a molecular phylogeny of the langurs of India, constructed using cytochrome b sequences of the mitochondrial DNA (mtDNA), found that the capped and golden langurs grouped with the *Semnopithecus* clade despite their classification as *Trachypithecus*. However, using nuclear DNA (nDNA) lysozyme c sequences, he found that the golden and capped langurs grouped with the *Trachypithecus* clade. To explain this apparent discordance between the mtDNA and nDNA he hypothesized that the capped – golden clade resulted from an ancient hybridization event 3.3 to 4 million years ago (MYA) between *Semnopithecus* and *Trachypithecus*. Karanth (2000) offered the following explanation as to how this could have arisen:

> Due to the drying of the central region of the Indian subcontinent, *Semnopithecus* likely split into two populations, one of which retreated into the Northeast, and the other into South India and Sri Lanka…This resulted in the divergence of the capped-golden langur mtDNA clade from the southern

populations of Semnopithecus; according to the mtDNA clock, this divergence happened around 3.3 to 4.0 MYA. In the meantime, the other Asian colobines had already dispersed into SE Asia (due to desiccation of the Tibetan plateau) and diverged into various species groups (including *Trachypithecus*). Later, as *Trachypithecus* spread west and colonized areas in the Northeast where the sea had receded, it may have hybridized with the isolated population of "*Semnopithecus*" (capped-golden langur) in the areas where their ranges overlapped in the Northeast. Capped and Golden langurs could thus be the product of this ancient hybridization between *Semnopithecus* and *Trachypithecus*.

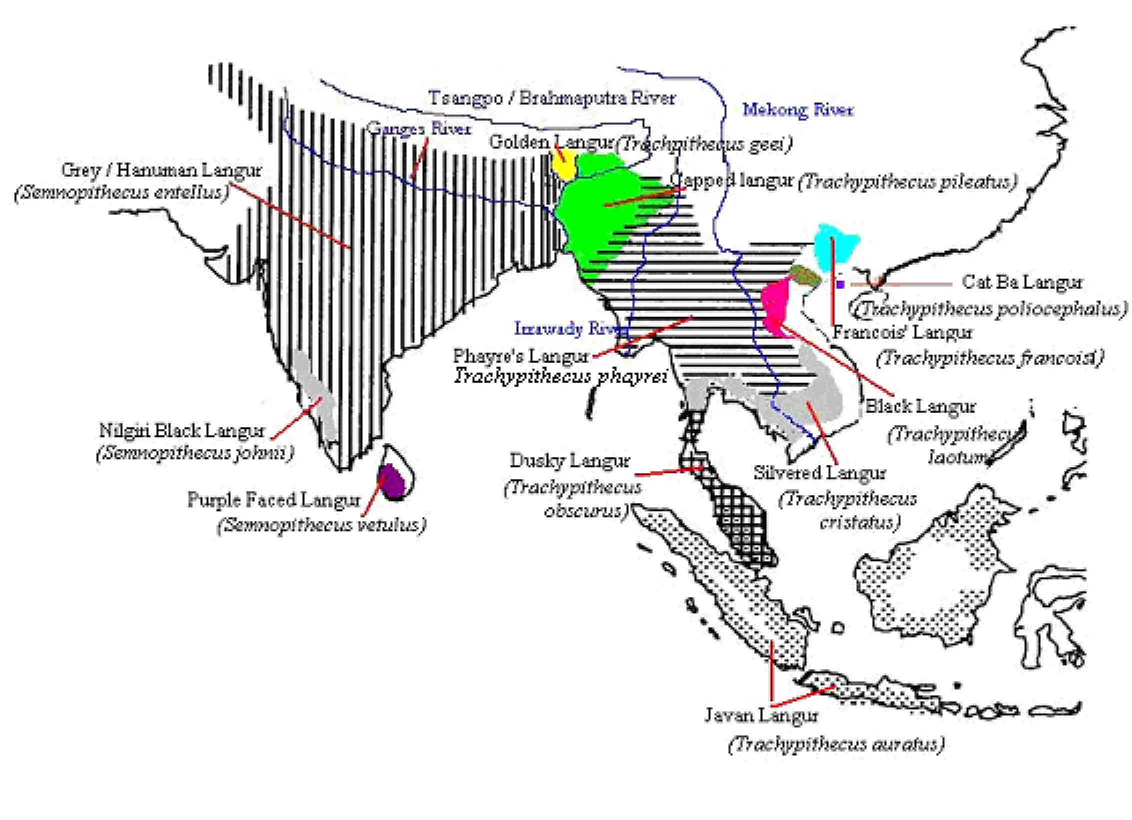
An alternative hypothesis can be developed from Brandon-Jones' (1996) climate model which he used to explain the distribution of disjunct populations of similar species separated by vast geographic distances. Rather than dwelling on the disjunct populations, I will focus on the Quaternary climatic changes, which are well recorded, and the effect they had on flora and fauna in Asia during the Pleistocene glaciations.

Brandon-Jones (1996) writes that 2 cycles of deforestation due to dry conditions during the Pliestocene glaciations 190,000 and 80,000 years Before Present (BP) extirpated many species in Asia and only those in moist warm refugia survived to recolonize the vacant areas during interglacials. In particular he writes that *Semnopithecus* was confined to refugia in south India and *Trachypithecus* in south west China. After the last glaciation (circa 80,000 years BP), *Semnopithecus entellus* evolved from *S. vetelus* (Brandon-Jones, 1996) and spread eastward and northwards across India.

This expansion continued up to Nepal and Bhutan in the Himalayas, as surveys have revealed (Wangchuk, 1995; Wangchuk *et al.* 2003). *Trachypithecus* spread out from the refugia in south east Asia / south west China northwestwards through Thailand and Burma to India and as I predict, to Bhutan. It is plausible that *Semnopithecus* and *Trachypithecus* met in Bhutan at the end of this dispersal, as is reflected in the distributions seen today. The interglacials resulted in warmer climates, melting glacial icecaps, enlarging rivers that became significant barriers to animal dispersal during interglacial periods of warmer temperatures. The Sunkosh river in Bhutan is one such river that effectively separates *Semnopithecus* on its west bank and *Trachypithecus* on its east bank (Wangchuk, 1995; Wangchuk *et al.* 2003; Wangchuk *et al*. 2004).

Brandon-Jones (1996) also notes that this recolonization is "accompanied by a unidirectional alteration in pelage colour, commencing from the predominantly black relic species…and passing through grey to brown." So in this schema, *Semnopithecus* in south India and Sri Lanka (*S. johnii* and *S. vetelus*) are black while *S. entellus* is grey. Likewise, *Trachypithecus* in southwest China and Vietnam are black, and as they spread westward change to grey (*T. pileatus* is ashy grey in Bhutan) and eventually to brown (or golden in the case of *T. geei*). Also, areas close to the glacial refuges have higher species richness than those further away from it. For instance in Vietnam and areas of southeast Asia there more than six species in the *Trachypithecus* genus with several subspecies while areas in south India and Sri lanka have three species in the *Semnopithecus* genus and several subspecies. The species richness diminishes as distance from the original relic forests increase. Fig 1.4 shows this distribution scheme.

Figure 1.4 Current Distribution of *Semnopithecus* and *Trachypithecus* in south and southeast Asia (adapted from Wangchuk *et al*., 2004; Baker *et al*., 2000; Karanth 2000, Brandon-Jones, 1996; and Oates *et al*. 1994).



Clearly then this hypothesis would support *T. geei* and *T. pileatus* as branching off from ancestral *Trachypithecus* from southeast Asia. South east Asian species such as *T. cristatus, T. aurauts, and T. obscurus would be more ancestral to T. geei* and *T. pileatus*. Also this would support *T. geei* branching off from *T. pileatus,* probably due to the increasing size of the Manas, Mangde, Chamkhar river system as glacial icecaps melted after the last glacial maximum circa 14,000 years BP. The exact time the rivers became significant barriers is hard to estimate, but I hypothesize that they did so after the last glacial maximum 14,000 years BP. Can molecular phylogeny provide support for this hypothesis? If so: 1) there should be a greater difference between *S. entellus* and *T. pileatus / T. geei* than there is between *T. geei* and *T. pileatus* and 2) *T. pileatus / T.geei* from Bhutan should group with the *Trachypithecus* clade from southeast Asia (regardless of whether mtDNA or nDNA markers are used) and *S. entellus* from Bhutan should group with the *S. entellus* groups from south India. 3) *T. pileatus* should be basal to *T. geei*, and 4) the divergence of the various species groups should be concordant between the fossil record and molecular record and should give similar dates for events such as the split between the *Semnopithecus* and *Trachypitecus* group and between *T. geei* and *T. pileatus*. Using biogeographical distribution data and historical climatic data, it is predicted that the divergence between *T. geei* and *T. pileatus* occurred after the last major glacial termination about 14,000 years BP when increasing temperatures melted glacial ice and increased the volume of rivers. The Chamkhar / Mangde / Manas river system could have become a significant barrier to langur dispersal after these rivers increased in size.

Semnopithecus would have arrived on the banks of the Sunkosh river (Figure 1.2) after the river became a barrier and likewise the *Trachypithecus* population that later evolved into *T. geei* would have arrived on the opposite bank of the Sunkosh after the river became a barrier and prevented hybridization.

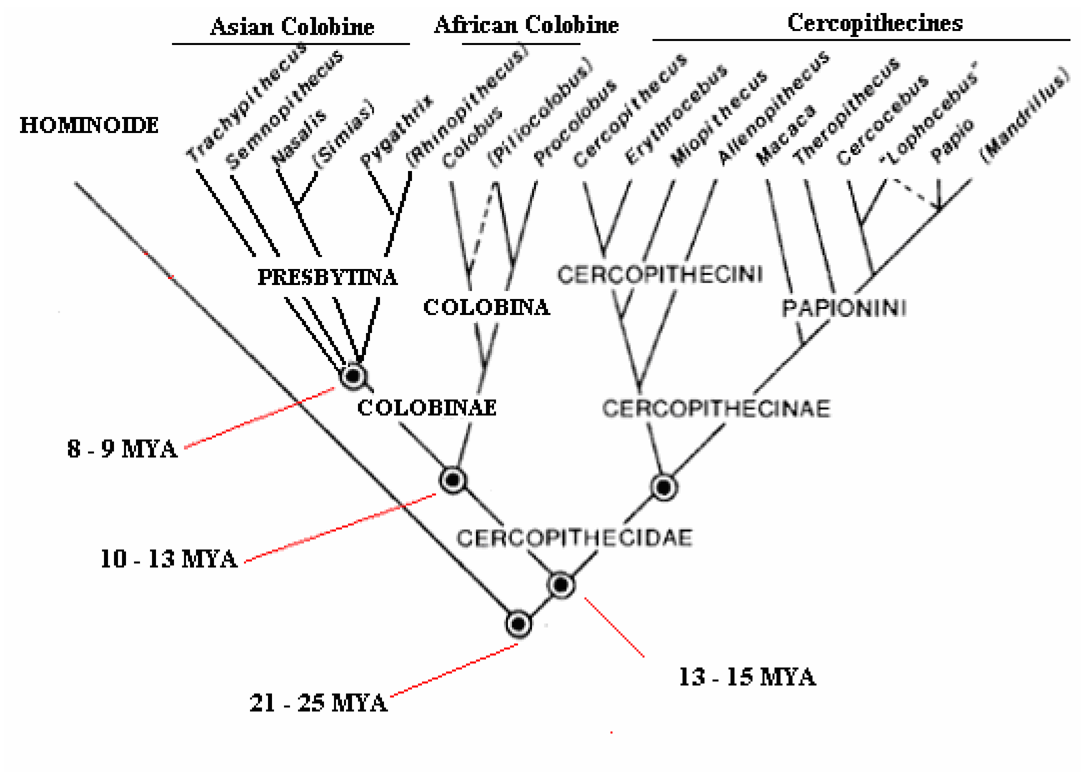
In the Himalayas, in addition to the north – south faunal distribution pattern described above, there is also an east-west pattern dictated largely by impassable river barriers and mountain ranges (Mackinnon, 1990). The formation of the mountain ranges of the Himalayas started about 65 million years ago during the Upper Cretaceous period when the Indian plate collided with the Eurasian plate (Gansser, 1980; Valdia, 1998). The collision uplifted the Tethyan Ocean basin into the present mountain range which continues to rise at 2-3 cm per year. This northward thrust of the plates results in the Himalayas generally having an east-west orientation. However, in certain areas along their 3,000 km length, the range twists and folds into north-south orientations. One such twist is the Black Mountain or Jowo Dungshing range in Bhutan, which effectively divides the country into an eastern region and a western region (Gannser, 1980). The Black Mountains thus present a major barrier for faunal distribution.

The formation of the other significant barrier - Himalayan rivers - is closely associated with the Glacial epochs. The major rivers such as the Indus and Tsangpo / Brahmaputra existed prior to the formation of the Himalayas, and arise north of the range and cut through the Himalayas as “the mountain rose but slowly” (Valdiya, 1998), creating gorges three times as deep as the Grand Canyon. Many other rivers, however, have their source in the glaciers and ice caps of the mountain massifs. Examples of such rivers of significance in Bhutan are the Sunkosh or Puna-Tsang Chu, the Chamkhar, Mangde, Drangme, and Manas (Figure 1.2). These rivers probably underwent cycles of growth and reduction coinciding with the glacial retreats and advances (Andrews, 1979). The glaciers in the Himalayas reached a maximum about 80,000 years BP during the last Ice Age. A general warming trend was experienced at the end of the Ice Age about 14,000 years BP. As temperatures rose during this interglacial period, glaciers melted increasing the volume and size of rivers all across the Himalayas. It is probable that the rivers became significant barriers to animal dispersal during interglacial periods of warmer temperatures

Fossil history of the Colobines

The ancestors of the colobines can be traced to the Miocene 20 to 15 MYA to fossils of *Victoriapithecus* from Kenya (Delson, 1994). The living Cercopithecidae are divided into two subfamilies, Colobinae and Cercopithecinae and *Victoriapithecus* is the common ancestor shared by these two subfamilies. The separation between Colobinae and Cercopithecinae is estimated at 13 to 15 MYA based on the fossil record (Harrison, 1989). The divergence between ancestral African colobines and Asian colobines is estimated between 10 MYA (Stewart and Disotell, 1998) to 13 MYA (Delson, 1994). By about 11 MYA the earliest well known colobine fossils, with remarkable resemblances in both skull morphology and behavior (semiterrestrial) to present day *Semnopithecus entellus*, were found from Eurasia from sites as far apart as Germany and Afghanistan. These fossils of *Mesopithecus pentelicus* date to between 8.5 to 11 MYA (Delson, 1994). A possible descendant is *Dolichopithecus*, which lived in Europe from about 4.5 to 2.5 MYA and perhaps in Mongolia and Siberia as well. Paleo ancestors of the langurs arrived in India from Eurasia in the *Selenoportax lydekkeri* Interval-Zone 5.3–7.4 MYA (Barry et al., 1982). Well preserved fossils of living genera *Presbytis*, *Trachypithecus*, and *Semnopithecus*, dating to about 2 MYA have been recovered from sites in Java (Delson, 1994). Figure 1.5 shows the divergence times based on the fossil record.

Figure 1.5. Primate divergence times estimated by the fossil record (adapted from Delson, 1994; Purvis, 1995; Strasser and Delson, 1987; Sterwart and Distotell, 1998; Goodman *et al*., 1998).



Phylogeny and Classification of the Asian Colobines

Classification of the Colobine and Cercopithecinae species referenced in the phylogenetic analysis below is presented following Brandon-Jones *et al*. (2004). Only species in the two subfamilies with direct reference in the analysis are shown and an exhaustive list has not been presented. Popular common names of species used widely in the literature and media are also shown.

Order Primates

Family Cercopithecidae

Subfamily Cercopithecinae

Macaca

Macaca fascicularis	Long-tailed Macaque

Subfamily Colobinae

Colobus

Colobus guereza	Guereza Colobus

Semnopithecus

Semnopithecus entellus	Hanuman / Grey / Common Langur
Semnopithecus johnii	Nilgiri Langur
Semnopithecus vetulus	Purple-faced Langur

Trachypithecus

Trachypithecus auratus	Javan Langur
Trachypithecus cristatus	Silvered Langur
Trachypithecus francoisi	Francoi's Langur
Trachypithecus geei	Golden Langur
Trachypithecus obscurus	Dusky Langur
Trachypithecus phayrei	Phayre's Langur
Trachypithecus pileatus	Capped Langur

Methods

The methods employed are biogeographical and molecular in nature given the questions above. To test the hypothesis that rivers and mountain systems acted as barriers isolating populations of langurs from ancestral langurs, it is necessary to map the distribution of the langurs of Bhutan. As hypothesized above, a population of capped langurs was isolated from the parental population by rivers that substantially increased in size as the glacial ice melted during the inter-glacial warming period and this barrier allowed the isolated population to speciate into the distinct golden langur species. Also, *Trachypithecus,* the genus to which both capped and golden langurs belong, spread westward from a Pleistocene Ice Age refuge in south China and *Semnopithecus* spread east and northward from a refuge in south India. As predicted above, these two genera may have met in Bhutan but could not mix due to biogeographical barriers.

Between November 1994 to December 2004, field surveys to determine the biogeographical distribution of the langurs of Bhutan were conducted.

The surveys included trekking along natural dispersal barriers such as the Manas, Drangme, Mangde, Chamkhar, and Sankosh rivers.

1) Interviews with local people and Department of Forestry staff provided initial information for selecting survey locations. Pictures of all three langur species were shown and I asked if they were found in specific localities.
2) Surveys were conducted normally during late fall and winter (September through February) when the trails are accessible and streams and rivers without bridges become fordable. Some rivers without bridges are inaccessible during the monsoons when water levels are high and currents are strongest.

3) Every survey season a specific locality that can be trekked within a period of four to six weeks was selected based on the interviews, and with the use of topographic sheets of the scale 1:50,000 from the Geological Survey of Bhutan. Trails were marked on the topo sheets and logistics for porters carrying supplies were arranged through local district administrators.
4) All together seven full survey seasons lasting from four to six weeks were made (1994-1995, 1995-1996, 1996-1997, 1999-2000, 2002-2003, 2003-2004, 2004-2005). Nine two- to three-week trips were made in spring (March-May) and summer (June-August), with shorter trips to cover accessible areas during those months. In total 407 field days were spent on the surveys excluding driving days to and from surveys' start and finish points. Exact distances trekked during the surveys over the years are difficult to calculate but a rough estimate is from 900 to 1000 km.
5) In November 1994 a census was also conducted in Trongsa and Zhemgang districts to estimate golden langur population size. The census was repeated along the same transect in 2003 to observe population trends. The results of the census are reported in Chapter 3.
6) Langur sightings were marked on the topo sheets and latitude and longitude coordinates recorded. Nearby streams and rivers were also recorded. If the terrain permitted GPS coordinates were also recorded. Usually, the topo sheets provided more accurate readings. The particular langur species sighted were carefully identified. Hair or fecal samples for DNA work were also collected when feasible. Other information like vegetation type, altitude, habitat quality, langur

group size, age, and sex were also recorded. Detailed field notes were kept at the end of each survey day noting impressions, conjectures, thoughts, and events of the day.

7) Sighting location coordinates by species were input into ArcView (ESRI, 1997) and ArcGis 8.1 (ESRI, 2002) and tentative distribution maps generated. These maps were then used to identify gaps in the distribution information. The next survey was planned based on questions arising from this process.

8) The entire process was repeated until all areas where langurs could exist in Bhutan were surveyed.

Sample Collection

Samples for DNA extraction and analysis were collected in the field between 1999 to 2003. All techniques were noninvasive. For instance, hair was collected from roosting sites (22 samples). Some samples were collected from feces and stored in a buffer of ethanol solution (82 samples). Other samples consisted of tissue collected from occasional encounters with carcasses during the surveys (3 samples). From these, 46 samples (Appendix 1) were used for DNA extraction and further analysis based on their condition. CITES Permit no. 03US067661/9 was used to import the samples into the US.

During collection, care was taken to avoid contamination of the samples by wearing latex gloves and using sterilized equipment. Fecal swabs of the surface were done to collect the epithelial layer of cells and stored in 99% ethanol in 2 ml tubes. Dried tissue such as skin and hair were stored in clean paper envelopes. Fecal swabs were collected along the survey transects from representative sites in the field. While conducting the biogeographic and species distribution surveys, samples were collected as and when the opportunity was available. At each langur sighting location, thorough search for hair and feces were made. In the area directly below the trees where the langurs were present searches for feces were conducted. For the majority of the time langurs did not flee if care was taken not to startle them or make sudden moves and loud noises. Just sitting and waiting for a few minutes after first sighting allowed langurs to acclimate to observers. Sometimes observations for up to three hours were done waiting for fresh droppings. Search for hair was done after langurs moved off to other trees, either foraging or following the alpha female either to rest or groom.

Mitochondrial DNA

Mitochondrial DNA (mtDNA) was selected to answer the phylogenetic questions since it is has commonly been used in the study of primate evolution (Melnick and Hoelzer, 1993) and various regions have been extensively sequenced (Johns and Avise, 1998) and are available for comparative work through GenBank with Bhutan sequences. Also, because of its "small size, conserved organization, mode of inheritance, and combination of rapidly and slowly evolving regions, mtDNA has appeared in many ways to be the ideal molecule for evolutionary studies of primates" (Melnick and Hoelzer, 1993). Each individual can be considered as an Operational Taxonomic Unit (OTU) since each individual displays "mtDNA haplotype inherited intact, without intermolecular genetic recombination, through maternal ancestors." (Avise, 2000).

In particular cytochrome b (*cyt b*) will be used to answer the phylogeographic questions in this chapter since the levels of divergence "typically associated with sister species, congeners, and confamilial genera…usually are in a range in which the cyt b gene is phylogenetically informative and unlikely to be severely compromised by saturation effects involving superimposed nucleotide substitutions." (Johns and Avise, 1998). Cyt b is a protein coding gene and it "is easier to align a protein-coding sequence that has evolved over the period spanning the origin of mammalian orders" (Irwin *et al*. 1991). Also, Brown et al. (1979) showed that saturation effects in mtDNA are only severe in lineages that have diverged earlier than 15 to 20 MYA. Because all the taxa considered here in this analysis have separated within the last 15 MY, saturation effects should not be a problem.

For resolution of phylogenetic questions involving more closely related taxa a rapidly evolving region of the mtDNA was used. In particular the control region is a non-coding region and not constrained by selective pressure. This region is highly variable as a result and suited for diagnostic tests between closely related taxa (Tamura and Nei, 1993). The control region of primates consists of highly variable hypervariable regions at the 5' and 3' ends while the central portion is highly conserved (Vigilant et al., 1991).

Lab methods for DNA analysis

Extraction of Genomic DNA from Fecal Swabs and Tissue

The QIAamp® DNA Stool Mini Kit was used for extraction of DNA from the fecal swabs. Specifically, the protocol for isolation of DNA from Stool for Human DNA Analysis was used with the following modifications:

1. Since the samples collected were surface swabs from fresh feces (approximately up to 2 days old) and not whole stool samples (for which the QIAamp® DNA Stool Mini Kit is optimized) and stored in ethanol buffer, the ethanol had to be removed. This was done by drying down 200µl of the sample in a speed vacuum at room temperature for up to 4 hours. The dried sample was then suspended in buffer ASL of the QIAamp kit, mixing thoroughly to resuspend the dried sample.

2. Instead of using buffer AE to elute DNA, 200 µl of double-distilled water was used. The elute was dried by speed vacuuming to concentrate the DNA, which was then resuspended in 50 µl of 1:10 TE buffer

DNA extraction from other tissue such as skin, muscle, and bone fragments was done following the Qiagen DNeasy Tissue Kit protocol for rodent tails without any modifications. To test for presence of amplifiable DNA, PCR was performed using 16s universal mtDNA primers. The short product length of 16s facilitated amplification and was used as a test for DNA quality.

DNA Amplification and Sequencing (Cytochrome b)

MtDNA Cytochrome b (*Cyt b*) sequences were amplified using primers L15162 (GCAAGCTTCTACCATGAGGACAAATATC) and H15915 (AACTGCAGTCATCTC CGGTTTACAAGAC) reported by Irwin *et al*. (1991). The PCR reaction consisted of 2.5 μl of 10× reaction buffer 2.5 μl of 50 mM MgCl, 0.5 μl of each 10 μM primer in a pair, 2.0 μl of a 2.5 mM dNTP solution in equimolar ratio, 0.25 μl of Taq polymerase, and 2.0 μl of template DNA and water added for a total volume of 25 μl. PCR conditions started with 3 minute hot start at 95°C; denaturing for 30 seconds at 95°C; then 35 cycles of 72°C for 1 min 30 sec, annealing for 30 sec at 45°C, and extension at 72°C for 3 min; followed by 1 min at 25°C.

The amplified regions were sequenced using the Applied Biosystems Big Dye terminator ver. 2.0 (Cat. No. 4303153). Both strands *cyt b* were sequenced using forward and reverse primers separately in different reactions. Raw sequences were verified using the Sequencher (Gene Codes Corp) software program to check automatic base calls by eye.

Useful sequences were obtained from 4 samples from Bhutan for *cyt b,* each 800 base pairs (bp) in length and 7 samples for the control region (774 bp). These sequences are listed in Appendix 3.

Cytochrome b (Cyt b) Data Analyses

The *cyt b* sequences of langurs from Bhutan were compared against orthologous sequences in GenBank by using the BLASTn search protocol. *Trachypithecus pileatus* found the *Cyt b* sequences producing significant alignments listed in Table 1.3. An identical result was obtained for BLASTn search with *T. geei* sequences from Bhutan. Table 1.4 shows *cyt b* sequences from GenBank producing significant alignments with grey langur (*S. entellus*) sequences from Bhutan.

Table 1.3. *Cyt b* sequences from GenBank producing significant alignments with Capped Langur (*Trachypithecus pileatus*) sequences from Bhutan. (The smaller the Expect value, the more homologous the sequence is to *T. pileatus*. An Expect value of zero indicates that no matches would be expected by chance and represents a near perfect match)

Species	Accession No.	Authors	Alignment (base pair matches)	Expect Value (Homology)	Location
Trachypithecus phayrei Phayre's Langur	AF294621	Karanth,P.K., Stewart,C.-B. Singh,L.	89.54% 642/717 (642 base pairs match out of 717)	0.0	India (isolate I1)
Trachypithecus obscurus Dusky Langur	AF295579	Collura,R.V., Karanth,P.K. Stewart,C.-B.	89.40% 641/717	0.0	
Trachypithecus cristatus Silvered Langur	AF295580	Collura,R.V., Karanth,P.K. Stewart,C.-B.	89.26% 640/717	0.0	
Trachypithecus francoisi Francois' Langur	AF295578	Collura,R.V., Karanth,P.K. Stewart,C.-B.	89.08% 636/714	0.0	
Trachypithecus phayrei	AF294622	Karanth,P.K., Stewart,C.-B. Singh,L.	89.06% 635/713	0.0	Vietnam isolate V1
Trachypithecus auratus Javan Langur	AY51945 5	Geissmann,T. , Groves,C.P. Roos,C.	90.14% 448/497	0.0	Java Indonesia

Table 1.4. *Cyt b* sequences from GenBank producing significant alignments with Grey Langur (*Semnopithecus entellus*) sequences from Bhutan.

Species	Accession No	Authors	Alignment (Base pair matches)	Expect Value (Homology)	Location
Semnopithecus entellus	AF293959	Karanth,P.K., Stewart,C.-B., Singh,L. Mohnot,S.M.	97.63% 700/717	0.0	Nepal isolate N4
Semnopithecus entellus	AF012470	Collura,R.V., Messier,W. Stewart,C.-B.	95.68% 686/717	0.0	
Semnopithecus entellus	AF293958	Karanth,P.K., Stewart,C.-B., Singh,L. Mohnot,S.M.	93.86% 673/717	0.0	North East India Calcutta Isolate N3
Semnopithecus entellus	AF295576	Collura,R.V., Karanth,P.K. Stewart,C.-B.	93.58% 671/717	0.0	
Semnopithecus entellus	AF293957	Collura,R.V., Karanth,P.K. Stewart,C.-B.	93.17% 668/717	0.0	North West India Jaipur Isolate N11
Semnopithecus entellus	AF293952	Collura,R.V., Karanth,P.K. Stewart,C.-B.	91.88% 656/714	0.0	South India Hyderabad Isolate S2
Trachypithecus geei	AF294618	Collura,R.V., Karanth,P.K. Stewart,C.-B.	91.63% 657/717	0.0	South India Hyderabad (Zoo)
Trachypithecus pileatus	AF294626	Collura,R.V., Karanth,P.K. Stewart,C.-B.	91.49% 656/717	0.0	South India Hyderabad (Zoo)
Semnopithecus johnii	AF294620	Collura,R.V., Karanth,P.K. Stewart,C.-B.	91.32% 652/714	0.0	South India Isolate NL2
Semnopithecus entellus	AF293955	Karanth,P.K., Stewart,C.-B., Singh,L. Mohnot,S.M.	89.90% 641/713	0.0	Sri Lanka Isolate S5

Cyt b sequences were downloaded from GenBank. In addition to the sequences in Tables 1.3 and 1.4 *cyt b* sequences from GenBank that matched searches under *Trachypithecus* and *Semnopithecus* were also downloaded and used for comparison with langur sequences from Bhutan (Appendix 2). Several were from the German Primate Centre and deposited in Gen Bank by Roos *et al*. (2004).

The sequences were aligned using CLUSTAL X (Thompson et al., 1997). The gap open penalty, the penalty for opening a gap in the alignment, was set at 8 (on a scale of 1 to 100) since at higher values CLUSTAL did not perform any alignments. The gap extension penalty for extending a gap by 1 residue, was set at 1. Pairwise alignments to compare each sequence with each other were done to calculate a distance matrix. The results of the distance matrix were used to produce a guide tree only to help determine in what order the sequences are aligned. Alignment from the guide tree was then done. Since *cyt b* is a coding region and highly conserved, no insertions or deletions were present in the alignment indicating that the sequences were not nuclear pseudogenes. Regions at the terminal ends that did not align due to missing data were cut off before using the alignment for phylogenetic analysis. This reduced the number of base pairs per taxa to 504 with no missing data or gaps. The aligned sequences were translated into amino acid sequences using the ExPasy Translate Tool (http://au.expasy.org/tools/dna.html). Six frames, presenting three forward and three reverse frames were obtained. All frames were submitted to the ProtParam tool and tested for stability of the protein using the Instability Index (II). The Instability Index provides an estimate of the stability of the protein. The frame with II score of 28 was selected since it was the lowest. A protein whose instability index is smaller than 40 is stable and higher values are unstable (http://au.expasy.org/tools/protparam-doc.html). The stable protein alignment of Bhutan sequences are shown in Appendix 4.

Phylogenetic analysis was conducted in PAUP* 4.0b10 (Swofford, 2002) using all three optimality criteria: Parsimony, Distance, and Maximum Likelihood. Maximum Parsimony was conducted under branch and bound search settings treating all characters as unordered and having equal weight, excluding parsimony-uninformative nucleotide sites. The nearest neighbor interchange (NNI) branch swapping algorithm was used and branches collapsed if maximum branch length was zero. Distance (minimum evolution) analyses used the Neighbor-Joining algorithm and maximum likelihood distances from the best model of nucleotide evolution for the cyt b data described next.

Maximum likelihood analysis was done after choosing the most suitable model of nucleotide substitution based on results from Modeltest 3.6 (Posada and Crandall, 1998). Modeltest compared different nested models of nucleotide substitution in a hierarchical manner beginning with the simplest model of evolution (Jukes Cantor) and compared this to increasingly complex models in a stepwise fashion till the most complex model (general time reversible with gamma distributed rate variation and estimating the proportion of invariant sites) was tested. The best model of evolution was the simplest model that did not significantly reduce the likelihood of the data according to the likelihood-ratio test. This model was the HKY+I+G model (Hasegawa, Kishino, Yano model with gamma distributed rate variation and estimating the proportion of invariant sites) which estimates different substitution rates for transitions and transversions. The base frequencies estimated by the model were used in subsequent analyses (Table 1.5).

Table 1.5 The best model of nucleotide substitution (HKY+I+G)

Model selected	HKY+ I+G
	-lnL = 2677.0808
Frequencies:	A = 0.3284
	C = 0.3337
	T = 0.1026
	G = 0.2352
Substitution model	Ti/Tv = 12.7427
	Among-site rate variation Proportion of invariable sites (I) = 0.4790 Variable Sites (G) Gamma distribution shape parameter = 1.8401
Using mixed χ^2 distribution	P-value = < 0.00381

The robustness of the phylogentic trees was tested by nonparametric bootstrap resampling and recording bootstrap percentages. Phylogenies obtained under each of the optimality criteria were randomly resampled 1000 times each.

Divergence Times

Divergence times between the different lineages were estimated using genetic distance and estimated evolution rates of mtDNA measured as substitutions per site per million years (s/s/my) following methods described in Johns and Avise (1998) Modifications were made where later data were available with regards to sequence evolution rates and complemented with use of nucleotide substitution models. In summary:

1. Estimate pairwise comparisons of nucleotide divergence among all sequences using the uncorrected p distance.

p = total number of nucleotide differences / total number of sites

2. This is then corrected based on Modeltest 3.6 (Posada and Crandall, 1998) results described above. The HKY+I+G model was posited as the best model of nucleotide substitution by Modeltest and was used to construct a genetic distance matrix as described in Swofford *et al.* (1996) and implemented in PAUP* (Swafford 2002).

3. The corrected p values were then used to estimate divergence times. Johns and Avise (1998) used a "mtDNA clock calibration of about 2% sequence divergence per Myr [million years]" based on work by Brown *et al*. (1979), who estimated this rate based on restriction mapping of mtDNA from four species of primates. These rates have subsequently been revised based on restriction mapping from a larger sample size of

human mtDNA and estimates of 0.02 to 0.04 s/s/my were calculated (Cann and Stoneking, 1987). Later substitution rates based on complete mtDNA nucleotide sequences have estimated revised estimates of 0.02 s/s/my for mtDNA without the D-loop and 0.04 s/s/my with the D-loop (Ingman et al. 2000). Gilloli et al. (2005) showed that scaling for body size and temperature are important factors in the estimation of substitution rates. Smaller sized animals have shorter generation times, higher metabolism and increased probabilities of mutations. They write that:

> differences in body size might explain the ''hominoid slowdown hypothesis,'' which proposed that rates of molecular evolution have slowed in hominoids since their split from Old World monkeys. Based on differences in average body mass between extant hominoids (50 kg) and Old World monkeys (7 kg), our model predicts a ~ 0.6-fold slowdown [= $(7\ kg/50\ kg)^{1/4}$].

This quarter power scaling was applied to Colobines, which on average are about 10 kg in weight. This results in ~ two times faster rates of sequence evolution in Colobines compared to humans (0.02 s/s/my). So an estimated sequence substitution rate of 0.04 s/s/my for the *cyt b* sequence of colobines seems appropriate.

The fossil record was used for calibration using estimates of genetic distance between taxa and substitution rates obtained for three lineages for which divergence times are available from fossil records (cercopithecine-colobine, Asian – African colobine, *Trachypithecus - Semnopithecus*). Substitution rates were calculated (= corrected distance / fossil divergence time) and divergence times estimated (= corrected distance / substitution rate).

Also, calibration was done by testing whether the data can be explained equally well with and without the assumption of a molecular clock using likelihood ratio (LR) tests. Significance was assessed by comparing $\Lambda = |2*LR|$, where LR is the difference between the -ln likelihood of the tree, with and without enforcing a molecular clock, with a χ^2 distribution with n-2 degrees of freedom, where n is the number of taxa in a fully resolved tree. The substitution model used was the one obtained from Modeltest (HKY+I+G) described above.

In addition to the distance based divergence estimates described above, estimates of substitution rates based on branch lengths from the likelihood tree were also calculated (= branch length / fossil divergence time). Divergence times based on the branch length and substitution rate were then estimated (= branch length / substitution rate).

Simple linear regression of estimated divergence time against nucleotide substitution was conducted to obtain confidence limits at the 95% level for the estimated divergence times.

Results

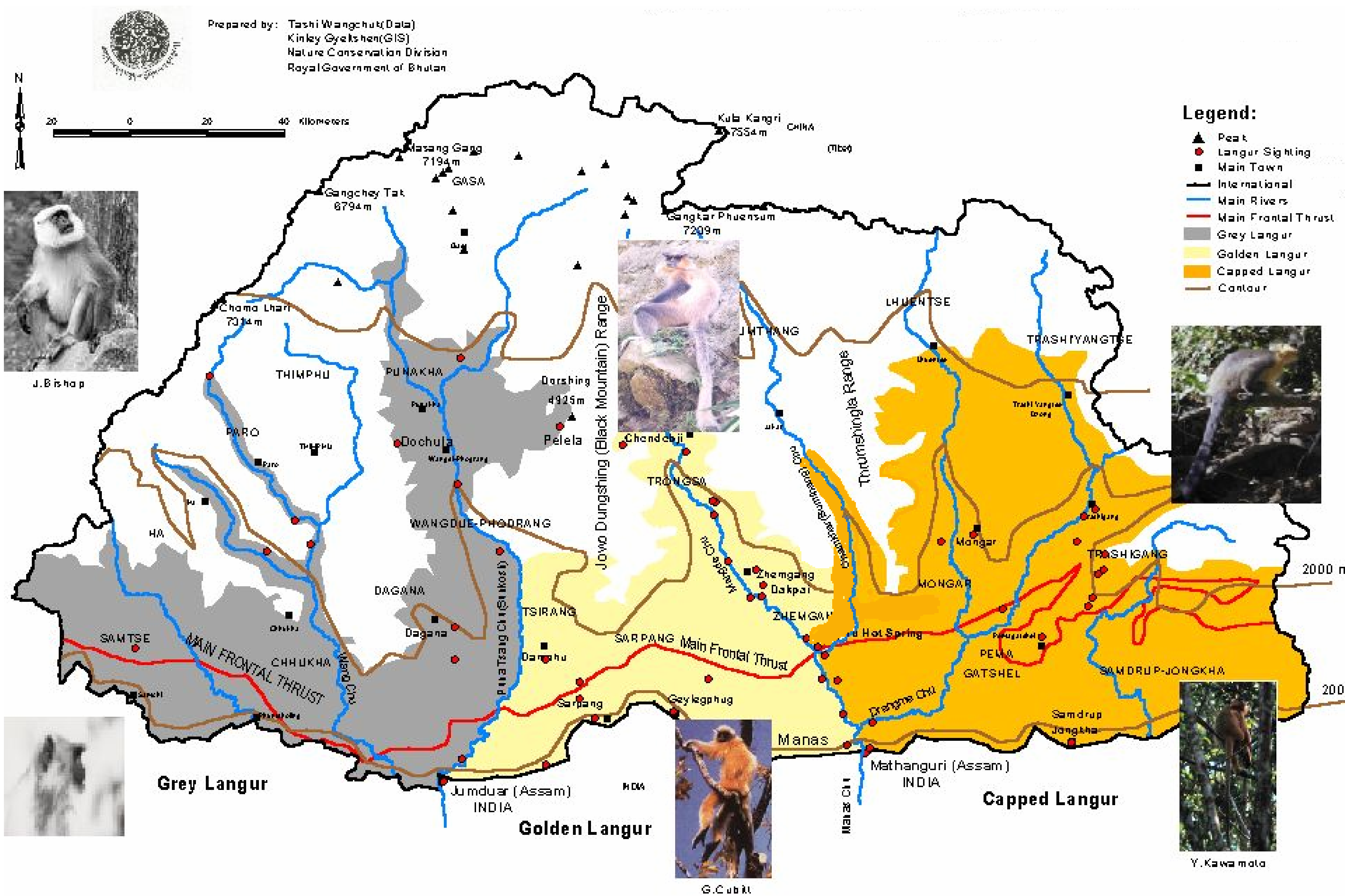
Biogeography

The results of the surveys reveal that the three langur species are allopatrically distributed with grey langurs (*S. entellus*) in the west, golden langurs (*T. geei*) in central Bhutan, and capped langurs (*T. pileatus*) in east Bhutan. Figure 1.6 shows the west to east allopatric distribution pattern of the langurs of Bhutan. Barriers to species dispersal include rivers and mountain ranges.

Grey Langur Distribution

Grey langurs are found west of the Puna Tsang Chu river which is known as the Sunkosh River as it flows into India. The river has its source in glacial lakes in the alpine districts of north Bhutan in Lunana, Laya, and Lingshi (Figure 1.8). Because glaciers in the Himalayas have been on the retreat since the end of the Ice Age 14,000 years BP when there was rapid warming, many glacial lakes from the melting glaciers have been formed which are the source of rivers (Valdia, 1998). Grey langurs are found exclusively to the west of the Puna Tsang Chu / Sunkosh River and the Black Mountain or Jowo Dungshing Range (Figure 1.6). There is no overlap between grey langur and golden langur distribution zones. Grey langurs are found from the foothills on the border with India in subtropical forests all the way up to subalpine forests. The highest point observed was a group of 15 individuals at Soe Thangthangkha at 3,630 m (Table 1.6) close to the tourist camp site on the Jumolhari Trek. The furthest east grey langurs have been recorded is near Nobding (Table 1.6), close to the Pelela pass at 3,400 m which forms the major pass from west Bhutan into central Bhutan over the Black Mountain range. Kalikhola, Kerabari, Sankosh, Dagana, Kamji, and Basochu (Table 1.6) are

Figure 1.6. Allopatric distribution pattern of the langurs of Bhutan



important sighting locations along the west bank of the Sunkosh river basin of the grey langurs. Kalikhola at 214 m is the southern most point in west Bhutan from where grey langurs have been recorded. Their range extends into India west of the Sunkosh and Brahmaputra and all the way down to south India and west into Pakistan (Roberts, 1997).

Golden Langur Distribution

Golden langurs are found west of the Sunkosh river and Black Mountain range. In the east the Manas and Mangde rivers are effective barriers between golden and capped langurs. The Chamkhar river further north may have been an effective barrier which in recent years has been dissolved due to the construction of bridges. The Chamkhar flows into the Mangde which in turn confluences with the Drangme to form the Manas (Figure 1.7). The furthest west golden langurs have been recorded from is Chendebji at 2600 m in the summer in mixed broadleaf forest (Table 1.5). The furthest north is from below the Trongsa Dzong at 2,353 m. The southern-most sighting records in Bhutan are from Manas in the east at 199 m and in general they are resident in broadleaf forests below 2,400 m in summer; occasionally some groups forage at higher altitudes for brief periods of time before returning to lower elevations, as in the case of Chendebji.

Golden langur sighting frequency is highest in Trongsa and Zhemgang districts and lowest in Tsirang district. In general an average density of 2.1 golden langurs / km^2 was estimated from the census in 1994 and 2003. This is reported in more detail in chapter 3. A contact zone between capped and golden langurs at Dunmang Tshachu on the east bank of the Mangde river (Figure 1.6) was also found. This is discussed in detail in chapter 2.

Capped Langur Distribution

Capped langurs are found in the Chamkhar river basin on both sides of the river and extend west up to Dunmang Hot Spring (Figure 1.6). The furthest record north in the Chamkhar river basin is north of Khen Shingkhar near the Gayzamchu stream where the forest type transitions from broadleaf to conifer. Further south the Mangde and Manas river separates capped from golden langurs. The furthest south they have been recorded from is Mathanguri on the east bank of the Manas. Their range extends further south into Assam India and into Burma. In the Kuri Chu basin where broadleaf forests extend much further north almost to the Tibet border, capped langurs are found as far north. The Kuri Chu is an older river system that predates the formation of the Himalayas and has its source in Tibet. The furthest records from east Bhutan are broadleaf forest along the Indian state of Arunachal Pradesh into which capped langur range extends.

Table 1.6 Selected GPS coordinates of Langur sighting locations.

Site (Nearest Village / Town)	Species	Longitude	Latitude	Elevation
Phipsoo	*T. geei*	90° 08.25' E	26° 45.27' N	200 m
Noonpani	*T. geei*	90° 13.50' E	26° 54.64' N	798 m
Darachu	*T. geei*	90° 13.35' E	26° 57.01' N	1799 m
Tsirang (Damphu)	*T. geei*	90° 08.35' E	27° 00.01' N	1200 m
Batasey	*T. geei*	90° 33.6' E	26° 57.15' N	454 m
Tama	*T. geei*	90° 39.6' E	27° 08.10' N	1601 m
Tingtinbi	*T. geei*	90° 42.01' E	27° 08.68' N	658 m
Dakpai	*T. geei*	90° 42.18' E	27° 10.33' N	1026 m
Birti	*T. geei*	90° 40.13' E	27° 08.66' N	657 m
Zhemgang	*T. geei*	90° 41.09' E	27° 12.51' N	1500 m
Nimshong	*T. geei*	91° 35.55' E	27° 14.18' N	1399 m
Wangdigang	*T. geei*	90° 36.67' E	27° 13.64' N	1457 m
Jangbi	*T. geei*	90° 34.50' E	27° 20.12' N	1232 m
Langthel	*T. geei*	90° 34.50' E	27° 22.02' N	1005 m
Surgang	*T. geei*	90° 34.40' E	27° 22.10' N	1007 m
Trongsa	*T. geei*	90° 30.32' E	27° 29.01' N	2353 m
Chendebji	*T. geei*	90° 20.25' E	27° 29.85' N	2607 m
Manas	*T. geei*	90° 58.65' E	26° 47.43' N	199 m
Chengazam	*T. geei*	90° 55.50' E	26° 52.43' N	217 m
Pantang	*T. geei*	90° 52.35' E	26° 57.15' N	313 m
Mamung	*T. geei*	90° 50.55' E	26° 59.72' N	400 m
Dunmang Hot Spring	*T. geei*	90° 47.60' E	27° 03.43' N	685 m
Kalikhola	*S. entellus*	89° 51.75' E	26° 43.08' N	214 m
Kerabari	*S. entellus*	89° 55.05' E	26° 46.22' N	336 m
Sankosh	*S. entellus*	90° 04.20' E	27° 01.35' N	611 m
Dagana	*S. entellus*	89° 54.00' E	27° 04.59' N	1421 m
Kamji	*S. entellus*	90° 01.00' E	27° 15.07' N	1512 m
Basochu	*S. entellus*	89° 54.33' E	27° 24.45' N	1002 m
Nobding	*S. entellus*	90° 10.46' E	27° 32.45' N	2816 m
Tsachuphu	*S. entellus*	89° 54.75' E	27° 42.15' N	1587 m
Dochu La	*S. entellus*	89° 45.05' E	27° 30.12' N	3110 m
Dobji	*S. entellus*	89° 31.50' E	27° 16.08' N	2612 m
Paro (Isuna)	*S. entellus*	89° 28.95' E	27° 19.40' N	2200 m
Soe Thangthangka	*S. entellus*	89° 15.60' E	27° 39.45' N	3612 m
Bitaykha	*S. entellus*	89° 24.75' E	27° 15.00' N	2801 m
Mathanguri	*T. pileatus*	90° 59.00' E	26° 47.40' N	198 m
Panbang	*T. pileatus*	90° 58.20' E	26° 51.62' N	345 m
Goshing	*T. pileatus*	90° 53.55' E	26° 57.02' N	1017 m
Kalamti	*T. pileatus*	90° 51.75' E	27° 00.54' N	712 m
Dunmang Hot Spring	*T. pileatus*	90° 48.81' E	27° 02.80' N	289 m
Pema Gatshel	*T. pileatus*	91° 25.50' E	27° 02.70' N	1016 m
Khen Shingkhar	*T. pileatus*	90° 49.71' E	27° 33.80' N	2120 m
Kengkhar	*T. pileatus*	91° 19.50' E	27° 06.75' N	1237 m
Wamrong	*T. pileatus*	91° 32.85' E	27° 06.89' N	2211 m
Khaling	*T. pileatus*	91° 35.25' E	27° 11.88' N	2250 m
Gomchu	*T. pileatus*	91° 35.38' E	27° 12.00' N	2150 m
Yonphula	*T. pileatus*	91° 31.20' E	27° 16.08' N	2450 m
Gamri	*T. pileatus*	91° 32.25' E	27° 19.42' N	850 m
Limithang	*T. pileatus*	91° 10.08' E	27° 16.22' N	611 m

Phylogenetics

Phylogeographic Patterns

A parsimony gene tree based on *cyt b* sequences showed that the golden langur (*T. geei*) and capped langur (*T. pileatus*) sequences from Bhutan formed a clade with other congenerics in the *Trachypithecus* group that was well diverged from and reciprocally monophyletic with the *Semnopithecus* clade (Figure 1.7). Of particular interest are the *T. geei* (AF294618)and *T. pileatus* (AF294626) sequences, obtained from zoos in South India by Karanth (2000), which clearly fall into the *Semnopithecus* clade. This zoo *T. geei* and *T. pileatus* clade is basal to *S. entellus* and *S. johnii,* similar to results obtained by Karanth (2000). *T. geei* and *T. pileatus* sequences obtained from the wild in Bhutan fall with the *Trachypithecus* clade in which the *T. cristatus* / *T. auratus* group from south Vietnam is basal. Phayre's Langurs from Indian and Burma, while basal to golden and capped langurs are intermediate between the golden / capped clade and the silvered langur (*T. auratus*) clade, clearly revealing a south to north phylogeographic pattern with the southern species being more basal and the northern species having diverged later. There is 98% bootstrap support for this pattern (Figure 1.8). In general there's strong bootstrap support for the clades; bootstrap support for a monophyletic *Semnopithecus* clade is 100% and 98% for a monophyletic *Trachypithecus* clade.

Within the *Semnopithecus* clade there is a similar pattern from south to north with the southern lineages being more ancestral and the northern ones having evolved later. For instance *S. entellus* from south India is basal to *S. entellus* from north India with the *S. entellus* sequences from Nepal and Bhutan being the most derived and accumulating the most number of nucleotide changes since a last common ancestor. Bootstrap support for this pattern is 87%. The distance-based tree also produced a similar topology. Figure 1.8 shows the distance tree with branch lengths above the branches and bootstrap values below the branches. The maximum likelihood tree is concordant with the phylogeographic pattern described above for the parsimony tree. A bootstrap value of 100% is obtained for the *Trachypithecus* clade while bootstrap support of 84% is present for the *Semnopithecus* clade (Figure 1.9).

Divergence Times

The likelihood score for the best tree obtained with and without the molecular clock assumption were –ln 2687.333376 and –ln 2672.83781 respectively. This resulted in the test statistic value of ((2687.333376 – 2672.83781)*2) 28.9919 which is less than the critical value of χ^2 at the 0.05 level with 23 degrees of freedom. Thus the obtained likelihood score with the molecular clock assumption does not differ from expected scores more than would be predicted by chance. There is no significant rate heterogeneity among lineages. The estimated divergence times are shown in Table 1.7. The average substitution rates estimated from the calibration with the fossil record are in agreement with the substitution rate scaled to colobine body size: ((0.5459/14000000), (0.4861 / 12000000), (0.3299 / 85000000)). The average substitution rate from the fossil calibration is 0.04 s/s/my. The divergence times estimated using the likelihood branch lengths are also in agreement with both the fossil record and distance based estimate. Figure 1.10 shows the regression of estimated time since divergence on cyt b substitutions. The confidence bands are narrow and the fit is high.

Table 1.7 Divergence Times

Taxa 1	Taxa 2	Corrected distance	Fossil Divergence Time MY	Fossil Calibrated Rates-Distance (s/s/my)	Distance Divergence Estimate MY	Fossil Calibrated Rates-Likelihood (s/s/my)	Likelihood Divergence Estimate MY
MacacafascicularisKaranth (Cercopithecinae)	ColobusguerezaROOS (Colobinae)	0.5459	13 – 15	0.039	13.65	0.052	13.93
ColobusguerezaKaranth (African Colobine)	SentellusS2Hyderabad (Asian Colobine)	0.4861	10 – 13	0.040	12.15	0.044	12.06
TauratusRoos (*Trachypithecus*)	SentellusS2Hyderabad (*Semnopithecus*)	0.3299	8 – 9	0.041	8.25	0.036	8.15
			Avg. Rate	0.040		0.044	
TauratusRoos (*T. auratus*)	TcristatusRoos (*T. cristatus*)	0.0328	?		0.82		0.97
TcristatusRoos (*T. cristatus*)	TobscurusRoos (*T. obscurus*)	0.0927	?		2.32		2.55
TobscurusRoos (*T. obscurus*)	TpphayreiRoos (*T. phayrei*)	0.0425	?		1.06		1.01
TphayreiRoos (*T. phayrei*)	TpileatusE20BHUTANWangchuk (*T. pileatus*)	0.1101	?		2.75		2.97
SentellusS2Hyderabad (*S. entellus* South India)	SentellusN11JaipurKaranth (*S. entellus* North India)	0.0998	?		2.49		2.46
SentellusS2Hyderabad (*S. entellus* South India)	SjohniiNL2Karanth (*S. johnii* South India)	0.0694	?		1.73		1.75
SentellusN11JaipurKaranth (*S. entellus* North India)	SentellusN4NepalKaranth (*S. entellus* Nepal)	0.0745	?		1.86		1.89
SentellusN4NepalKaranth (*S. entellus* Nepal)	Sentellus84BHUTANWangchuk (*S. entellus* Bhutan)	0.0209	?		0.52		0.51

Figure 1. 7 Maximum Parsimony Tree from *cyt b*. Branch lengths are shown above the branches and bootstrap values below. (CI = 0.928)

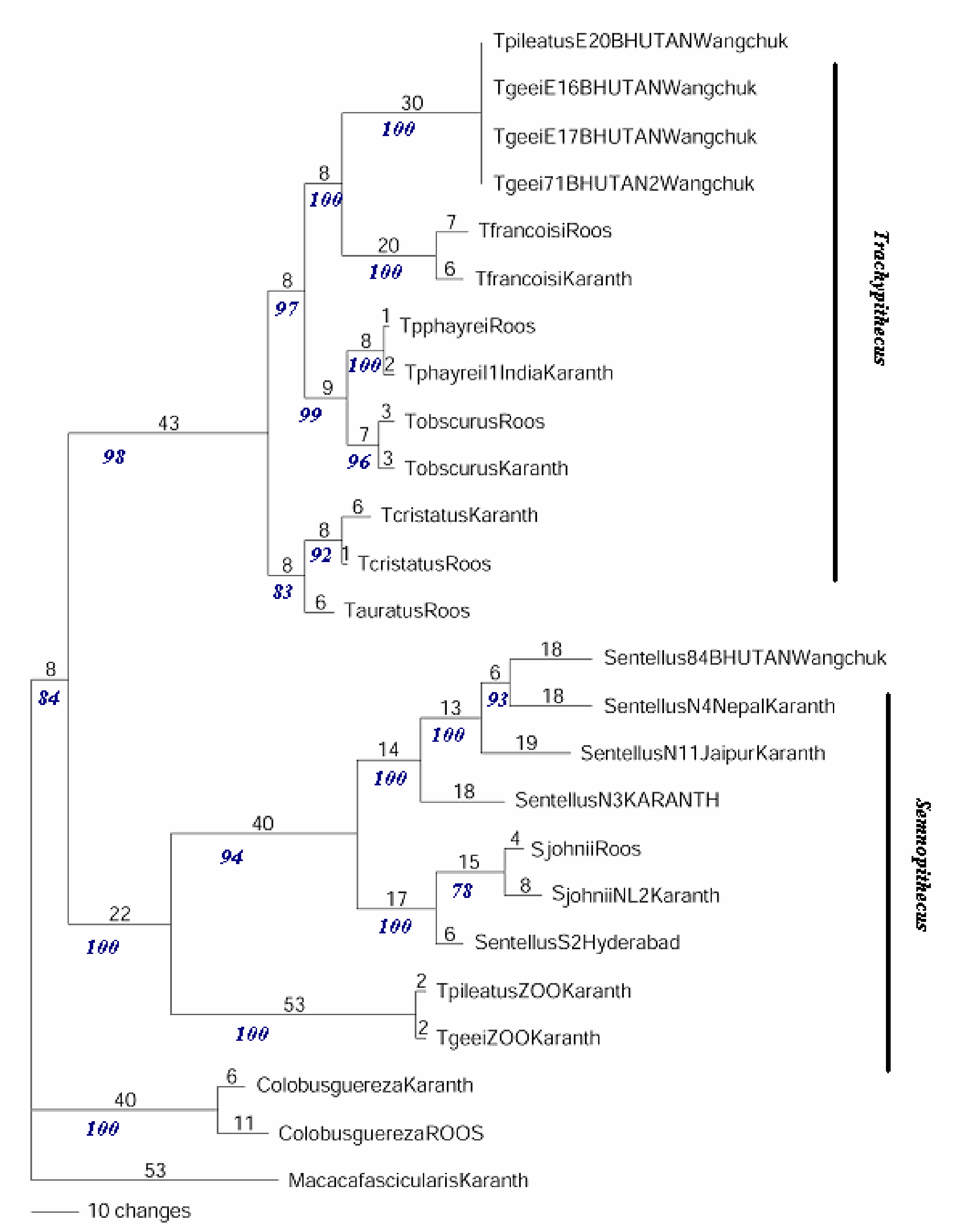


Figure 1.8 Minimum Evolution tree based on HKY+G+I distance settings with gamma shape 1.8401). Bootstrap values are shown below the branches.

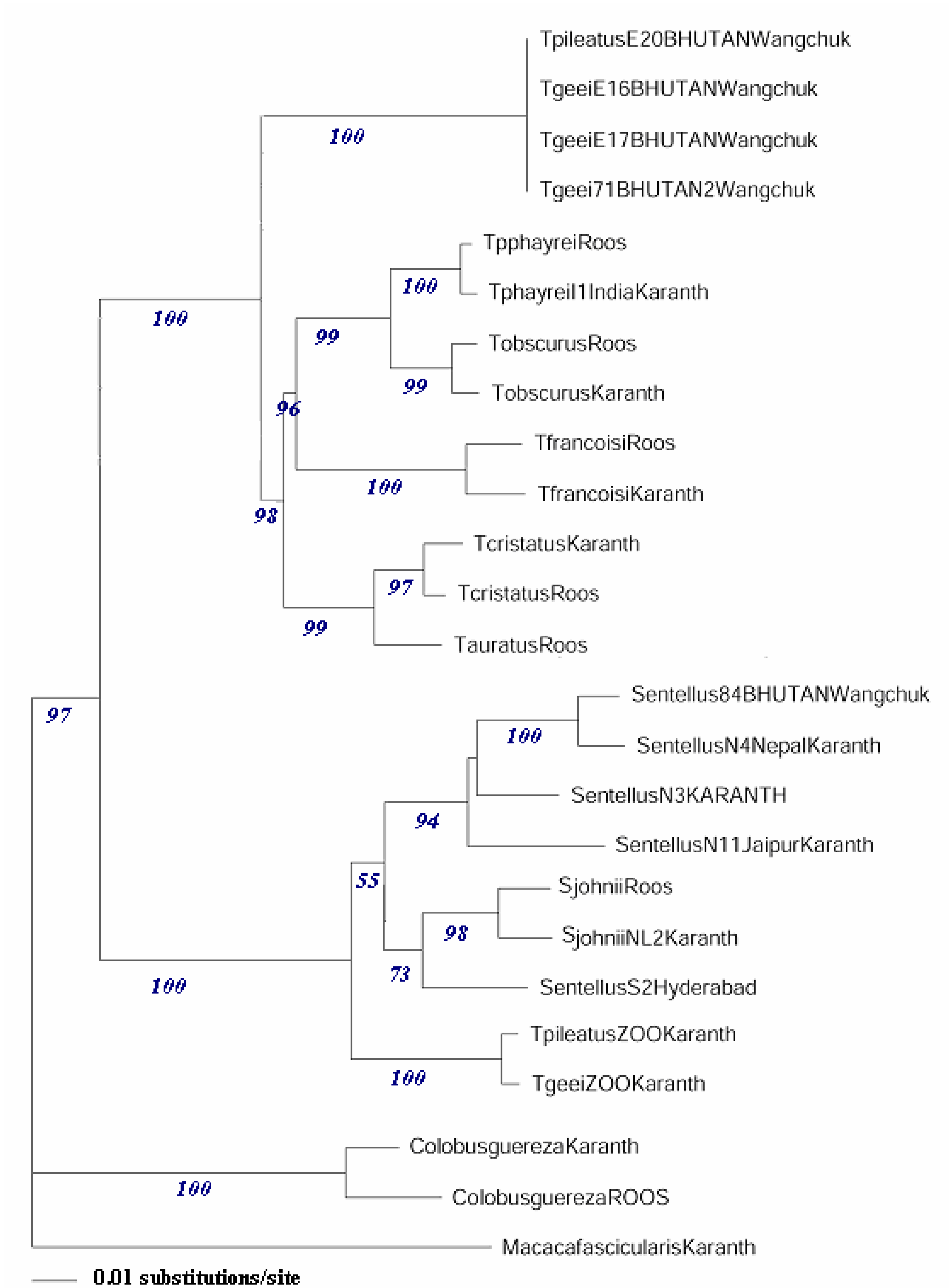


Figure 1.9 Maximum Likelihood Tree based on HKY + G + I substitution model (I = 0.4790, G = 1.8401, Ti/Tv ratio: 12.7427). Divergence times (MYA) are shown at the nodes with upper and lower estimates in parentheses.

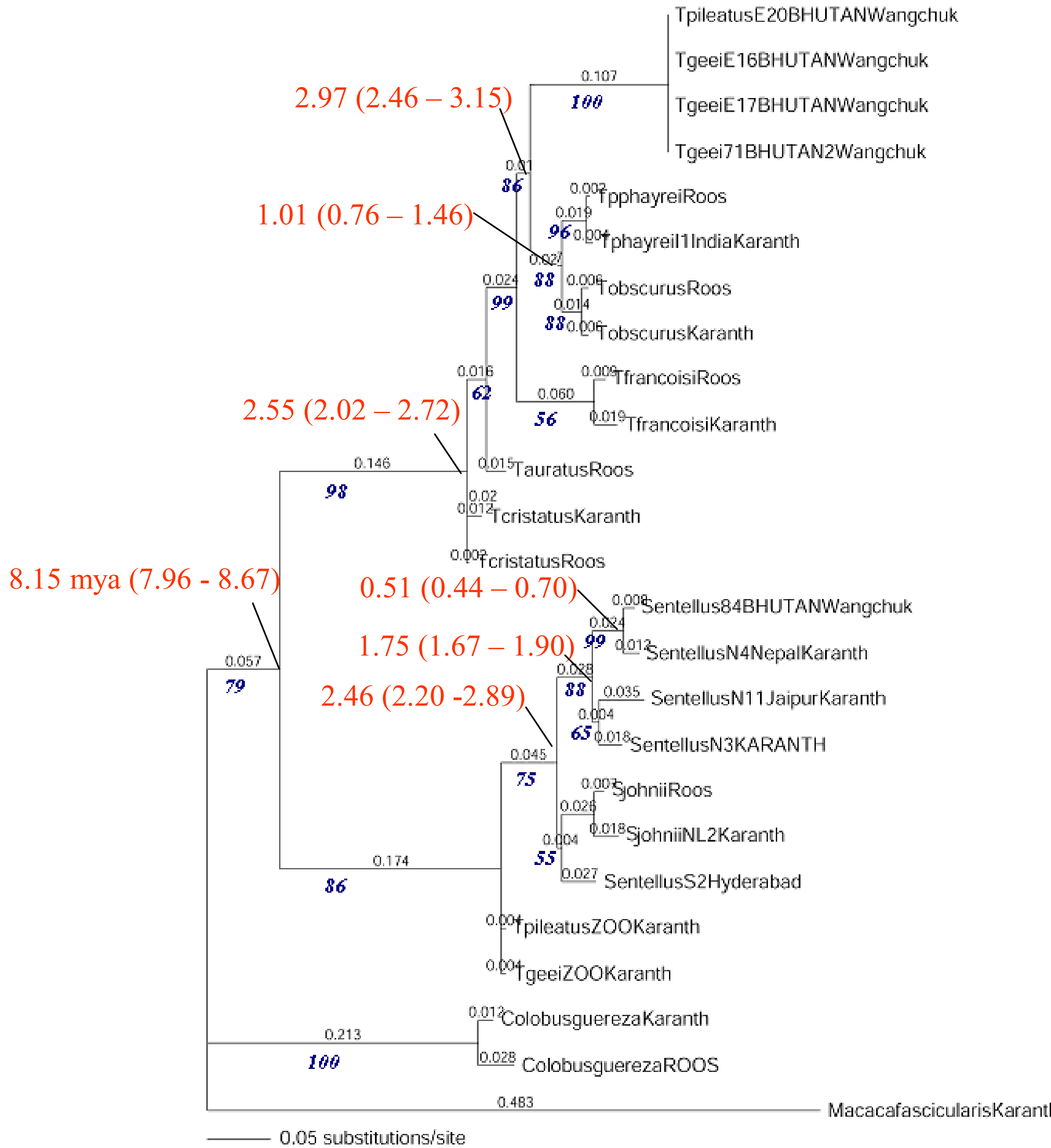
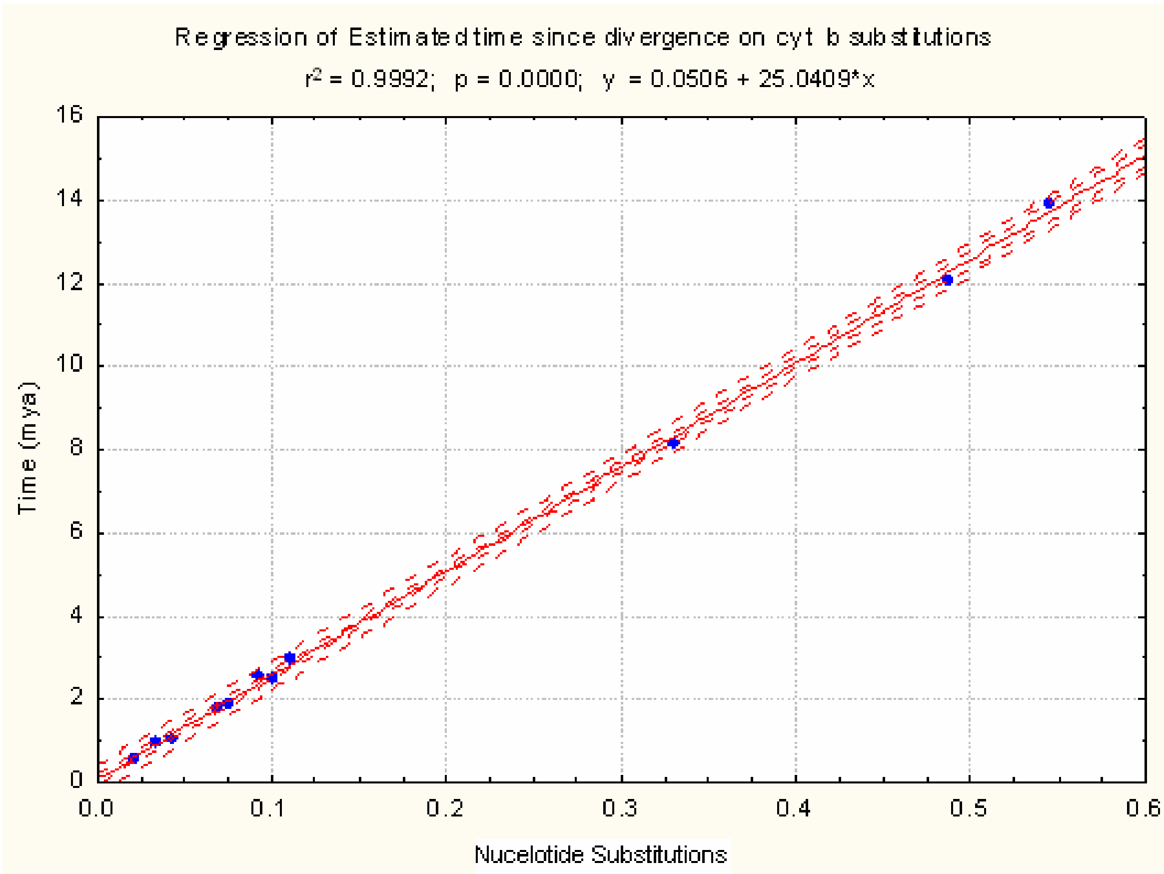


Figure 1.10 Regression of estimated time since divergence on cyt b substitutions. The inner bands are the 95% confidence limits of the regression line. The outer bands are the 95% confidence limits for predicted values of time based on new measurements of sequence divergence.



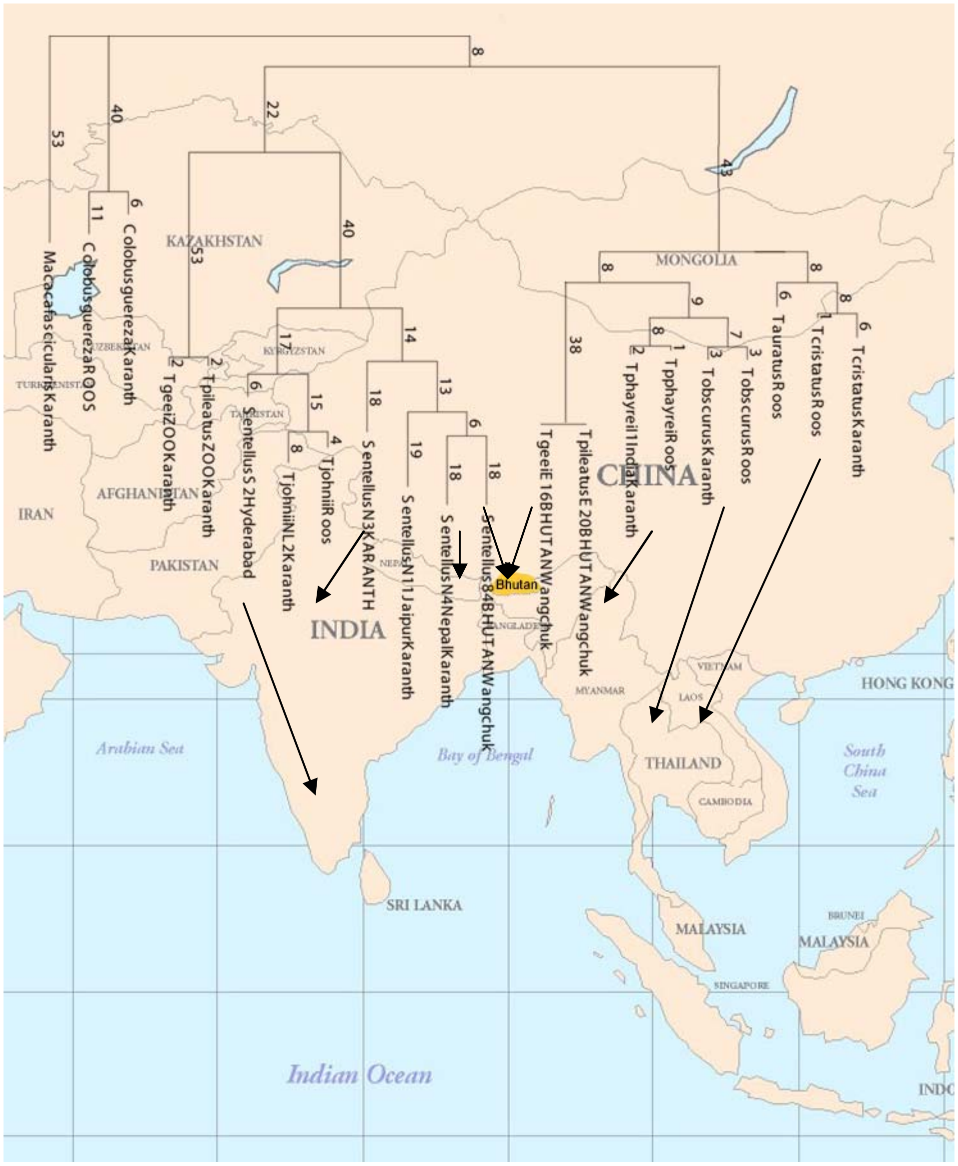
Discussion

The results clearly indicate a phylogeographic pattern consistent with a south to north dispersal of the *Semnopithecus* from south India and *Trachypithecus* from south China and Vietnam towards the Himalayas (Figure 1.11). These two genera converged in Bhutan on the banks of the Sunkosh river, which served as a barrier and actually prevented their interbreeding. One can imagine these two species staring across the river at each other as each species arrived on the opposite bank hundreds of thousands of years ago. This is reflected in the present distribution of the langurs of Bhutan as shown by the distribution surveys and maps (Figure 1.6). This is also consistent with Brandon-Jones' (1996) theory that langurs retreated south into relic forests during deforestation events in the north. However, the timing of these events does not agree with that postulated by Brandon-Jones (1996), i.e., during the Pliestocene glaciations 190,000 years BP and 80,000 years B.P. Rather the divergence times estimated here are greater by about 13 to 31 fold and date back to the Pliocene (5.3 – 1.8 MYA). The Pliocene was a time of global cooling after the warmer Miocene. The cooling and drying of the global environment resembled events during the Pleistocene glaciations. The northern parts of the Indian subcontinent and the foothills of the Himalayas (which were still experiencing rapid increases in height) turned to grasslands and savannas (Valdiya, 1998). The Terai grasslands in the foothills today are relics of this Pliocene grassland formation. Tropical forests retreated south to more moist areas. *Semnopithecus* may have retreated south with the forests. However, it could be postulated that some populations may have remained back and adapted to the drier conditions. Grey langurs are the most terrestrial of the langurs and can be found in near desert-like conditions in north western India (Hrdy, 1977; Roonwal and Mohnot, 1977). Whatever the scenario, this split between northern and southern populations of *Semnopithecus* happened around 2.49 MYA. Karanth (2000) estimates a divergence time between northern and southern populations of *Semnopithecus* 2.3 – 2.5 MYA.

The split between the lineage of *S. entellus* found in the foothills of Nepal (classified today as a subspecies *S. e. hector*) and the Bhutan *S. entellus* (*S. e. schistaceus*) occurred around 520,000 years B.P. (Table 1.7). This happened about 80,000 years after the last great upheaval of the Himalayas during the late Pleistocene about 600,000 years ago. This final phase more or less determined the present geomorphic form of the Himalayas (Valdiya, 1998). It is possible then that after the landscape had stabilized somewhat, *S. e. schistaceus* could have gradually moved north into the Bhutan Himalaya. Figure 1.1 show the changes such as a thick coat and larger body size *S. e. schistaceus* evolved in response to the mountain conditions.

The *cyt b* phylogeny resolves an important question regarding the placement of the golden langur and capped langur. Karanth (2000) and Geissman et al. (2004) used the sequences obtained by Karanth (2000) from zoos in India to build *cyt b* phylogenies of langurs. These phylogenies placed capped and golden langur within the *Semnopithecus* group, causing much confusion and giving rise to Karanth's (2000) hybrid hypothesis where he postulated that the capped – golden clade resulted from an ancient hybridization between *Semnopithecus* and *Trachypithecus.* My results reject this hypothesis and are more in agreement with Brandon-Jones' (1996)

Figure 1.11. The phylogeographic patterns of *Semnopithecus* and *Trachypithecus* in South Asia. The two genera meet in Bhutan.



theory of paleoclimatic and ecological changes playing a large role in animal dispersal. An explanation for Karanth's (2000) aberrant results for the *cyt b* phylogeny could be that the samples he obtained from the zoos were from hybrid animals. Zoos have long been known to produce hybrids ranging from tigons (tiger-lion hybrids, the females of which are fertile) to jaguleps (http://www.lairweb.org.nz/tiger/).

There is evidence that grey langurs (*S. entellus*) can hybridize with capped langurs (*T. pileatus*) in zoos. The following is from observations at the London Zoo in Sterndale's Mammalia of India (Finn, 1980):

> A pair [of capped langurs] lived for years at the London Zoo before the war…The female had three young at different times…two of them duly changed their infant golden fur for that of the colours of the adult. ..but the first born, though also golden at birth, assumed a dark brown coat against which the white whiskers showed up very distinctly. This was evidently a hybrid, originally a male hanuman [*S. entellus*] had shared the capped pair's quarters.

Given this information it is likely that the two samples obtained by Karanth (2000) could have come from hybrids. In particular since Karanth's (2000) nDNA lysozyme c sequences grouped the golden and capped langurs with the *Trachypithecus* clade while the *cyt b* sequences grouped them with the *Semnopithecus* clade, it is likely that the samples were from hybrids of male *Trachypithecus* and female *Semnopithecus*. Also, the same sequences of the zoo *T. geei* and *T. pileatus*, obtained by Karanth (2000) and used for comparative purposes here, group with the *Semnopithecus* clade whereas field samples from the wild of *T. geei* and *T. pileatus* group with the *Trachypithecus* (Figure 1.7, 1.8, 1.9).

So clearly then Brandon-Jones' (1996) climate model is a better predictor of langur phylogeny. Paleoclimatic changes and the effect they had on flora and fauna better explain the current observed patterns of species distribution. The results support the hypothesis of *T. geei* and *T. pileatus* branching off from ancestral *Trachypithecus* from southeast Asia. Southeast Asian species such as *T. cristatus, T. aurauts*, and *T. obscurus* are ancestral to *T. geei* and *T. pileatus*. The divergence of the various taxonomic groups are approximately concordant with the fossil record and similar divergence dates for events such as the split between Colobines and Cercopithecines (13- 15 MYA), the African and Asian colobines (10-13. MYA) and *Semnopithecus* and *Trachypitecus* (8 - 9 MYA) group are in agreement.

There was less than 5% sequence divergence in *cyt b* between capped and golden langurs, indicating a recent divergence and thus *cyt b* did not resolve some questions. The hypothesis that *T. pileatus* should be basal to *T. geei* and that *T. geei* branched off from *T. pileatus* is probably due to the increasing size of the Manas, Mangde, Chamkhar river is therefore addressed with the control region sequences in chapter 2.

Literature Cited Chapter 1

Baker, L., T. Nadler, and T. Geissmann, T. 2000. *Viet Nam: Primate Field Guide*. Fauna & Flora International, Indochina Programme, Hanoi. 8 pp. (English and Vietnamese text).

Barry, J., E. Lindsay and L. Jacobs, 1982. A biostratigraphic zonation of the Middle and Upper Siwaliks of the Potwar Plateau of Northern Pakistan. *Palaeogeography, Palaeoclimatology, Palaeoecology* 37 (1): 95-130.

Bishop, N. 1979. Himalayan langurs: temperate colobines. *J. of Human Evolution*. 8: 251-281

Blunier, T., J. Chappellaz, J. Schwander, A. Dällenbach, B. Stauffer, T. Stocker, D. Raynaud, J. Jouzel, H. Clausen, C. Hammer and S. Johnsen, 1998: Asynchrony of Antarctic and Greenland climate change during the last glacial period. *Nature* 394: 739-743.

Brandon-Jones, D., 1996. The Asian Colobinae (Mammalia: Cercopithecidae) as indicators of Quaternary climatic change. *Biological Journal of the Linnean Society* 59:327-350.

Brandon-Jones D; A. Eudey, T. Geissman, C. Groves, D. Melnick, J. Morales, M. Shekelle, C-B. Stewart, 2004. Asian primate classification. *Int. J. Primatology* 25(1): 97-164.

Brown, W., M. George, and A. C. Wilson. 1979. Rapid evolution of animal mitochondrial DNA. *Proc. Natl. Acad. Sci.* USA 76:1967–1971.

Cann, R., M. Stoneking, M., and A. Wilson, 1987. Mitochondrial DNA and human evolution. *Nature* 325: 31-36.

Corbet, G., and J. Hill, 1992. *The mammals of the Indomalayan region: a systematic review.* Oxford University Press, Oxford

Delson, E, 1994. Evolutionary history of the colobine monkeys in paleoenvironmental perspective, p. 11-44 in *Colobine Monekys: Their Ecology, Behaviour and Evolution*, A. Davies and J. Oates, eds. Cambridge Univ. Press, Cambridge:

Ellerman, J., and T. Morrison-Scott, 1966. *Checklist of Palaearctic and Indian Mammals 1758 to 1946.* 810 pp. British Museum (Natural History). London.

Finn, F., 2002. *Sterndale's Mammalia of India*. Cosmo, New Delhi 347p.

Fischer, H., M. Wahlen, J. Smith, D. Mastroiani and B. Deck, 1999. Ice core records of atmospheric CO_2 around the last three glacial terminations. *Science*, 283: 1712-1714

Geissmann, T., C. Groves, C. Roos, 2004. The Tenasserim Lutung, *Trachypithecus barbei* (Blyth, 1847) (Primates: Cercopithecidae): Description of a live specimen, and a reassessment of phylogenetic affinities, taxonomic history, and distribution. *Contributions to Zoology*, in press.

Goodman, M., C. Porter, J. Czelusniak, S. Page, H. Schneider, J. Shoshani, G. Gunnell, and C. Groves, 1998. Toward a phylogenetic classification of primates based on DNA evidence complemented by fossil evidence. *Mol. Phylogenet. Evol*. 9:585–598.

Groves, C. 2001. *Primate taxonomy*. Smithsonian Series in Comparative

Evolutionary Biology.: Smithsonian Institution Press. Washington and London.

Grierson, A. J., and D.G. Long. 1983. *Flora of Bhutan.* Royal Botanic Garden, Edinburgh.

Hrdy, S., 1977. *The Langurs of Abu: Female and Male Strategies of Reproduction*. Cambridge: Harvard Univ. Press.

Gillooly J., A. Allen, G. West, J. Brown, 2005. The rate of DNA evolution: effects of body size and temperature on the molecular clock. *Proc. Natl. Acad. Sci.* USA. 4, 102(1):140-5.

Karanth, P., 2000. Molecular Systematics and Phylogeography of the Langurs of Asia. Ph.D. dissertation, University at Albany, State Univ. of New York.

Hayasaka, K., T. Ishida, and S. Horai. 1991. Heteroplasmy and polymorphism in the major noncoding region of mitochondrial DNA in Japanese monkeys: Association with Tandemly Repeated Sequences. *Mol. Biol. Evol.* 8(4):399-415.

Ingman, M., H. Kaessmann, S. Paabo and U. Gyllensten, 2000. Mitochondrial genome variation and the origin of modern humans. *Nature* 408:708-712.

Irwin D. M, T.D. Kocher, A.C. Wilson. 1991. Evolution of cytochrome *b* gene in mammals. *J. Mol. Evol.* 32(2):128-144.

Johns, G., and J. Avise. 1998. A domparative summary of genetic distances in the vertebrates from the mitochondrial cytochrome *b* gene. *Molecular Biology and Evolution*, 15(11): 1481-1490.

Kocher, T. D., W. K. Thomas, A. Meyer, S. V. Edwards, S. Pääbo, F. X. Villablanca, and A. C. Wilson. 1989. Dynamics of mitochondrial DNA evolution in animals: amplification and sequencing with conserved primers. *Proc. Natl. Acad. Sci*. USA. 86:6196–6200

Melnick, D., and G. Hoelzer, 1993. What is mtDNA good for in the study of primate evolution? *Evolutionary Anthropology*. 2:191-199.

Posada D and Crandall KA 1998. Modeltest: testing the model of DNA substitution. *Bioinformatics* 14 (9): 817-818.

Purvis, A. 1995. A composite estimate of primate phylogeny. *Phil. Trans. R. Soc. London* 348: 405-421.

Roberts, T., 1997. *Mammals of Pakistan*. Oxford University Press, Oxford.

Roos C., 2004. Molecular Evolution and Systematics of Vietnamese Primates. p 23-28 in *Conservation of Primates in Vietnam* T. Nadler, U. Streicher, and Ha Thang Long eds., 23-28. Publisher? City?

Roos, C., T. Geissmann, C. Groves, 2004. Molecular phylogeny of leaf monkeys. Unpublished direct sequence submission to GenBank. (http://www.ncbi.nlm.nih.gov/entrez/viewer.fcgi?db=nucleotide&val=46410423)

Sinha, A., Datta, A., Madhusudan, M.D., and Mishra, C. The Arunachal macaque *Macaca munzala*: a new species from western Arunachal Pradesh, northeastern India. *Intl. Journal of Primatology* (in press).

Sowers, T. and M. Bender, 1995. Climate records covering the last deglaciation. *Science*, 269: 210-214.

Sristava, A., J. Biswas, J. Das, and P. Bujarbarua, 2001. Status and distribution of golden langurs (*Trachypithecus geei*) in Assam, India. *Am. J. of Primatology* 55:15–23

Stewart C-B, and T. Disotell, 1998. Primate evolution: In and out of Africa. *Current Biology* 8:R582-R587.

Strasser, E and E. Delson, 1987. Cladistic analysis of cercopithecid relationships. *J. Human Evol.*, 16(1):81-99.

Swofford, D., 2002. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4. Sinauer Associates, Sunderland, Massachusetts.

Tamura, K. and M. Nei, 1993. Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. *Mol. Biol. Evol.* 10:512-526.

Thompson, J., T. Gibson, F. Plewniak, F. Jeanmougin, and D. Higgins, 1997. The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic Acids Research*, 25:4876-4882.

Valdiya, K., 1988. *Dynamic Himalaya*. Jawaharlal Nehru Centre for Advanced Scientific Research. Hyderabad, India, Universities Press.

Vigilant, L., M. Stoneking, H. Harpending, K. Hawkes, and A. C. Wilson. 1991. African populations and the evolution of human mitochondrial DNA. *Science* 253: 1503- 1507.

Wangchuk, T., 1995. A census and biogeography of golden langurs (*Presbytis geei*) in Bhutan. *TigerPaper FAO, UN Bulletin on Wildlife and National Parks Management* 22 (3): 1-6.

Wangchuk, T., Y.Kawamto, M.Aimi, 2001. Discovery of a contact zone between golden langurs (*Trachypithecus geei*) and capped langurs (*Trachypithecus pileatus)* in Bhutan. *Am. J. of Primatology* 54 (Supplement 1): 40.

Wangchuk T., D. Inouye, M. Hare**,** 2003**.** A new subspecies of golden langur (*Trachypithecus geei*) from Bhutan. *Folia Primatologica*. 74(2):104-108

Wangchuk, T., P. Thinley, K. Tshering, C. Tshering, and D. Yonten, 2004. *A Field Guide to the Mammals of Bhutan.* Royal Government of Bhutan, Thimphu.

<u>*Appendices for Chapter 1*</u>

Appendix 1: Samples used for DNA Extraction

	Sample	Type	Locality	Species	Sex/Age	Date
1	H-6	Hair	Dakpai	**T. geei**	Unknown	10/31/99
2	H-6.1	Hair	Dakpai	*T. geei*	Ad. ♂	10/31/99
3	H-6.2	Hair	Dakpai	*T. geei*	Jv. ♀	10/31/99
4	H-6.3	Hair	Dakpai	*T. geei*	Jv ♂	10/31/99
5	H-7	Hair	Tingtinbi	*T. geei*	Unknown	10/31/99
6	H-7.1	Hair	Tingtinbi	*T. geei*	Ad. ♀	10/31/99
7	H-7.2	Hair	Tingtinbi	*T. geei*	Unknown	10/31/99
8	H-8	Hair	Nobding	*S. entellus*	Unknown	11/3/99
9	H-8.1	Hair	Nobding	*S. entellus*	Unknown	11/3/99
10	H-8.2	Hair	Nobding	*S. entellus*	Unknown	11/3/99
11	H-8.3	Hair	Nobding	*S. entellus*	Jv. ♀	11/3/99
12	H-8.4	Hair	Nobding	*S. entellus*	Unknown	11/3/99
13	H-1	Hair	Tingtinbi	**T. geei**	Unknown	10/23/99
14	H-2	Hair	Dunmang HS	*T. geei*	Unknown	10/27/99
15	H-3	Hair	Dunmang HS	*T. geei*	Unknown	10/27/99
16	H-4	Hair	Dunmang HS	*T. geei*	Unknown	10/27/99
17	H-M1	Hair	Manas	*T. geei*	Jv. ♂	12/29/98
18	H-M2	Hair	Manas	*T. geei*	Ad, ♀	12/25/98
19	H-M3	Hair	Manas	*T. geei*	Ad. ♂	12/25/98
20	H-K1	Hair	Khaling	**T. plieatus**	Unknown	12/20/95
21	H-L1	Hair	Limethang	*T. pileatus*	Unknown	12/23/95
22	H-L3	Hair	Limethang	*T. pileatus*	Unknown	12/23/95
23	F-1.1	Feces	Trongsa	*T. geei*	Ad. ♂	10/21/99
24	F-2	Feces	Tingtinbi	*T. geei*	Unknown	10/21/99
25	F-3	Feces	Tingtinbi	*T. geei*	Jv. ♀	10/21/99
26	F-4	Feces	Tingtinbi	*T. geei*	Unknown	10/21/99
27	F-5.2	Feces	Tingtinbi	*T. geei*	Unknown	10/22/99
28	F-6	Feces	Tingtinbi	*T. geei*	Unknown	10/22/99
29	F-7	Feces	Tingtinbi	*T. geei*	Unknown	10/22/99
30	F-8.2	Feces	Tingtinbi	*T. geei*	Unknown	10/22/99
31	F-9.2	Feces	Subrang	*T. geei*	Unknown	10/26/99
32	F-10.2	Feces	Subrang	*T. geei*	Unknown	10/26/99
33	F-11	Feces	Kalamti	*T. pileatus*	Ad. ♂	10/27/99
34	F-12	Feces	Kalamti	*T. pileatus*	Unknown	10/27/99
35	F-13	Feces	Kalamti	*T. pileatus*	Unknown	10/27/99
36	F-14	Feces	Phangkar	*T. pileatus*	Unknown	10/28/99
37	F-15.2	Feces	Phangkar	*T. pileatus*	Ad. ♂	10/28/99
38	F-16.2	Feces	Phangkar	*T. pileatus*	Jv. ♂	10/28/99
39	F-18.2	Feces	Phangkar	*T. pileatus*	Jv. ♀	10/28/99
40	F-19.2	Feces	Pele-la	*S. entellus*	Ad. ♂	11/3/99
41	F-20.2	Feces	Pele-la	*S. entellus*	Jv. ♀	11/3/99
42	F-21.1	Feces	Pele-la	*S. entellus*	Jv. ♂	11/3/99
43	F-22.2	Feces	Pele-la	*S. entellus*	Unknown	11/3/99
44	T-1	Tooth	Manas	*T. geei*	Jv. ♂	12/25/98
45	M-1	Muscle	Zhemgang	*T. geei*	Ad. ♂	12/30/98
46	S-1	Dried Skin	Zhemgang	*T. geei*	Ad. ♂	11/11/94

Appendix 2: Cyt b sequences downloaded from GenBank

1.AY519463.1| *Colobus guereza* cytochrome b gene ROOS
2. AF293958.1| *Semnopithecus entellus* isolate N3 Calcutta cytb gene KARANTH
3. AY519453.1| *Semnopithecus johnii* cytochrome b gene ROOS
4. AY519455.1| *Trachypithecus auratus auratus* cytochrome b gene ROOS
5. AY519456.1| *Trachypithecus cristatus* cytochrome b gene ROOS
6. AY519458.1| *Trachypithecus francoisi francoisi* cytochrome b gene ROOS
7. AF294620.1| *Semnopithecus johnii* isolate NL2 cytochrome b KARANTH
8. AY519459.1| *Trachypithecus obscurus* cytochrome b gene ROOS
9. AF295584.1| *Macaca fascicularis* cytochrome b gene KARANTH
10. AF293959.1| *Semnopithecus entellus* isolate Nepal N4 cytb gene KARANTH
11. AY519460.1| *Trachypithecus phayrei phayrei* cytochrome b gene ROOS
12. AF293957.1| *Semnopithecus entellus* isolate N11 cytochrome b KARANTH
13. AF293952.1| *Semnopithecus entellus* isolate S2 cytochrome b KARANTH
14. AF293951.1| *Semnopithecus entellus* isolate S1 cytochrome b KARANTH
15. U38264.1|CGU38264 *Colobus guereza* cytochrome b gene KARANTH
16. AF294626.1| *Trachypithecus pileatus* cytochrome b KARANTH
17. AF294618.1| *Trachypithecus geei* cytochrome b KARANTH
18. AF295578.1| *Trachypithecus francoisi* cytochrome b gene KARANTH
19. AF295580.1| *Trachypithecus cristatus* cytochrome b gene KARANTH
20. AF294621.1| *Trachypithecus phayrei* isolate I1 cytochrome b KARANTH
21. AF295579.1| *Trachypithecus obscurus* cytochrome b gene KARANTH

Appendix 3 Aligned cyt b Sequence of langurs from Bhutan

```
TgeeiE17BHUTANWangchuk/1-738          GGCGCCACAGTTATCACAAACTTATTATCTGCAATCCCATATATCGGAAC 50
Tgeei71BHUTAN2Wangchuk/1-738          GGCGCCACAGTTATCACAAACTTATTATCTGCAATCCCATATATCGGAAC 50
TpileatusE20BHUTANWangchuk/1-738      GGCGCCACAGTTATCACAAACTTATTATCTGCAATCCCATATATCGGAAC 50
TgeeiE16BHUTANWangchuk/1-738          GGCGCCACAGTTATCACAAACTTATTATCTGCAATCCCATATATCGGAAC 50
Sentellus84BHUTANWangchuk/1-738       GGCGCCACAGTAATCACAAACCTATTATCCGCAATTCCATATATTGGGCC 50
                                      *********** ********* ******* ***** ******** **  *

TgeeiE17BHUTANWangchuk/1-738          AAATCTCGTCCAATGGGTCTGAGGTGGTTACTCCATTGATAGCCCAACCC 100
Tgeei71BHUTAN2Wangchuk/1-738          AAATCTCGTCCAATGGGTCTGAGGTGGTTACTCCATTGATAGCCCAACCC 100
TpileatusE20BHUTANWangchuk/1-738      AAATCTCGTCCAATGGGTCTGAGGTGGTTACTCCATTGATAGCCCAACCC 100
TgeeiE16BHUTANWangchuk/1-738          AAATCTCGTCCAATGGGTCTGAGGTGGTTACTCCATTGATAGCCCAACCC 100
Sentellus84BHUTANWangchuk/1-738       CGACCTTGTCCAATGACTTTGAGGGGGGTACTCCATCGATAATCCAACCC 100
                                        * ** ********  * ***** ** ******** ****  *******

TgeeiE17BHUTANWangchuk/1-738          TCACACGATTTTTTACCCTTCACTTTACCCTACCCTTCGTTATTGCCACT 150
Tgeei71BHUTAN2Wangchuk/1-738          TCACACGATTTTTTACCCTTCACTTTACCCTACCCTTCGTTATTGCCACT 150
TpileatusE20BHUTANWangchuk/1-738      TCACACGATTTTTTACCCTTCACTTTACCCTACCCTTCGTTATTGCCACT 150
TgeeiE16BHUTANWangchuk/1-738          TCACACGATTTTTTACCCTTCACTTTACCCTACCCTTCGTTATTGCCACT 150
Sentellus84BHUTANWangchuk/1-738       TTACACGATTTTTTACCCTTCACTTTATCCTACCCTTTATTATCGCAACC 150
                                      * ************************* *********  **** ** **

TgeeiE17BHUTANWangchuk/1-738          CTAACAGCTCTCCACCTGCTCTTCCTACACGAAACAGGATCAAACAACCC 200
Tgeei71BHUTAN2Wangchuk/1-738          CTAACAGCTCTCCACCTGCTCTTCCTACACGAAACAGGATCAAACAACCC 200
TpileatusE20BHUTANWangchuk/1-738      CTAACAGCTCTCCACCTGCTCTTCCTACACGAAACAGGATCAAACAACCC 200
TgeeiE16BHUTANWangchuk/1-738          CTAACAGCTCTCCACCTGCTCTTCCTACACGAAACAGGATCAAACAACCC 200
Sentellus84BHUTANWangchuk/1-738       TTCACAGTCTTACACCTACTTTTCCTACATGAAACAGGGTCAAATAATCC 200
                                       * ****   * ***** ** ******** ******** ***** ** **

TgeeiE17BHUTANWangchuk/1-738          CTGCGGAATCTCCTCCAACTCCGACAAAATCCCCTTCCACCCCTACTATA 250
Tgeei71BHUTAN2Wangchuk/1-738          CTGCGGAATCTCCTCCAACTCCGACAAAATCCCCTTCCACCCCTACTATA 250
TpileatusE20BHUTANWangchuk/1-738      CTGCGGAATCTCCTCCAACTCCGACAAAATCCCCTTCCACCCCTACTATA 250
TgeeiE16BHUTANWangchuk/1-738          CTGCGGAATCTCCTCCAACTCCGACAAAATCCCCTTCCACCCCTACTATA 250
Sentellus84BHUTANWangchuk/1-738       CTGTGGAATCCCCTCCGATTCCGACAAAATCCCCTTCCATCCCTATTATA 250
                                      *** ****** ***** * ******************** ***** ****
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```
TgeeiE17BHUTANWangchuk/1-738            CAATTAAAGATATTCTAGGTCTGATTTTCCTTATCCTTACCCTAACAACT 300
Tgeei71BHUTAN2Wangchuk/1-738            CAATTAAAGATATTCTAGGTCTGATTTTCCTTATCCTTACCCTAACAACT 300
TpileatusE20BHUTANWangchuk/1-738        CAATTAAAGATATTCTAGGTCTGATTTTCCTTATCCTTACCCTAACAACT 300
TgeeiE16BHUTANWangchuk/1-738            CAATTAAAGATATTCTAGGTCTGATTTTCCTTATCCTTACCCTAACAACT 300
Sentellus84BHUTANWangchuk/1-738         CAACTAAAGATATCCTAGGCATAGCCCTTCTCCTCCTTATCCTAATAACA 300
                                        *** ********* *****  *     * **  ****** ***** *** 

TgeeiE17BHUTANWangchuk/1-738            CTAGTACTATTTTCACCCGATCTTTTAAGTGACCCAGACAACTACACCCC 350
Tgeei71BHUTAN2Wangchuk/1-738            CTAGTACTATTTTCACCCGATCTTTTAAGTGACCCAGACAACTACACCCC 350
TpileatusE20BHUTANWangchuk/1-738        CTAGTACTATTTTCACCCGATCTTTTAAGTGACCCAGACAACTACACCCC 350
TgeeiE16BHUTANWangchuk/1-738            CTAGTACTATTTTCACCCGATCTTTTAAGTGACCCAGACAACTACACCCC 350
Sentellus84BHUTANWangchuk/1-738         TTAGTGTTATTTTCACCCGATCTTTTAAGCGACCCAGATAACTACGTACC 350
                                         ****  ********************** ******** ******   **

TgeeiE17BHUTANWangchuk/1-738            AGCTAACCCACTAAACACCCCACCACATATCAAGCCAGAATGATATTTCC 400
Tgeei71BHUTAN2Wangchuk/1-738            AGCTAACCCACTAAACACCCCACCACATATCAAGCCAGAATGATATTTCC 400
TpileatusE20BHUTANWangchuk/1-738        AGCTAACCCACTAAACACCCCACCACATATCAAGCCAGAATGATATTTCC 400
TgeeiE16BHUTANWangchuk/1-738            AGCTAACCCACTAAACACCCCACCACATATCAAGCCAGAATGATATTTCC 400
Sentellus84BHUTANWangchuk/1-738         AGCCAACCCGCTGAGCACCCCACCACATATTAAACCAGAATGATACTTCC 400
                                        *** ***** ** * *************** ** *********** ****

TgeeiE17BHUTANWangchuk/1-738            TATTTGCATACGCAATTCTACGATCCGTCCCTAACAAATTAGGAGGTGTG 450
Tgeei71BHUTAN2Wangchuk/1-738            TATTTGCATACGCAATTCTACGATCCGTCCCTAACAAATTAGGAGGTGTG 450
TpileatusE20BHUTANWangchuk/1-738        TATTTGCATACGCAATTCTACGATCCGTCCCTAACAAATTAGGAGGTGTG 450
TgeeiE16BHUTANWangchuk/1-738            TATTTGCATACGCAATTCTACGATCCGTCCCTAACAAATTAGGAGGTGTG 450
Sentellus84BHUTANWangchuk/1-738         TGTTCGCATACGCAATCCTACGGTCCATTCCCAATAAATTAGGGGGGGTC 450
                                        * ** *********** ***** *** * ** ** ******** ** ** 

TgeeiE17BHUTANWangchuk/1-738            CTGGCCCTCCTCCTATCCATTCTTATCTTAGCAATTATACCTATACTTCA 500
Tgeei71BHUTAN2Wangchuk/1-738            CTGGCCCTCCTCCTATCCATTCTTATCTTAGCAATTATACCTATACTTCA 500
TpileatusE20BHUTANWangchuk/1-738        CTGGCCCTCCTCCTATCCATTCTTATCTTAGCAATTATACCTATACTTCA 500
TgeeiE16BHUTANWangchuk/1-738            CTGGCCCTCCTCCTATCCATTCTTATCTTAGCAATTATACCTATACTTCA 500
Sentellus84BHUTANWangchuk/1-738         TTGGCACTTCTACTATCCATTCTCATTCTGACAATTGTACCCATACTCCA 500
                                         **** ** ** *********** **  *  ***** **** ***** **
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```
TgeeiE17BHUTANWangchuk/1-738              TAAATCCAAACAACAAAGCATAGCATTCCGCCCACTCAGCCAATTTCTAC 550
Tgeei71BHUTAN2Wangchuk/1-738              TAAATCCAAACAACAAAGCATAGCATTCCGCCCACTCAGCCAATTTCTAC 550
TpileatusE20BHUTANWangchuk/1-738          TAAATCCAAACAACAAAGCATAGCATTCCGCCCACTCAGCCAATTTCTAC 550
TgeeiE16BHUTANWangchuk/1-738              TAAATCCAAACAACAAAGCATAGCATTCCGCCCACTCAGCCAATTTCTAC 550
Sentellus84BHUTANWangchuk/1-738           CAAGTCCAAACAACAGAGCATAATATTCCGCCCACTCAGTCAATTCCTAT 550
                                           ** *********** ******  *************** ***** ***

TgeeiE17BHUTANWangchuk/1-738              TATGATTCCTAATCACAATTCTACTAACCCTAACCTGAATCGGAAGCCAA 600
Tgeei71BHUTAN2Wangchuk/1-738              TATGATTCCTAATCACAATTCTACTAACCCTAACCTGAATCGGAAGCCAA 600
TpileatusE20BHUTANWangchuk/1-738          TATGATTCCTAATCACAATTCTACTAACCCTAACCTGAATCGGAAGCCAA 600
TgeeiE16BHUTANWangchuk/1-738              TATGATTCCTAATCACAATTCTACTAACCCTAACCTGAATCGGAAGCCAA 600
Sentellus84BHUTANWangchuk/1-738           TATGATTCCTAATTATAATTCTATTAATTCTTACCTGAATTGGGAGTCAA 600
                                          ************* * ******* ***  ** ******** ** ** ***

TgeeiE17BHUTANWangchuk/1-738              CCAGTAAGCCAACCCTTTATTATAATTGGACAAGTAGCATCCACGATATA 650
Tgeei71BHUTAN2Wangchuk/1-738              CCAGTAAGCCAACCCTTTATTATAATTGGACAAGTAGCATCCACGATATA 650
TpileatusE20BHUTANWangchuk/1-738          CCAGTAAGCCAACCCTTTATTATAATTGGACAAGTAGCATCCACGATATA 650
TgeeiE16BHUTANWangchuk/1-738              CCAGTAAGCCAACCCTTTATTATAATTGGACAAGTAGCATCCACGATATA 650
Sentellus84BHUTANWangchuk/1-738           CCAGTAAACCAACCCTTCATTGTAATTGGACAAGCAGCGTCCATAATATA 650
                                          ******* ********* *** ************ *** ****  *****

TgeeiE17BHUTANWangchuk/1-738              TTTTACCACAATTTTAATTCTAATACCACTAGCCTCTCTAATTGAAAATA 700
Tgeei71BHUTAN2Wangchuk/1-738              TTTTACCACAATTTTAATTCTAATACCACTAGCCTCTCTAATTGAAAATA 700
TpileatusE20BHUTANWangchuk/1-738          TTTTACCACAATTTTAATCCTAATACCACTAGCCTCTCTAATTGAAAATA 700
TgeeiE16BHUTANWangchuk/1-738              TTTTACCACAATTTTAATCCTAATACCACTAGCCTCTCTAATTGAAAATA 700
Sentellus84BHUTANWangchuk/1-738           TTTCATTACAATCTTAATCTTAATACCTCTTGCTTCCCTAATCGAAAACA 700
                                          *** *  ***** *****  ******* ** ** ** ***** ***** *

TgeeiE17BHUTANWangchuk/1-738              AACTCCTCAAATGAACCTGCCCCCGTAGTATAAATCAA 738
Tgeei71BHUTAN2Wangchuk/1-738              AACTCCTCAAATGAACCTGCCCCCGTAGTATAAATCAA 738
TpileatusE20BHUTANWangchuk/1-738          AACTCCTTAAATGAACCTGCCCCCGTAGTATAAATCAA 738
TgeeiE16BHUTANWangchuk/1-738              AACTCCTTAAATGAACCTGCCCCCGTAGTATAAATCAA 738
Sentellus84BHUTANWangchuk/1-738           ACCTCCTCAAATGAACCTGTCCTCGTAGTATAAACTCA 738
                                          * ***** *********** ** ***********   *
```

Appendix 4: Protein Alignment of Bhutan Sequences

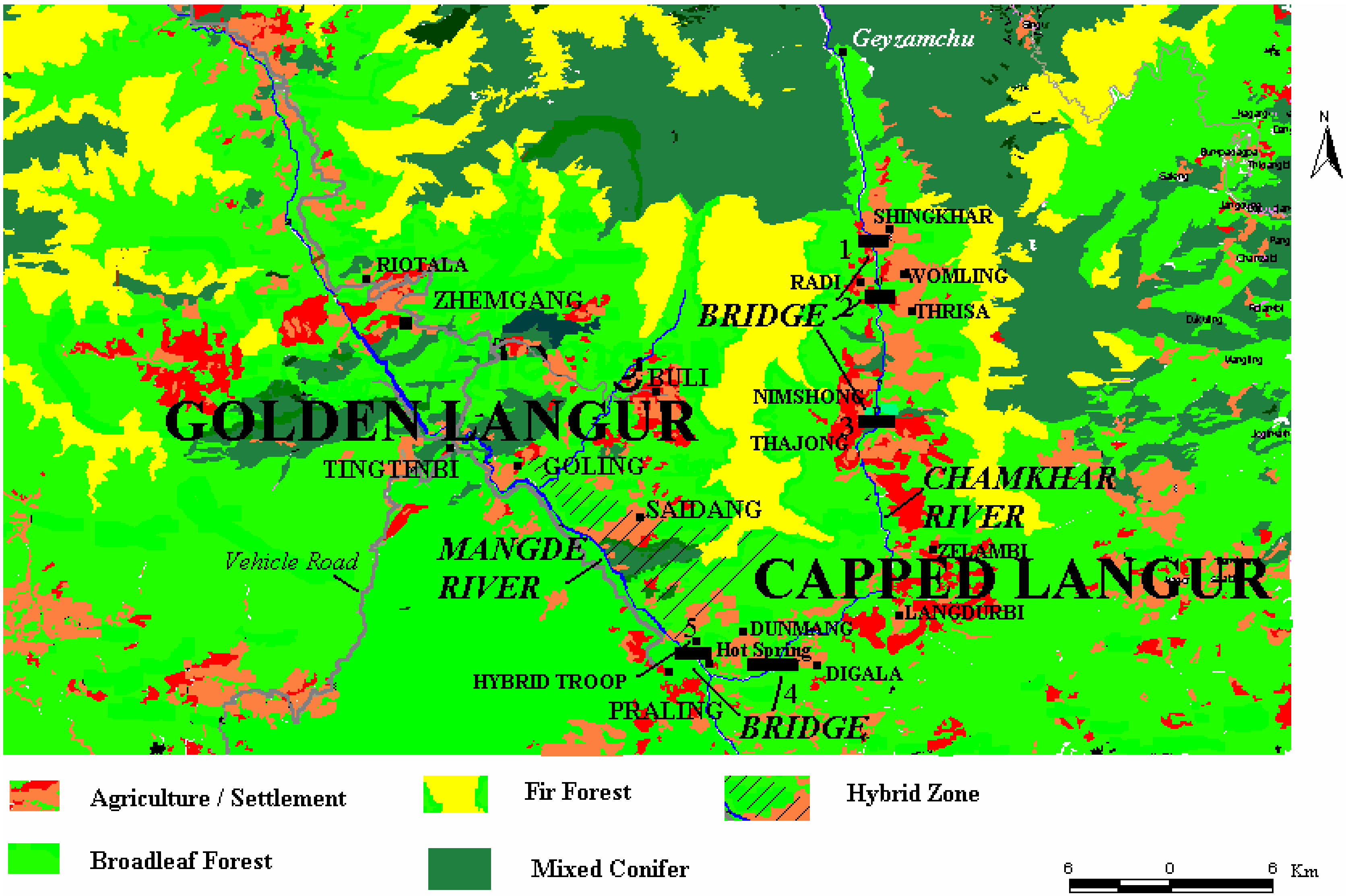
```
@T.geei/E-16            1 GATVITNLLSAIPYIGTNLVQWVWGGYSIDSPTLTRFFTLHFTLPFVIATLTALHLLFLH    60
@T.geei/E-17            1 ............................................................    60
@T.geei/Hair 7-1        1 ............................................................    60
@T.pileatus/E-20        1 ............................................................    60
@S.entellus/Hair 8-4    1 ................PD....L.......N...........I...I...F.V.......    60
                          ****************..****.*******.***********.***.***.*.*******

@T.geei/E-16           61 ETGSNNPCGISSNSDKIPFHPYYTIKDILGLIFLILTLTTLVLFSPDLLSDPDNYTPANP   120
@T.geei/E-17           61 ............................................................   120
@T.geei/Hair 7-1       61 ............................................................   120
@T.pileatus/E-20       61 ............................................................   120
@S.entellus/Hair 8-4   61 ..........P.D...........T.....MAL.L.I.M................V....   120
                          **********.*.***********.*****...*.*.*.****************.****

@T.geei/E-16          121 LNTPPHIKPEWYFLFAYAILRSVPNKLGGVLALLLSILILAIMPMLHKSKQQSMAFRPLS   180
@T.geei/E-17          121 ............................................................   180
@T.geei/Hair 7-1      121 ............................................................   180
@T.pileatus/E-20      121 ............................................................   180
@S.entellus/Hair 8-4  121 .S....................I.................T.V...........M.....   180
                          *.********************.*****************.*.***********.*****

@T.geei/E-16          181 QFLLWFLITILLTLTWIGSQPVSQPFIMIGQVASTMYFTTILILMPLASLIENKLLKWTC   240
@T.geei/E-17          181 ............................................................   240
@T.geei/Hair 7-1      181 ............................................................   240
@T.pileatus/E-20      181 ............................................................   240
@S.entellus/Hair 8-4  181 ........M...I.........N....V...A..M...I..............N......   240
                          ********.***.*********.****.***.**.***.**************.******
@T.geei/E-16          241 PRSMNQ                                                         246
@T.geei/E-17          241 ......                                                         246
@T.geei/Hair 7-1      241 ......                                                         246
@T.pileatus/E-20      241 ......                                                         246
@S.entellus/Hair 8-4  241 .....S                                                         246
                          *****.
```

Chapter 2: Species, Hybrids, and Conservation Units

In this chapter I look at the phylogenetic relationship between capped (*T. pileatus*) and golden langurs (*T. geei*). Most recently completed field surveys (Wangchuk et al., 2004) show that all of the Chamkhar river basin is inhabited by the capped langur, both the right and left banks (Figure 2.1). Previously it was thought that the Chamkhar river served as an effective barrier between the two species (Wangchuk et al., 2003). However, the presence of four bridges, built between 1977 to 1987, at various points across the river may have allowed capped langurs to come into golden habitat and hybridize. Preliminary interviews with local people indicate that in the past all the bridges were temporary and used only during the winter months when the river is calmer. During the summer monsoon months, the bridges were washed away. In most instances the bridge consisted of a cane rope stretching from one side to the other along which a wooden hoop or box with people and goods was shuttled back and. Each winter a new rope bridge was built since it was easier to travel in the dry winter season when river levels are low, streams fordable, and trails accessible. A more durable wooden bridge over the Chamkhar was built near Shingkhar village to move the king's cattle to their winter grazing lands in the broadleaf forests of Zhemgang. This was washed away during the monsoons and rebuilt every winter in time for the migration.

Historically, the ranges of the capped and golden langurs were probably separated by the Chamkhar River in the north, the Mangde River further south (of which the Chamkhar is a tributary, and eventually the Manas River (of which the Mangde is a tributary). (Figure 1. 7). The Mangde and Manas are still effective barriers separating the

Figure 2.1 Hybrid Zone Detail



two species. There are no bridges across the Manas river in Bhutan. Two suspension bridges across the Mangde where golden and capped ranges are adjacent to each other (the Phangkar Zam and Chenga Zam) were built in 1977 and 1990 respectively.

A hybrid zone was found in February 2000 and the exact boundaries of the hybrid zone were mapped by October 2003. The hybrids are fertile as observed from different generations of hybrids and this gives rise to a new set of questions. Are the capped and golden langurs actually distinct species since the hybrids are viable? What species concept should be applied to this problem to manage the hybrids from a conservation perspective? What are some management options available to solve the problem of the bridges?

Species

For the conservation of the endangered golden langur it is thus necessary to understand the taxonomic status of the golden langur (*T. geei*) *vis-a-vis* the capped langur (*T. pileatus*). The golden langur is defined as an endangered species, yet there is disagreement about whether it is an independent monophyletic species or whether it is a subspecies of the capped langur. Based on the difference in coat color between the golden langur and the capped langur, Khajuria (1956) designated the golden langur as a specific rank. But Oboussier and von Maydell (1959) regarded the golden langur as a subspecies of the capped langur, *Presbytis* (=*Trachypithecus*) *pileatus geei* because there is no difference in the skull morphology between them.

Resolution of this problem is necessary to make recommendations for development in their habitat. If they are indeed independent species then the construction of bridges, which allows for hybridization and potential extinction of the golden langurs (which have smaller populations) , needs to be rethought. The bridges are vital links for villages in the area but are being used by langurs to traverse river barriers (Wangchuk, 1995; Wangchuk et al., 2001).

Conservation Units

Identification of what populations or species are "evolutionarily significant units" and therefore "worthy of separate conservation efforts" can be accomplished by tools from phylogenetic systematics (Moritz, 1994; Melnick et al., 1999). Moritz (1994) defined evolutionary significant units (ESU) for conservation using genetic criterion:

> "ESUs should be reciprocally monophyletic for mtDNA [mitochondrial DNA] alleles and show significant divergence of allele frequencies at nuclear loci."

These criteria ensure that the "evolutionary heritage and potential of ESUs" is recognized and protected (Moritz, 1994). In other words, an ESU is a group of organisms that has been isolated for a sufficiently long period of time from other conspecifics and accumulated meaningful genetic divergence (Ryder 1986; Paetkau, 1999). "Meaningful" in this case means that reciprocal monophyly has been achieved. Since a monophyletic group includes all descendent lineages of a single ancestor and the ancestor itself, in a reciprocally monophyletic group no lineages would share a more-recent common ancestor with any lineages in the other monophyletic group. For instance, for the golden langur to be reciprocally monophyletic would require that all of its lineages and their most-recent common ancestor are unique and do not share any lineages with that of the capped langurs which would have their own unique most-recent common ancestor. Moritz (1994) explains the stages that a population progresses through to achieve reciprocal monophyly:

> "After the division of one population into two, the phylogenetic relations of the…two daughter populations typically proceed from polyphyly, through various paraphyletic conditions to reciprocal monophyly as ancestral polymorphism are sorted and replaced by derived states. The rate depends on effective population size, usually taking at least 4N generations to achieve reciprocal monophyly, and is also influenced by mutation rate, population demography and the phylogeographic distribution…before the separation of the two populations."

This approach has the advantage, according to Moritz, of overcoming the issue of "how much divergence is enough" that plagues quantitative criteria such as allele frequency divergence and genetic distance. Subjective cut off points at which two populations maybe judged "diverged enough" to consider as distinct conservation units are overcome by using this established phylogenetic technique.

However Crandall et al. (2000) and Paetkau (1999) are critical of these criteria as being too restrictive. Paetkau (1999) points out that the ESU status of a daughter population is overly dependent on the size of the parental population (N) and a "considerable amount of chance." If the parental population is small then ESU status will be achieved rapidly resulting in over-splitting whereas if the parental population is large, ESU status will not be achieved even after millions of years of separation. He uses the example of the brown bear and polar bear as a practical case study. Polar bears split off from brown bears during the Pleistocene, isolated during a glacial episode. However, due to the large population size of the parental brown bear population, reciprocal monophyly with polar bears has still not been achieved. Some brown bear populations still share similar mtDNA lineages with polar bears. Under the ESU criteria the two would be treated as a single ESU and not receive separate conservation status. Paetkau (1999) instead suggests that "ESU definitions should be based on as many sources of information, genetic or otherwise, as are available."

Crandall et al. (2000) provide more specific alternatives for a "broader categorization of population distinctiveness based on concepts of ecological and genetic exchangeability." Templeton (1989) defines genetic exchangeability as the "ability to exchange genes via sexual reproduction" and a population would be considered distinct if there is evidence for restricted gene flow. Ecological exchangeability is defined as "the factors that define the fundamental niche" and the ability of populations to adapt to that ecological niche via natural selection or genetic drift. A population would be considered distinct if there is evidence for morphological, life history, and habitat specialization (and therefore under selection) for that niche. Crandall *et al*. then "emphasizes variation in phenotypes thus allowing preservation of important adaptive characters and their associated genetic variation." These factors are considered important and I use genetic, ecological, and biogeographical approaches in resolving conservation units.

Objective 1

The first objective here then is to test the hypothesis whether the golden langur (*T. geei*) and the capped langur (*T. pileatus*) are distinct species worthy of separate conservation efforts. This will be done through a combination of molecular phylogenetic and biogeographical approaches. Specifically, a rapidly evolving region of the mitochondrial DNA (mtDNA) will be used combined with the biogeogprahical distribution information of the capped and golden langurs. As mentioned in chapter 1, mtDNA has several advantageous features such as low or no recombination, haploidy, maternally inheritance, and a rapid rate of evolution or substitution rate relative to the nuclear genome (Melnick et al., 1992). In particular the control region is a non-coding region and not constrained by selective pressure. This region is highly variable as a result and suited for diagnostic tests between closely related taxa (Tamura and Nei, 1993). The control region of primates consists of highly variable hypervariable regions at the 5' and 3' ends while the central portion is highly conserved (Vigilant et al., 1991).

Given the ecological and geological conditions of the Himalayas as described above, it is probable that biogeography was a critical factor in reducing genetic and ecological exchangeability. According to Mayr, the formation of species or "the origin of discontinuities" requires isolating mechanisms that primarily are geographical in nature and result in reproductive isolation. Such reproductively isolated populations are defined as species (Mayr, 1963, p431). Dobzhansky (1970) shares a similar concept of species and emphasizes that species are populations that share a common gene pool that do not exchange genes with other populations due to reproductive isolating mechanisms.

Mayr is deeply skeptical of other possible modes of speciation. For instance, "phyletic speciation" or the transformation of species through mutation, selection, or introgression "is compatible with the story of creation in the Book of Genesis," and in higher animals "…introgression is rare and probably negligible as an evolutionary factor," (p. 429). This is a strong critique of the Phylogenetic Species Concept which relies heavily on demonstrations of monophyly and the evolutionary pattern of ancestry and descent to draw species boundaries (Cracraft, 1983; Donoghue, 1985).

The strongest criticism, however, is reserved for dissenters within Mayr's own camp of what de Querizo (1998) calls "isolation species concept" advocates. Sympatric ecological speciation, Mayr writes, is "like the Lernaean Hydra which grew two new heads whenever one of its old heads was cut off. There is only one way in which final agreement can be reached and that is to clarify the whole relevant complex of questions to such an extent that disagreement is no longer possible" (Mayr, 1963, p 451). Mayr argues that geographical isolation, and not ecological factors of isolation, provides the best explanation for barriers to gene flow. He concedes that sympatric speciation may be possible only in rare instances where "forms with exceedingly specialized ecological requirements may diverge genetically without benefit of geographical isolation." One such case has been with the freshwater cichlid fish that Mayr cites as a case of sympatric speciation (Pray, 2003) where sexual selection plays a larger role than geographical isolation.

Following Mayr and Dobzhansky's arguments so far the question can be asked, what factors contribute to reduction in gene flow and reproductive isolation among colobine primates in the Eastern Himalayas? Did the geographic barriers lead to reproductive isolation between the currently known langur species of Bhutan and to eventual speciation? Ecological and geological support for the hypothesis stated above can come from the assumption that speciation of langurs in the Eastern Himalayas followed a geographic or allopatric model. Mountain ranges and especially rivers, as they grew in size after the last glacial age may have isolated populations of langurs from each other. As the rivers became significant barriers, isolated populations of langurs may have diverged and adapted to their particular ecological conditions. The divergence may have been further enhanced by the effect of random genetic drift in small isolated populations and the fixation of certain alleles. This may especially hold true for the 2 species of langurs in the genus *Trachypithecus*, the golden langur (*T. geei*) and the capped langur (*T. pileatus*) in Bhutan.

Mayr's (1963, p.481) statement that "geographic speciation is the almost exclusive mode of speciation among animals" is perhaps too restrictive if narrowly applied. Other concepts of species and speciation are valid according to de Queiroz (1998) and Avise and Ball (1990) and de Queiroz writes that the many different species concepts:

> "…do not reflect fundamental differences with regard to the general concept of species. I do not mean to say that there are no conceptual differences among the diverse contemporary species definitions but rather that the differences in question do not reflect differences in the general concept of what kind of entity is designated by the term species. All modern species definitions either explicitly or

> implicitly equate species with segments of population level evolutionary lineages."

Speciation then is a single lineage splitting into two or more polytomous taxa regardless of the cause of the initial split (de Queiroz, 1998). Mayr of course would maintain that only geographic factors can cause the initial separation. Others however posit that ecological and adaptive niches (Schulter, 1998; Taylor et al., 1997), intrinsic prezygotic and postzygotic barriers (Butlin, 1989, 1998), and host specific mating (Bush, 1969; Feder, 1998) can be important factors in the speciation process.

In addition to de Queiroz's unifying theme for a species concept, Avise and Ball's (1990) "genelogical concordance" and Baum and Shaw's (1995) "exclusive groups" provide other means of uniting species concepts. These models provide a more dynamic and three-dimensional conceptualization of species as resulting from cause and effect processes in time and space. Specifically, Avise and Ball explore the concordance between the biological species concept and the phylogenetic species concept. They argue that "…independent gene phylogenies…arise only when populations have been reproductively separated from one another…for reasonably long periods of time." In other words, monophyletic groups are a result of isolated gene pools without gene exchange, or as Hennig (1966) writes:

> "…the concept of "phylogenetic relationships" is based on the fact that reproduction …usually takes places only within the framework

> of confined reproductive communities which are genetically isolated
> from each other."

Concordance between biogeographic distribution patterns and the evolutionary histories of the langurs as reflected in gene phylogenies will lend strong support for the hypothesis. Organismal phylogenies then needed to be integrated with existing biogeographical and ecological conditions for a full understanding of the situation. If the above argument holds true then it can be predicted that *T. geei* and *T. pileatus* should be independent monophyletic groups. Despite the hybridization problem caused due to human-induced factors such as the construction of bridges, the molecular phylogeny as constructed from the control region and biogeographical evidence can either support or fail to support the hypothesis that *T. geei* and *T. pileatus* are reciprocally monophyletic. Also, the control region phylogeny should provide approximate divergence dates between *T. geei* and *T. pileatus* if the above hypothesis holds true. Unresolved questions from chapter 1 regarding the hypothesis that *T. pileatus* should be basal to *T.geei* and that *T. geei* branched off from *T. pileatus* are therefore addressed here with the control region sequences. In the evolutionary scheme of *Trachypithecus*, species in Vietnam and South China are more ancestral while those further away from the relic source such as in Bhutan are more derived as shown in Chapter 1.

Objective 2

The second objective is to test for phylogenetic differences between the golden langurs (*T. geei*) in the north and south of Bhutan. This objective arises from the fact that the ecological conditions are vastly different in the north and south of Bhutan yet golden langurs inhabit both extremes. Also, field surveys showed remarkable difference in size, pelage coloration, and color pattern between the north and south (Wangchuk, 2000). Clearly there seems to be support for Crandall et al.'s (2000) idea of limited ecological exchangeability. The "factors that define the fundamental niche" are different and perhaps the ability of populations to adapt to that ecological niche via natural selection or genetic drift are different too and this may be reflected, at least in this case, at the morphological and phenotypic level. My objective is to test whether these differences have a genetic, adaptive and heritable basis.

The following differences were observed during field surveys in 1999-2000. The northern type is much lighter in color and from a distance appears almost whitish. The coat is thick and wooly. The ventral part of the body and top of the head and abdomen is pale yellow which gives the langur almost a whitish appearance. The long cheek hairs, throat and chest region is more reddish gold. The most striking difference between the northern type and southern type is in the forelimbs, which are dark grey to black extending all the way from the shoulder to the wrist in the northern type. The crown hairs are black along the fringes and much longer while it is pale and shorter in the middle. The legs and tail are also greyish in color. In the tail, about 10% of the hair was tipped with black (the root however was whitish) giving it its grey appearance in the upper two thirds. The tip is bunched and pale.

Variations between adults and juveniles and between males and females were observed in terms of shades of darkness of the limbs and tail. The basic color pattern however did not vary and was consistent through out all the northern type. For instance, juveniles are paler and whiter in color but tend towards adult coloration with traces on grey in the limbs, tail, and crown.

The southern types were uniformly reddish gold in color without any traces of black in the crown (except for the eyebrows consisting of three or four strands of long black hair) and limbs. Gee (1956) offers the following description "… the coat is an almost uniform deep cream colour in dull light and bright golden in sunlight." Prater (1980), and Srivastava (1999) similarly describe the pelage of the Golden Langurs found in Assam near the Bhutan border. When sighted from a distance, the *T. geei* in the south appear reddish gold in color.

Despite Mayr's strong opposition to the idea of "the splitting of the gene pool itself by ecological factors" (1963, p. 451), Schluter says that there is "accumulating evidence that resource-based divergent natural selection indeed plays a major role in the evolution of reproductive isolation" (1998). He cites examples from novel environments such as remote islands and newly formed lakes where speciation rates are twice as high as on mainland and other environments "saturated" with species.

Is it possible then that the diverse ecological conditions, ranging from tropical to alpine ecosystems within the "normal cruising range" of the population of langurs of a single species result in "subdivided…genetically distinct sets of geographic populations exhibiting considerable historical, phylogenetic separation from one another…" (Avise and Ball, 1990)? Specifically, the ecological differences between the north and south of the distribution range of the langurs are significantly different and may result in genetically distinct subpopulations or subspecies in the north and south. For instance, within *S. entellus*, the subspecies in the high altitude Himalayas is differentiated as

S. e. achilles from *S. e. entellus* found in the foothills and plains of India. Morphological differences mainly in body size and pelage length and thickness have been reported (Bishop, 1979). Using *S. entellus* as a "control" taxon another prediction about langur speciation can be made that ecological differences between the tropical and temperate zones will give rise to unique and phylogenetically distinguishable subspecies in *T. geei.*

Objective 3

The third objective is to document the hybrid zone and record the physical descriptions of the hybrids. Also the size and extent of the hybrid zone will be documented.

Methods

The methods employed are biogeographical and molecular in nature and many are similar to methods used in Chapter 1. To map the biogeographical distribution of the capped and golden langurs in Bhutan I conducted surveys as described in Chapter 1. Surveys along Chamkhar river on both sides started at the northern limits of langur distribution near Geyzamchu, two days trek north of Shigkhar at the transition zone between broadleaf and mixed blue pine (*Pinus wallachia*) and fir (*Abies densa*) forests. The survey continued south towards Digala and looped back up to Shingkhar via Thajong, Nimshong, and Radi in December and January 2003 (Figure 2.2). In May 2003 the hybrid zone was surveyed and mapped between Dunmang, Saidang, Buli, and Goling. Praling to Tingtinbi was also surveyed in May 2003. Surveys consisted of verification of the presence or absence of hybrids. Intensive surveys were conducted on both sides of the river near bridges using photo and video documentation as well as a survey form

(Appendix 6). The forms recorded location of the langur sightings on 1:50000 topo sheets, number of individuals in group, age and sex, and visual description of individuals in groups using dorsal and ventral schematic drawings. Samples of hair and feces were collected when possible.

Control Region

For resolution of phylogenetic questions involving more closely related taxa a rapidly evolving region of the mtDNA was used. In particular the control region is a non-coding region and not constrained by selective pressure. This region is highly variable as a result and suited for diagnostic tests between closely related taxa (Tamura and Nei, 1993). The control region of primates consists of highly variable hypervariable regions at the 5' and 3' ends while the central portion is highly conserved (Vigilant et al., 1991). Useful sequences were obtained from 7 samples for the control region. These sequences are listed in Appendix 5.

Sample Collection, Extraction, Amplification and Sequencing

Samples for DNA extraction and analysis were collected in the field between 1999 to 2003 as described in chapter 1. Hair and fecal samples were collected non invasively. Appendix 1 lists the samples used for the study. Extraction protocols are similar to those used for cyt b as described in Chapter 1.

A first round of amplification for the entire mtDNA control region was done using the polymerase chain reaction (PCR) with universal primers L-Pro and H-Phe. However, this did not result in successful amplifications. An alternative approach was experimented with mainly by changing the primers and annealing temperature. Each PCR reaction consisted of 2.5 µl of 10× reaction buffer, 0.5 µl of 50 mM MgCl, 0.5 µl of each 10 μM primer in a pair, 2.0 μl of a 2.5 mM dNTP solution in equimolar ratio, 0.12 μl of Taq polymerase, and 2.0 μl of template DNA and water added for a total volume of 25 μl. All amplifications were in rapid-ramping machines (Perkin Elmer 9600) and began with a 5 minute hot start at 94°C; denaturing for 30 seconds at 95°C; then 35 cycles of 94°C for 30 sec, annealing for 30 sec at 45°C, and extension at 72°C for 3 min; followed by 30 secs at 24°C. Successful amplifications were made using L-Pro (CTACCTCCAACTCCC AAAGC) and 12SAR-H (ATAGTGGGGTATCTAATCCC AGTT) at the 3' end, a longer fragment including the control region and a portion of the adjacent 12S region. The first round of PCR product obtained from L-Pro and 12 SAR amplification was used as a template for a second round of PCR. Internal primer pair Saru 4 (ATCACGGGTCTAT CACCCTA) and Saru 5 (GGCCAGGACCAAGCCTATTT) designed for Japanese Macaques by Hayasaka et al. (1991) were used. The gel bands of the first round PCR product were stabbed with a sterile needle for use in the 2nd round of PCR.

The amplified regions were sequenced using the Applied Biosystems Big Dye terminator ver. 2.0 (Cat. No. 4303153). Both strands of control region were sequenced using forward and reverse primers separately in different reactions. Raw sequences were verified using the Sequencher (Gene Codes Corp) software program to check automatic base calls by eye.

Control Region Data Analyses

The sequences were aligned using CLUSTAL X (Thompson et al., 1997). The penalty for opening a gap in the alignment, was set at 15. The gap extension penalty for extending a gap by 1 residue, was set at 1. Pairwise alignments to compare each sequence with each other were done to calculate a distance matrix. The results of the distance matrix were used to produce a guide tree only to help determine in what order the sequences are aligned. Alignment from the guide tree was then done. Regions at the terminal ends that did not align due to missing data were cut off before using the alignment for phylogenetic analysis. This reduced the number of base pairs per taxa to 599 (Appendix 4). Also, all gaps were excluded from further analysis.

Phylogenetic analysis was conducted in PAUP* 4.0b10 (Swofford, 2002) using all three optimality criteria: Parsimony, Distance, and Maximum Likelihood. Maximum Parsimony was conducted under branch and bound search settings treating all characters as unordered and having equal weight, excluding parsimony-uninformative nucleotide sites. The nearest neighbor interchange (NNI) branch swapping algorithm was used and branches collapsed if maximum branch length was zero.

Maximum likelihood analysis was done after choosing the most suitable model of nucleotide substitution using a hierarchical likelihood ration test as implemented in Modeltest 3.6 (Posada and Crandall, 1998). The best model of evolution was the HKY+G model (Hasegawa, Kishino, Yano model with gamma distributed rate variation) shown in Table 2.1. The base frequencies estimated by the model were used in subsequent analyses in PAUP*.

Table 2.1. Best Model of Nucleotide Evolution for Control Region data set.

Model selected	HKY+G
	-lnL = 2142.6873
Frequencies:	A = 0.3042
	C = 0.3266
	T = 0.1213
	G = 0.2479
Substitution model	Ti/Tv = 2.1939
	Among-site rate variation Proportion of invariable sites (I) = 0 Variable Sites (G) Gamma distribution shape parameter = 0.8116
Using mixed χ^2 distribution	P-value = < 0.035090

Distance (minimum evolution) analyses used the Neighbor-Joining algorithm and maximum likelihood distances from the model described above. The robustness of the phylogenetic trees was tested by nonparametric bootstrap resampling and recording bootstrap percentages. Phylogenies obtained under each of the optimality criteria were randomly resampled 1000 times each.

Divergence Times

Divergence times were estimated as described in Chapter 1. The only difference was that estimates were based using the full control region sequence as well as the hypervariable region 1 (HVR1) since the terminal regions have faster rates of evolution and this may bias time estimates. Lambert et al. (2002) estimated HVR1 substitution rates of 0.4 to 1.4 substitutions/site/million years (s/s/my) using ancient and extant DNA from Adelie penguins. Both the full region and HVR1 were subject to likelihood ratio tests for clock-like behavior. Both fossil calibrated distance based and likelihood based estimates of divergence times were obtained following similar methods described in Chapter 1.

Results

Biogeography and Hybrid Zone

The results of the surveys reveal that the golden and capped langur species are allopatrically distributed but with a contact zone west of the Chamkhar river in Zhemgang. Figure 2.1 shows the details of this contact zone. A troop at Dunmang Hotspring displayed the strongest hybrid traits and is described in detail below. There is a gradient with decreasing hybrid traits further away from this contact zone. However, the transition into pure capped langur traits is more abrupt with troops about a kiliometer past Dunmang in Gubi Pam already displaying pure capped traits. The transition zone into pure golden traits is much larger and hybrid traits can be seen as far as Riotala. At a very simple level, this gradient can be described as a decrease in the amount of grey on the back of the langurs as one moves away from the contact zone into golden habitat. Figure 2.2 shows the color variation on the back of the langurs. The amount of grey on the back seems to be the fixed difference between hybrids and parentals. The amount of greyness of limbs is less useful in discerning hybrids.

Golden langurs in the north of Bhutan in general have more grey in the limbs and this seems to be a fixed difference between golden langurs in the north and south of Bhutan. Golden langurs in the south of Bhutan have very little grey in the limbs and appear pure gold (Figure 2.4).

The back of pure capped langurs is completely grey. The hybrids at the contact zone (Figure) have a gold patch in between the shoulder blades and the amount of grey narrows towards the waist. Hybrids away from the contact zone have a grey rump patch only. Away from the contact zone not all members of troops display the hybrid grey rump patch. The alpha males in such troops are often the only ones with a hybrid grey rump patch. The grey rump patch increases in size towards the contact zone until it fuses with the grey patch extending down from the arms, leaving only the gold patch between the shoulder blades.

The amount of grey in the tail also varies. Figure shows the variation in the hybrid troop at the contact zone near the Dunmang Hot Spring. Juveniles have pure gold tails which changes to varying proportions of grey as they mature. Some adults only have gold tips while others have a band of gold. The ventral side of the tail is gold in all instances.

Hybrids were not sighted on the west bank of the Mangde river. The hybrid zone is estimated at about 380 km^2 and extends between Dunmang to Saidang and further up to Buli The hybrid zone consists of mixed broad leaf forests and Chir pine (*Pinus roxburghii*) at the lower elevations. At the higher elevations it is bound by mixed hemlock (*Tsuga dumosa*) and fir (*Abies densa*) forests. The Chamkhar river basin, on both sides of the river, is inhabited by capped langurs

Figure 2.2 Hybrid Color Variation

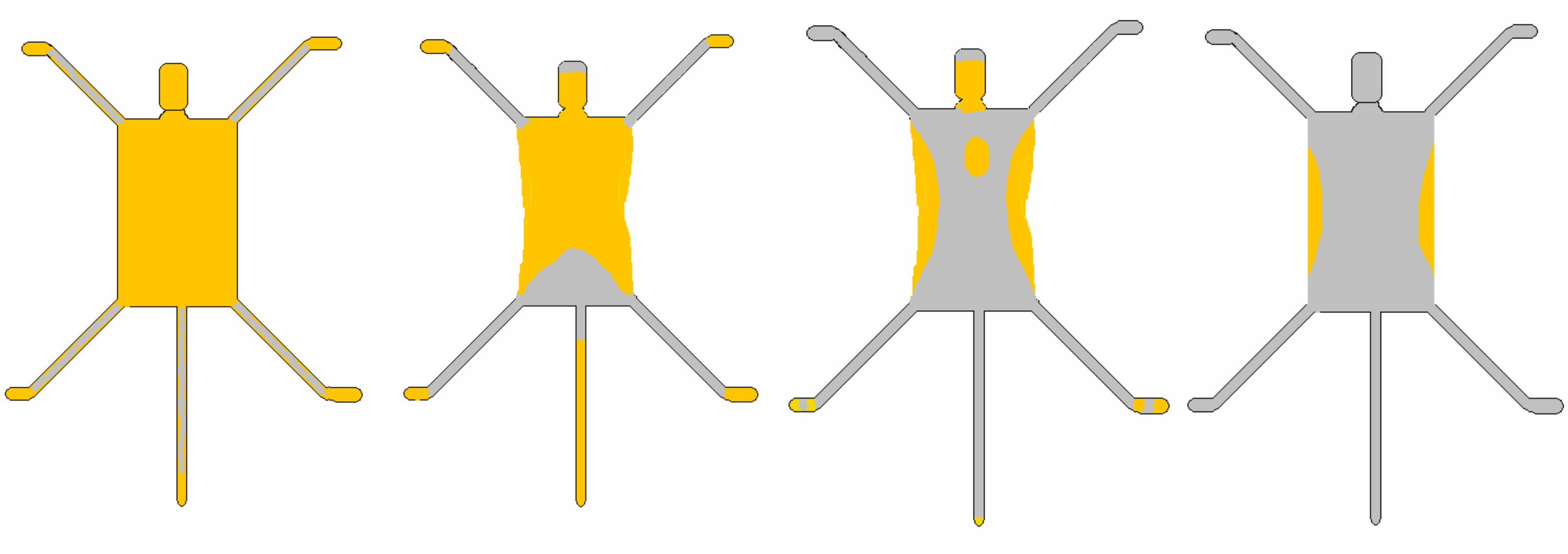


Figure 2. 3 Hybrid Tails: Dorsal View (top) and dorso-ventral view (bottom)

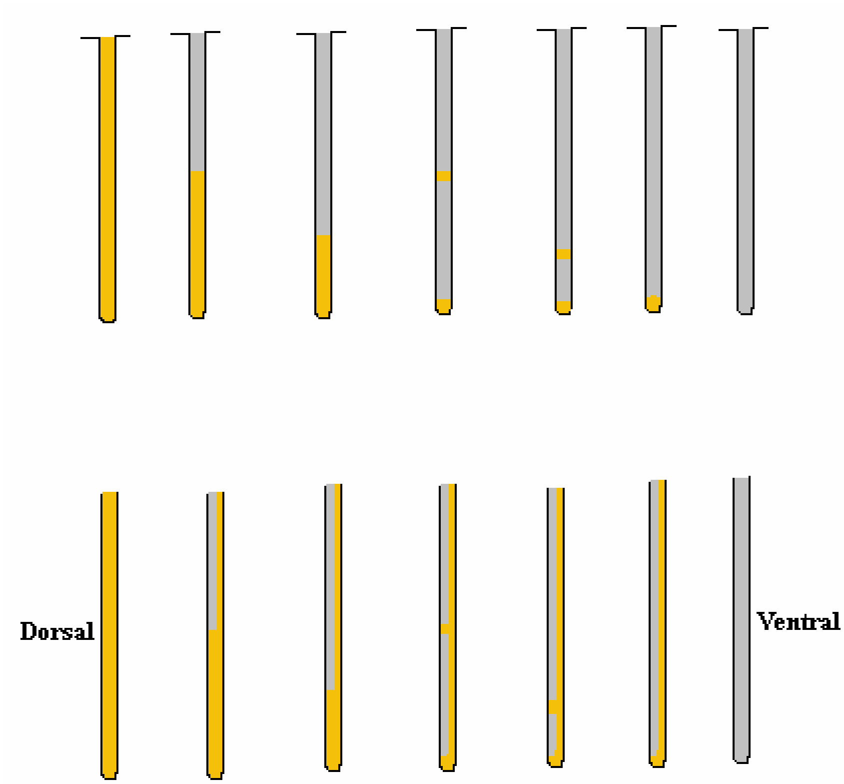


Figure 2.4 Golden Langurs from Manas (South Bhutan), Riotala (North Bhutan), Male with a faint Rump Patch (Riotala).

Figure 2.5 Hybrids at the contact Zone (Dunmang Hot Spring).

Figure 2.6 Bridge at Dunmang Hot Spring. The Hybrid troop in Fig 2.5 was photographed left of the bridge

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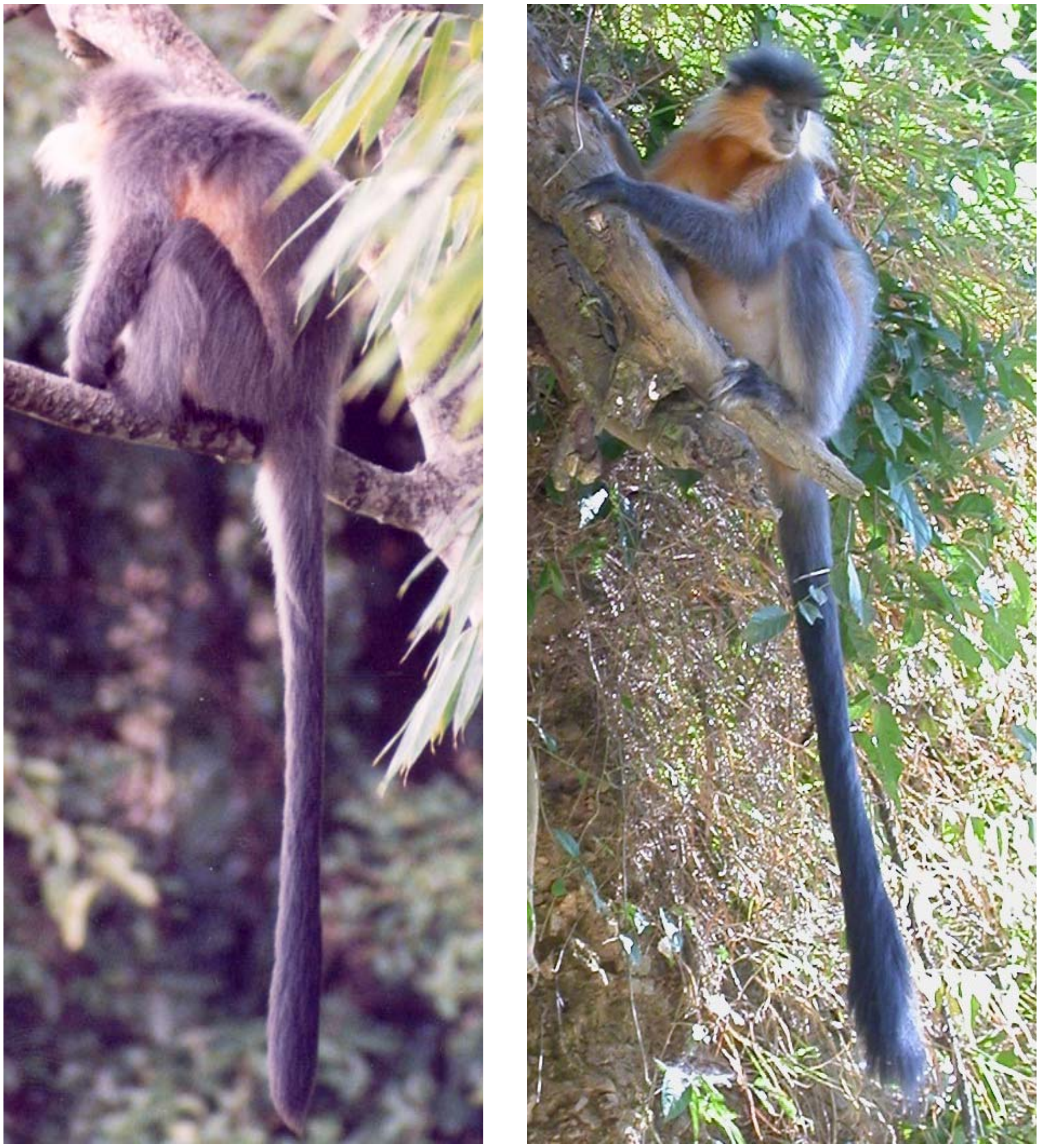
Figure 2.7 Capped Langurs from East Bhutan (Limithang)



Phylogenetics

Despite the ability to hybridize, maximum parsimony (MP), minimum evolution (ME) and maximum-likelihood (ML) gene trees based on the control region sequences show that *T. geei* and *T. pileatus* are well diverged from and reciprocally monophyletic with each other (Figure 2.6, 2.7, 2.8). There is high bootstrap support for the capped clade (MP 98%, ME 93%, ML 100%; 1000 replicates each) and golden clade (MP 100%, ME 100%, ML 100%; 1000 replicates each). All three analysis produced an identical topology. The capped langur is basal to the golden langur. The divergence between capped and golden langurs is estimated at 4.51 to 5.92 MYA by various methods described below (Table 2.2).

There is also support for phylogenetic differences between the golden langurs (*T. geei*) in the north and south of Bhutan. All three trees support this differentiation and have an identical topology. There is high bootstrap support for the northern golden langur clade (MP 100%, ME 99%, ML 100%; 1000 replicates each) and southern golden clade (MP 82%, ME 87%, ML 100%; 1000 replicates each). The divergence time between the northern and southern clades is estimated at 0.10 to 0.26 MYA (Table 2.2).

Figure 2.8 Maximum Parsimony Tree (Branch lengths above and bootstrap values below).

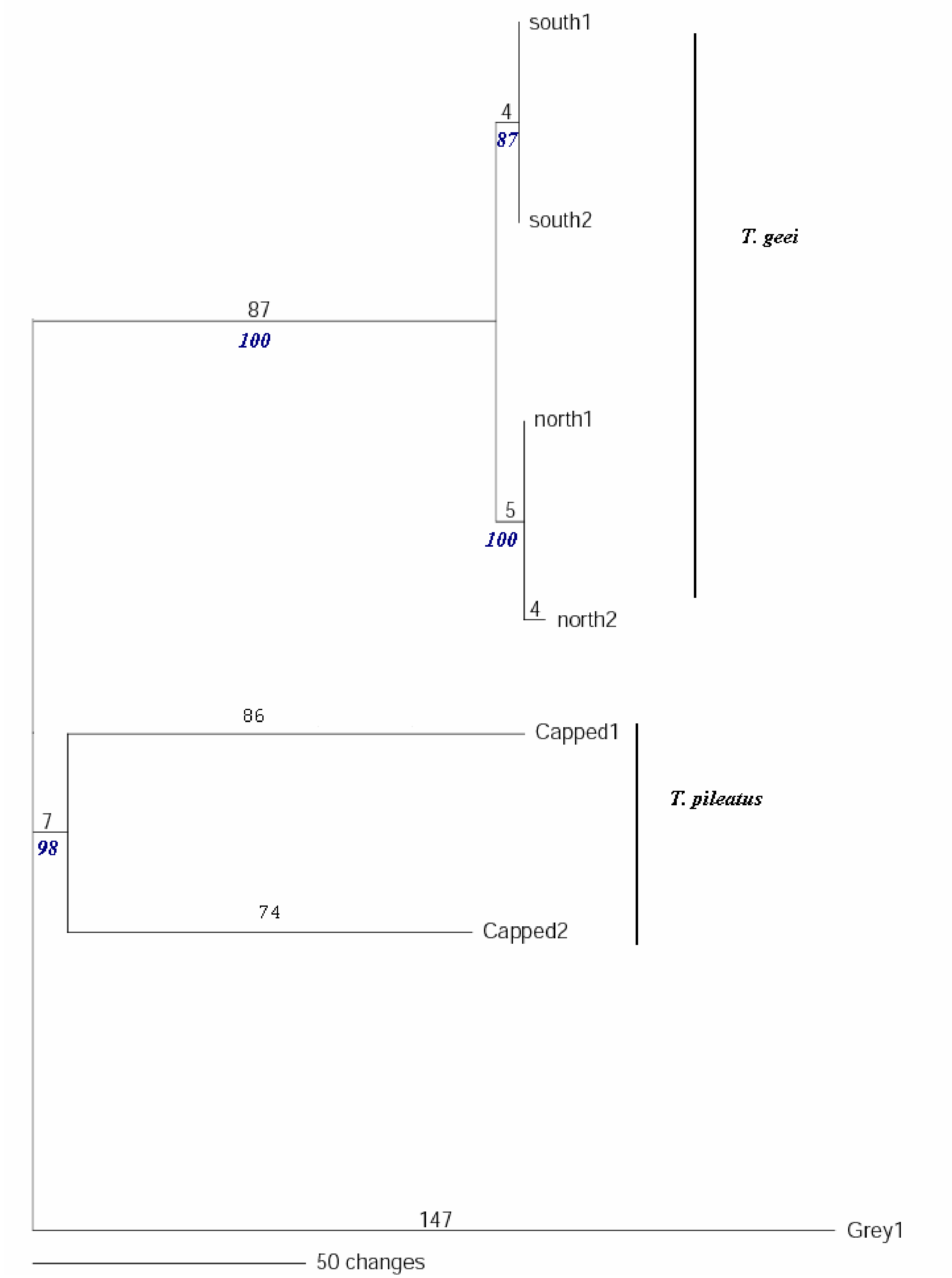


Figure 2.9 Minimum Evolution Tree (Branch lengths above and bootstrap values below).

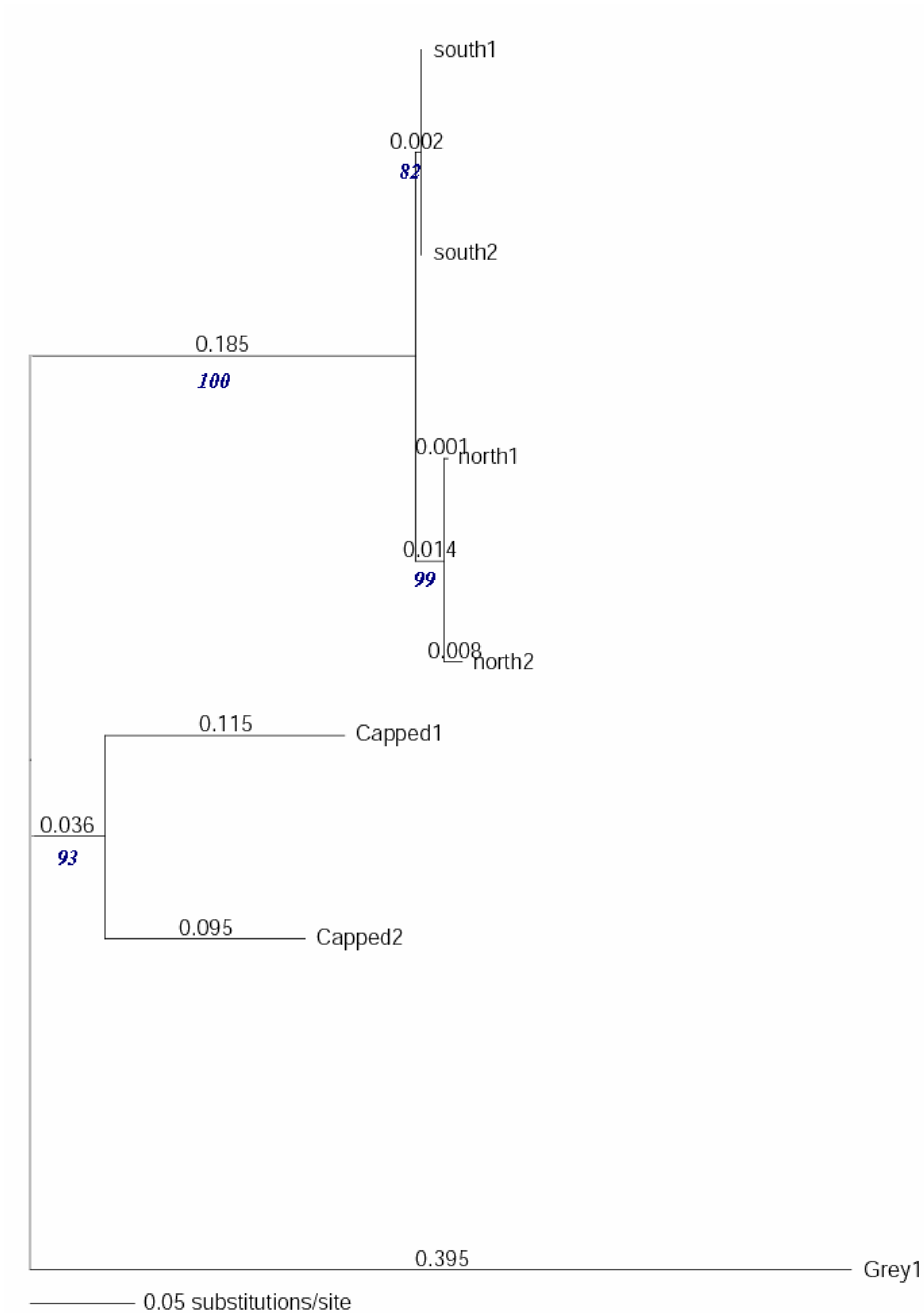
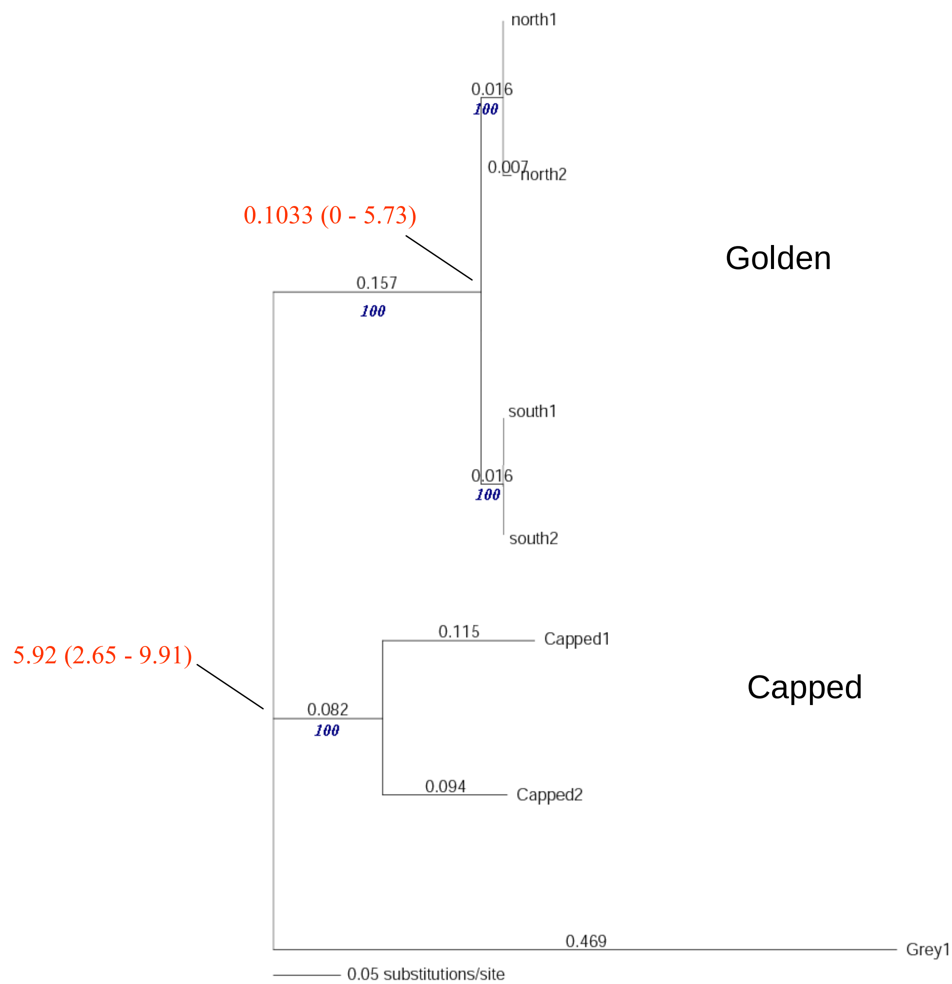


Figure 2.10 Maximum Likelihood Tree (Branch lengths above and bootstrap values below). Divergence times (MYA) are shown at nodes with upper and lower estimates.



Divergence Time Results

The estimated divergence times are shown in Table 2.2 based on the full control region and just the HVR1 region. The divergence time estimated based on a corrected sequence divergence distance and likelihood branch lengths are in agreement with the fossil record. The full control region sequence estimates *Semnopithecus* is to have diverged from *Trachypithecus* ~ 8.46 MYA (likelihood estimate) to 8.54 MYA (distance estimate). The HVR1 gives a similar range from 8.49 MYA (likelihood) and 8.53 MYA (distance). Golden langur (*T. geei*) and capped langur (*T. pileatus*) divergence dates estimates range from 4.51 MYA (distance) and 4.52 MYA (likelihood) for the full control region to 4.98 MYA (distance) and 5.92 MYA (likelihood) for the HVR1.

The likelihood score for the best tree obtained with and without the molecular clock assumption for the full control region were –ln 2149.91034 and –ln 2142.86265 respectively. This resulted in the test statistic value of (7.04769*2) 14.09538 which is less than the critical value of χ^2 at the 0.01 level with 5 degrees of freedom. Thus the obtained likelihood score with the molecular clock assumption does not differ from expected scores more than would be predicted by chance. There is no significant rate heterogeneity among lineages.

The likelihood score for the best tree obtained with and without the molecular clock assumption for the HVR1 region were –ln 1291.88214 and –ln 1343.26588 respectively. This resulted in the test statistic value of 102.76748 which is greater than the critical value of χ^2 at the 0.01 level with 5 degrees of freedom. There was significant rate heterogeneity among lineages despite lineages constrained to have the same substitution rates. This was addressed by removal of a sequence of capped langur

(Capped 1) which displayed increased rates relative to the others. The subsequent test statistic value of 8.82 is less than the critical value of χ^2 at the 0.01 level with 4 degrees of freedom.

Figure 2.11 Regression of time since divergence on control region substitutions. Inner bands are the 95% confidence limits of the regression line. The outer bands are the 95% confidence limits for predicted values of time based on new measurements of sequence divergence.

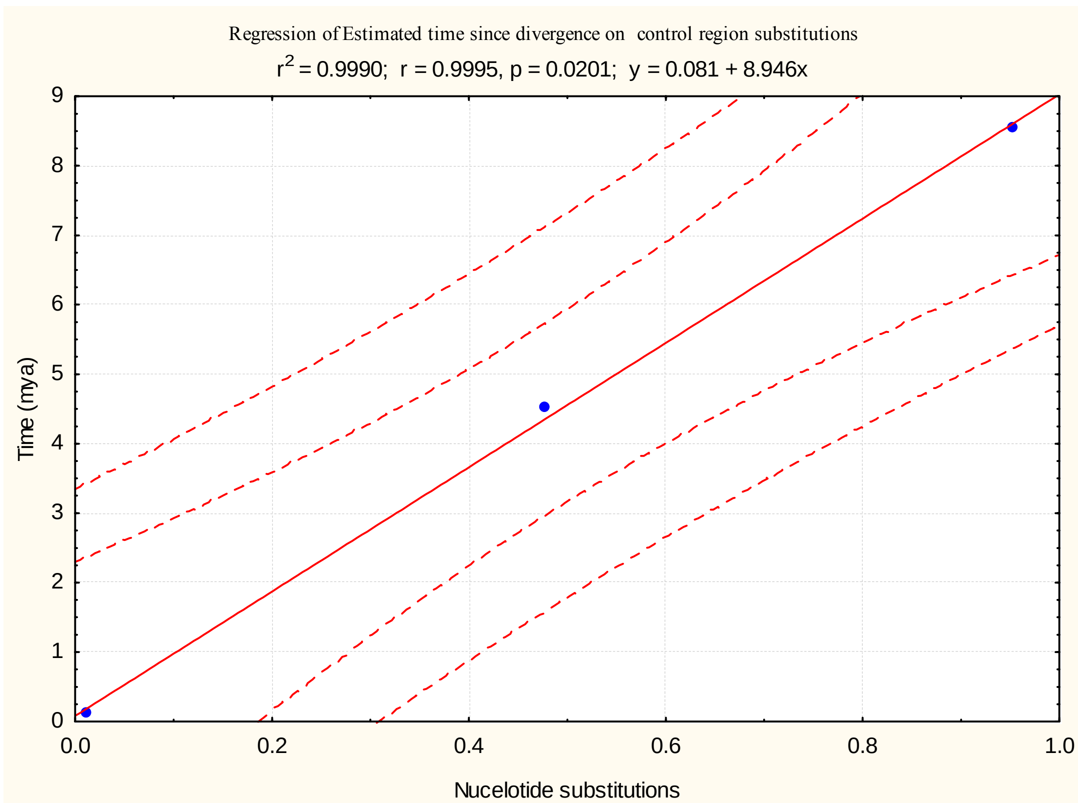


Table 2.2 Divergence Times: Full Control Region (Top) and HVR1 (below)

Taxa 1	Taxa 2	Corrected distance	Fossil Divergence Time MY	Fossil Calibrated Rates-Distance (s/s/my)	Distance Divergence Estimate MY	Fossil Calibrated Rates-Likelihood (s/s/my)	Likelihood Divergence Estimate MY
Grey Langur (*Semnopithecus*)	Capped langur (*Trachypithecus*)	0.9540	8 – 9	0.106	8.54	0.077	8.46
Capped Langur (*T. pileatus*)	Golden Langur (*T. geei*)	0.4778			4.51		4.52
Golden langur north (*T. g. bhutanensis*)	Golden langur south (*T. g. geei*)	0.0119			0.11		0.26

Taxa 1	Taxa 2	Corrected distance	Fossil Divergence Time MY	Fossil Calibrated Rates-Distance (s/s/my)	Distance Divergence Estimate MY	Fossil Calibrated Rates-Likelihood (s/s/my)	Likelihood Divergence Estimate MY
Grey Langur (*Semnopithecus*)	Capped langur (*Trachypithecus*)	0.5883	8 - 9	0.069	8.53	0.72	8.49
Capped Langur (*T. pileatus*)	Golden Langur (*T. geei*)	0.3436			4.98		5.92
Golden langur north (*T. g. bhutanensis*)	Golden langur south (*T. g. geei*)	0.0113			0.16		0.10

Discussion

The results indicate that lineages in the capped langurs are genealogically closer to one another than to any lineages in the golden langurs and are therefore reciprocally monophyletic (Avise, 2000). So despite the recent hybridization event due to the bridges, barriers to gene flow have been in place for an adequately long period of time to allow for lineage sorting to replace ancestral polymorphisms by derived states. This meets Mortiz's (1994) criteria for treating the golden langur and capped langur as evolutionary significant units (ESU) for conservation purposes. Apparently the two species have been separated for more than 4N generations where N is the effective population size. The current estimated population of golden langurs is about 6000 individuals in Bhutan (discussed in chapter 3) and about 1000 in India (Srivastava et al, 2002). So golden langurs have had a small population to begin with. This would have facilitated fast lineage sorting. The divergence time estimates indicate that golden and capped langurs diverged about 4.51 to 5.92 MYA providing ample time for lineage sorting (very roughly an effective population size of about 2500 is calculated based on observed sex ratios and breeding adults. The generation time of golden langurs is about 6 years and this would result in about 60,000 years for monophyly to be reached).

So by these criteria the "evolutionary heritage and potential " (Moritz, 1994) of golden and capped langurs as distinct evolutionary significant units needs to be recognized and protected.

Another important ESU is the genealogical distinction between golden langurs in the north and south of Bhutan. These correspond with observed differences in body size and coat colour in the golden langurs in the north and south of Bhutan. Golden langurs in

Manas and other areas in the south are smaller and "uniform deep cream colour in dull light and bright golden in sunlight" (Gee, 1956). Khajuria (1956) who collected the holotype, an adult female from Jumduar in Assam, describes the colour as "creamy white" with a head and body length of 488 mm and tail length of 762 mm. A paratype adult male collected by Khajuria from the same locality has head and body length of 720 mm and tail length of 900 mm. In contrast, the golden langurs in the north near Trongsa and Zhemgang are larger and have darker limbs and tails. The dorsal region of the forearms are dark grey to black extending from the shoulder to the wrist. The outer shank and thigh region are also grey to black extending to the ankles. The tail has about 10 % of the hair which are black tipped, giving the tail a grayish appearance in the upper two-thirds.

Extensive surveys show that golden langurs in Bhutan occur from subtropical forests in the south to temperate and sub-alpine forests in the north (Wangchuk, 1995, Wangchuk et al., 2001). The great variation in the species' range, from almost sea level in the south to above 3,000 meters in the north, creates an abundance of ecological niches to which they can adapt in unique ways, potentially reducing genetic and ecological exchangeability.

A distinct ecological separation between north and south is the sudden uprise created by the Main Frontal Thrust (MFT) of the Indian plate hitting into the Himalayas (Bhargava, 1997). Elevation south of the MFT ranges from 40 m to 900 m while north of the MFT elevation ranges from 1000 m to over 7000 m. Rainfall south of the MFT averages 5000 mm while to the north average rainfall is 1000 mm. Vegetation in the foothills is consequently subtropical while to the north it is temperate and alpine (Grierson and Long, 1984).

Concordant fit between the ecology, morphology and phylogeny of golden langurs in the north and south of Bhutan provide consistent support for the distinction between the golden langurs in the north and south of Bhutan. Based on this support, and corroborating examples from grey and capped langurs in different ecosystems and elevation zones, it was recommended that the golden langur in north Bhutan be recognized as a subspecies and be called the Bhutan langur, *Trachypithecus geei bhutanensis* and that the subspecies in south Bhutan and Assam be maintained as *T. g. geei*. (Wangchuk, et al., 2003).

The subspecies of grey langurs (*S. entellus*)north of the MFT in Bhutan most closely resembles the Himalayan Langur *S. e. achilles* (=*schistaceus*) (Pocock, 1928) while in the foothills the subspecies resembles *S. e . hector* (Pocock, 1928) following the description and classification of Napier (1985). Napier (1985) distinguishes the Nepalese races of langurs as follows: *S. e. achilles* (=*schistaceus*) "darker browner langurs from the higher altitudes" and *S. e. hector* as "smaller paler grayer langurs of the lesser hills." Sympatric capped langurs in Nagaland reveal a similar elevational variation where "the yellow-bellied *P. p. pileata* is found at 5000 ft [1,500 m] and the red-bellied *P. p. durga* at 2000 ft [600 m] and below (Pocock, 1939 cited in Napier, 1985).

The results also indicate that capped and golden langurs can hybridize and that the hybrids are viable. The fixed morphological character of hybrids is the color pattern in the back and the size of the grey patch on the back. An effective way to monitor for the spread of hybrid traits in the golden langurs is to observe trends in the observation of individuals with grey rump patches (especially adult males). Given the philopatric behavior of langurs, males are ousted from the group and move to other areas. The furthest north such an adult male has reached is Riotala in 2004 (Figure 2.1). However, this does not mean that all troops south of Riotala are hybrids by default since troops further south have been observed without any hybrid traits. So it seems that hybrid males (perhaps backcrossed two or three times with parental golden langurs) randomly move through the population. The hybrid rump patch perhaps disappears after a certain number of backcrossing with parentals. Observations over several generations in the hybrid zone are required to monitor the spread of hybrid traits and in addition to the rump patch, molecular markers needed to quantify the extent of hybridization.

An alternative explanation could be that the contact zone is a natural gradient between two species or phylogroups (Avise, 2000). One could envisage two phylogroups with largest difference (% sequence divergence) between populations of golden langurs and capped langurs at extreme ends of their distribution range and lowest difference between adjacent closest populations. This pattern would also be revealed within capped langurs i.e. populations of capped langurs in Yunnan, China would be closer to Burma populations which would be more different from Assam, India populations, and most different from Bhutan populations. One could then posit species as gradients of incremental differences and species boundaries assessed on several factors including morphology, phylogeny, ecology, and geography (distribution), rather than reproductive isolation alone. The hybrid / contact zone between capped and golden langurs could be viewed within such a framework, but perhaps at the risk of losing a distinct species to a hybrid swarm.

Literature Cited Chapter 2

Avise, J., 2000. *Phylogeography: The History and Formation of Species*. Harvard Univ. Press, Cambridge.

Avise, J., and R. Ball., 1990. Principles of genealogical concordance in species concepts and biological taxonomy. *Oxford Survey Evol. Biol*. 7:45-67

Baum, D., and K. Shaw., 1995. Genealogical perspectives on the species problem. In P.C. Hoch and A.G. Stephenson, eds., *Experimental and Molecular* Approaches to Plant Biosystematics. Missouri Botanical Garden.

Bhargava, O., 1997. *The Bhutan Himalaya : A Geological Account.* Geological Survey of India. New Delhi.

Bush, G.L. 1969. Sympatric host race formation and speciation in frugivorous flies of the genus *Rhagoletis* (Diptera: Tephritidae). *Evolution* 23:237-251.

Butlin, R. 1989. Reinforcement of premating isolation. p. 158–179 in D. Otte and J. Endler, eds. *Speciation and its consequences*. Sinauer Associates, Inc., Sunderland, MA.

Cracraft, J., 1983. Species concepts and speciation analysis. *Current Ornithology* 1: 159-87.

Crandall, K., O. Bininda-Emonds, G. Mace and R. Wayne, 2000. Considering evolutionary processes in conservation biology *Trends Ecol. Evol.* 15 (7): 290-295.

de Queiroz, K. 1998. The general lineage concept of species, species criteria, and the process of speciation: A conceptual unification and terminological recommendations. p. 57-75 in *Endless Forms: Species and Speciation*, D. Howard and S. Berlocher eds. Oxford University Press, Oxford.

Dobzhansky, T. 1970. *Genetics of the evolutionary process*. Columbia Univ. Press. de Queiroz, K., and M. Donoghue. 1988. Phylogenetic systematics and the species problem. *Cladistics* 4:317-338.

Donoghue, M. J. 1985. A critique of the biological species concept and recommendations for a phylogenetic alternative. *Bryologist* 88:172-181.

Feder, J., 1998. The apple maggot fly, *Rhagoletis pomonella*: flies in the face of conventional wisdom about speciation? p. 130-144 in *Endless Forms: Species and Speciation,* D. Howard, S. Berlocher, eds. Oxford University Press, Oxford.

Gee, E.P. 1956. A new species of langur in Assam. J. Bombay Nat. Hist. Soc. 53: 252- 254.

________1961. The distribution and feeding habits of the golden langur, *Presbytis geei* Gee (Khajuria, 1956). J. Bombay Nat. Hist. Soc., 58: 1-12.

Ghosh, A. K., and Biswas, S. 1975. A note on ecology of the golden langur (*Presbytis geei* Khajuria). J. Bombay Nat. Hist. Soc., 72: 524-528.

Grierson AJC, Long DG (1984). *Flora of Bhutan. Volume 1: Part 1*. Royal Botanic Garden, Edinburgh,

Hennig W., *Phylogenetic Systematics* (English trans); U. Ill. Press, Urbana.

Khajuria, H. 1956. A new langur (Primates: Colobidae) from Goalpara district, Assam. *Ann. Mag. Nat. Hist*., 12 (9): 86-88.

Khajuria, H. 1978. The golden langur, *Presbytis geei* Khajuria: Its discovery, authorship, taxonomic status, and bibliography. Primates, 19: 237-240.

Mayr, E., 1963. *Animal species and evolution*. Harvard Univ. Press. Cambridge.

Moritz, C., 1994. Defining ‘evolutionary significant units’ for conservation. *Trends Ecol. Evol.* 9 (10) 373–375

Mukherjee, R. P. 1978. Further observations on the golden langur (*Presbytis geei* Khajuria, 1956), with a note to capped langur (*Presbytis pileatus* Blyth, 1843) of Assam. Primates, 19: 737-747.

Mukherjee, R. P. 1981. Distribution and present status of the golden langur, *Presbytis geei* Khajuria, in some forests of Assam, India. Proc. Wild Life Workshop, 129-131.

Napier, P., 1985. Catalogue of primates in the British Museum (Natural History). Part III. British Museum of Nat. Hist., London.

Oboussier, H., and von Maydell, G. A. 1959. *Zur Kenntnis des indischen Goldlangurs: Ergebnisse der Deutschen Indien-Expetition 1955-1957 Leitung G. A. Frhr. V. Maydell*. Z. Morph. Ökol. Tiere, 48: 102-114.

Paetkau, D., 1999. Using genetics to identify intraspecific conservation units: a critique of current methods. *Conserv. Biol.*13, 1507–1509.

Pocock, R., 1928. The langurs, or leaf monkeys, of British India. J. Bombay Nat. Hist. Soc. 32: 472 – 677.

__________, 1934. The monkeys of the genera Pithecus (or Presbytis) and Pygathrix found to the east of the Bay of Bengal. *Proc. Zool. Soc. London*. 895 - 961.

Pray, L. 2003 Mechanisms of Speciation. *The Scientist*. 17(21) 14-18.

Ryder, O., 1986. Species conservation and systematics: the dilemma of subspecies. *Trends Ecol. Evol.*1, 9–10.

Schluter, D. 1998. Ecological causes of speciation. p. 114-129 in *Endless Forms: Species and Speciation,* D. Howard, S. Berlocher, eds. Oxford University Press, Oxford.

Schluter, D. and L. M. Nagel. 1995. Parallel speciation by natural selection. *American Naturalist*. 146:292-301

Sristava, A., J. Biswas, J. Das, and P. Bujarbarua, 2001. Status and distribution of golden langurs (*Trachypithecus geei*) in Assam, India. *Am. J. of Primatology* 55:15–23

Tamura, K. and M. Nei , 1993. Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. *Mol. Biol. Evol.* 10:512-526.

Taylor E., J. McPhail, D. Schluter, 1997. History of ecological selection in sticklebacks: uniting experimental and phylogenetic approaches, p. 511-534 in *Molecular Evolution and Adaptive Radiation* T. Givnish, K. Sytsma, eds. Cambridge Univ. Press, Cambridge.

Templeton, A., 1989. The meaning of species and speciation: a genetic perspective. in D. Otte and J. Endler, eds. *Speciation and its consequences*. Sinauer Associates, Inc., Sunderland, MA.

Thompson, J., T. Gibson, F. Plewniak, F. Jeanmougin, and D. Higgins, 1997. The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic Acids Research*, 25:4876-

4882.

Vigilant, L., M. Stoneking, H. Harpending, K. Hawkes, and A. C. Wilson. 1991. African populations and the evolution of human mitochondrial DNA. *Science* 253: 1503- 1507.

Wangchuk, T., Y.Kawamto, M.Aimi, 2001. Discovery of a contact zone between golden langurs (*Trachypithecus geei*) and capped langurs (*Trachypithecus pileatus)* in Bhutan. *Am. J. of Primatology* 54 (Supplement 1): 40.

Wangchuk T., D. Inouye, M. Hare**,** 2003**.** A new subspecies of golden langur (*Trachypithecus geei*) from Bhutan. *Folia Primatologica*. 74(2):104-108

Appendices for Chapter 2

Appendix 5: Control region sequence alignment

```
Capped1       1 -------------------------------------------------------TATCT 60
Capped2         --------------------------------------------------------ATCT
south1          GGGTCTATCACCATATTAACCAGTCACGGGAGCTCTCCATGCATTTGGTATCTTTTATCT
south2          --------------------------------------------------------ATCT
north1          -----------------------------------------------------GGGGCCT
north2          -----------------------------------------------------GGGGCCT
Grey1           ----------------------------------------------------------GT
                                                                           *


                61                                                         121
Capped1         CTGG----TCTGCACGCAACCCCATTGCAG-TATGCTGACTCCCACCACATCCCGTCCTG
Capped2         CTGG----TCTGTACGCAACCCCATTGCAG-ACAGCTGACTCCCACCCCCTCCCGTCCTG
south1          CTGG----TCTGCATGCGACCCCATCGCAGTAAAGCCGG-TCCTGCCACACTACATGCTG
south2          CTGG----TCTGCATGCGACCCCATCGCAGTAAAGCCGG-TCCTGCCACACTACATGCTG
north1          CTGGAG--TCTGCATGCGACCCCATCGCAG-AAAGCCGG-TCCTGCCACACTAGATGCTG
north2          TGGGAGGGTCTGCATGCGACCCCACCGCAG-AAAGCCGG-TCCTGCCACACTAGATGCTG
Grey1           CTGGGGGGTGTGCACGCGATAGCATTGCGATTCGCTGGGAGCCGGTAACACCCTATGTCG
                  **    * ** * ** *   **  **         *   **     *      *   *


                122                                                        182
Capped1         AATGCGCCTGTCTTTGATTCCTAGTACATGCAGTTATTGATCGCACCTACGTTCAATATT
Capped2         TATGGACCTGTCTTTGATTCCTGGTACATACAACTATTAACCGCACCTACGTTCAATATC
south1          CA-GCACCTGTCTTTGATTCCTAGTTCATACCATTATTAACCGCACCTACGTTCAATGTC
south2          CA-GCACCTGTCTTTGATTCCTAGTTCATACCATTATTAACCGCACCTACGTTCAATGTC
north1          CA-GCACCTGTCTTTGATTCCTAGTTCATACCATTATTAACCGCACCTACGTTCAATGTC
north2          CA-GCACCTGTCTTTGATTCCTAGTTCATACCATTATTAACCGCACCTACGTTCAATGTC
Grey1           CA-GTATCTGTCTTTGATTCCTGCCTCATCCTATTATTTATCGCACCTACGTTCAATATT
                 * *   ***************    *** *   **** * **************** *

                183                                                        243
Capped1         CTAGCTCCACGCAAGCTTTAGCAAGGTGTTATTTAATCCATGCTTGTAGGACATATTAAT
Capped2         CTAGTTCCACGCGGACCTTAGCAAGGTGTTATTTAATTCATGCTTGTAGGACATACCAAT
south1          CTAGCTCCACATAA--TACCATAAGGTGTTATTTAATTCATGCTTGTAAGACATACAAGC
south2          CTAGCTCCACATAA--TACCATAAGGTGTTATTTAATTCATGCTTGTAAGACATACAAGC
north1          CTAGCTCCACATAA--TACCATAAGGTGTTATTTAATTCATGCTTGTAAGACATACAAGC
north2          CTAGCTCCACATAA--TACCATAAGGTGTTATTTAATTCATGCTTGTAAGACATACAAGC
Grey1           ACAGGCGAACATAC-TTACTAAAGTGTGTTAATTAATTAATGCTTGTAGGACATAATAAT
                  **    **            *  ****** *****  ********* ******  *

                244                                                        304
Capped1         AACCATTCTAGTCAGTA-TTACTCACACTACGC-----CGTTAAC----CACAACCGTAT
Capped2         AATTACTCTAGCCAAC--TTATTCCCACCACGC-----CATAAAC----CGTAACTATAC
south1          AGTATGTCTTACA-ACAGTTAACTACACAACGCACCCTCGTTAACACTACAAAACCGCAA
south2          AGTATGTCTTACA-ACAGTTAACTACACAACGCACCCTCGTTAACACTACAAAACCGCAA
north1          AGTATGTCTTACAGACAGTAAACAACACAACACACCCTCGTTAACACTACAAAACCGCAA
north2          AGTATGTCTTACAGACAGTAAACAACACAACACACCCTCGTTAACACTACAAAACCGCAA
Grey1           AACAATTGATGTCTGCA--CAGCCGCTTTCCACACAGACATCATA-----ACAAAAAATT
                *     *             *    *    * *       * *         **
                305                                                        365
Capped1         CCTATCAAACCC----CCCCACCCCC-ATCTCCGACCTTCATCCAAA--CCCACTCTTGC
Capped2         CTGATCAAACCC----CCCTACCCCCCATCTCCGATCTTCATCCAAAAACCCACTCTTGC
south1          CAAATTTATGCCAAACTCCCCTCCCCCATCTCCGACCTTTCCCCACAAATCCACTTTTGC
south2          CAAATTTATGCCAAACTCCCCTCCCCCATCTCCGACCTTTCCCCACAAATCCACTTTTGC
north1          CAAATTTATGCCAAACTCCCCTCCCCCATCTCCGACCTTTCCCCACAAATCCACTTTTGC
north2          CAAATTTATGCCAAACTCCCCTCCCCCATCTCCGACCTTTCCCCACAAATCCACTTTTGC
Grey1           TCCACCAAACCC---CCCCCTCCCCCCGCTTTTGGCCACAGCACTTAAACACATATTTGC
                   *   *  **     **   ****    *  *  *      *  *    **   ****
```

```
               366                                                          426
Capped1        CAAACCCCAAAAACAAAAGTCTT-AACAT--ATCCAGTCGGAGTCCATATTTTTATCTTT
Capped2        CAAACCCCAAAAACAAAAGTCTT-AATAC--ATCCGATCAGAGCCTACATTTTCATCTTT
south1         CAAACCCCAAACACAAAAGCCTTTAATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTT
south2         CAAACCCCAAACACAAAAGCCTTTAATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTT
north1         CAAACCCCAAACACAAAAGCCTTTAATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTT
north2         CAAACCCCAAACACAAAAGCCTTTAATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTT
Grey1          CAAACCCCAAAAACAAAGAACCCTAACACCAGCCTAACCAGATTTCAAATTTT-ATCTTT
               *********** *****   *    **       *    * **      *** * ******

               427                                                          487
Capped1        TGGGTGTACACAACTCCAACTGCCATTCCCTCAACTAATAAAC-ATTTACTTCACCA---
Capped2        TAGGTGTGCACAACTCCAACTGCCACTCCCTCAACTAATAAAA-ACTTACTTCACCA---
south1         TAGCTATGCACAACTTCAACTGCTATTCCCTCAACTAATAAAA-ATTTACTTCACCCTAC
south2         TAGCTATGCACAACTTCAACTGCTATTCCCTCAACTAATAAAA-ATTTACTTCACCCTAC
north1         TAGCTATGCACAACTTCAACTGCTATTCCCTCAACTAATAAAA-ATTTACTTCACCCTAC
north2         TAGCTATGCACAACTTCAACTGCTATTCCCTCAACTAATAAAA-ATTTACTTCACCCTAC
Grey1          TGGCGGTATGCACTTTTAACAGTCAC-CCCCCAACTAACACATTATTTTCCCCTCCCACT
               * *   *   **  *  *** *  *  *** ******* * *  * ** *  * **

               488                                                          548
Capped1        -------------AACACCCTTCACC----------A-CCAACCCGCGAC-AAAT-----
Capped2        -------------AACACCCTTCACC----------A-CCAACCCACAACTAGGC-----
south1         CACTCTTGACTCCATTCTCCCTCTCTTTTCCCAAATA-CTTGCACAATACCAAATTCACC
south2         CACTCTTGACTCCATTCTCCCTCTCTTTTCCCAAATA-CTTGCACAATACCAAATTCACC
north1         CACTCTTGACTCCATTCTCCCTCTCTTTTCCCAAATA-CTTGCACAATACCAAATTCACC
north2         CACTCTTGACTCCATTCTCCCTCTCTTTTCCCAAATA-CTTGCACAATACCAAATTCACC
Grey1          CCCATACTACTAATCTCATCAATACAACCCCCGCCCATCCTACCCAGCAC-ACACAC---
                                   *    *           * *   * *   ** *
               548                                                          608
Capped1        -CCTTCTCAT-ACA-ACCCAAAAGAAAATACCTCACAATTGCTCTGACACCTCTGTTTAT
Capped2        -CCTTCTCAC-ACA-ACCCGAAAGAAATCACCACACAATCGCACTGACACC-CCGTTTAT
south1         CCCTTATCACCACA-ACCCCAAAGACAGCACTTCACAATTA-TCTG-CTTTTCTGTTTAT
south2         CCCTTATCACCACA-ACCCCAAAGACAGCACTTCACAATTA-TCTG-CTTTTCTGTTTAT
north1         CCCTTATCACCACA-ACCCCAAAGACAGCACTTCACAATTA-TCTG-CTTTTCTGTTTAT
north2         CCCTTATCACCACA-ACCCCAAAGACAGCACTTCACAATTA-TCTG-CTTTTCTGTTTAT
Grey1          CGCTGCTAACCCCATACCCCGAACCAACCAAACCCCAAAGACACC--CCCCACAGTTTAT
                 **  * *   ** ****  **   *  *   * ***     *   *    * ******

               609                                                          669
Capped1        GTAGCTTAAACCCCCCCAAAGCTA-ACNCCCAAAATGCCTAGATGGGTTCGCA-TACCCC
Capped2        GTAGCTTAAACCCACACAAAGCAAGACACTGAAAATGCCTAGATGGGTTCGCA-TACCCC
south1         GTAGCTTAA-TTCACTCAAAGCAAGACACTGAAAATGCCTAGACGGGTCTGCG-CACCCC
south2         GTAGCTTAA-TTCACTCAAAGCAAGACACTGAAAATGCCTAGACGGGTCTGCG-CACCCC
north1         GTAGCTTAA-TTCACTCAAAGCAAGACACTGAAAATGCCTAGACGGGTCTGCG-CACCCC
north2         GTAGCTTAA-TTCACTCAAAGCAAGACACTGAAAATGCCTAGACGGGTCTGCG-CACCCC
Grey1          GTAGCTTA--CCTCCTCAAAGCAATACACTGAAAATGTTTAGACGGGCTCACATAACCCC
               ********      * ****** * ** *  ******  ** * ***         ****

               670                       696
Capped1        ATAAACAAATAGGCTTGGTCCTGGCC-
Capped2        ATAAACAAATAGGCTTGGTCCTGGCC-
south1         ATGAACAAATAGGCT------------
south2         ATGAACAAATAGGCTTGGTCCTGGCCA
north1         ATGAACAAATAGGCTTGGTCCTGGCC-
north2         ATGAACAAATAGGCTTGGTCCT-----
Grey1          ATAAACAAATAGGCTTG----------

               ***************
```

Appendix 6: HVR1 sequence alignment

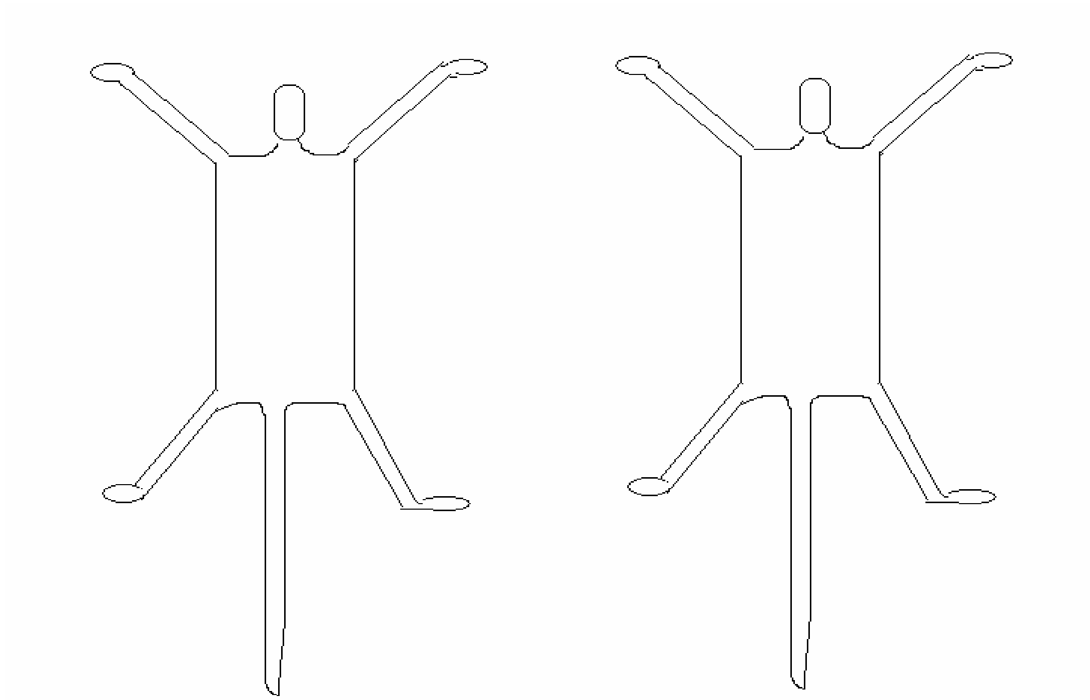
```
Capped1        1 AG-TATGCTGAC-TCCCACCACATCCCGTCCTGTATGGACCTGTCTTTGATTCCTGGTAC 60
Capped2          AG-ACAGCTGAC-TCCCACCCCCTCCCGTCCTGTATGGACCTGTCTTTGATTCCTGGTAC
south1           AG-AAAGCCGG--TCCTGCCACACTACATGCTGCA-GCACCTGTCTTTGATTCCTAGTTC
south2           AG-AAAGCCGG--TCCTGCCACACTACATGCTGCA-GCACCTGTCTTTGATTCCTAGTTC
north1           AG-AAAGCCGG--TCCTGCCACACTAGATGCTGCA-GCACCTGTCTTTGATTCCTAGTTC
north2           AG-AAAGCCGGC-TCCTGCCACACTAGATGCTGCA-GCACCTGTCTTTGATTCCTAGTTC
Grey1            AGATTCGCTGGGAGCCGGTAACACCCTATGTCGCA-GTATCTGTCTTTGATTCCTGCCTC
                  *    ** *    **     *      *   * * *   ***************    *

Capped1       61 ATACAACTATTAACCGCACCTACGTTCAATATCCTAGTTCCACGCGGACCTTAGCAAGGT 121
Capped2          ATACAACTATTAACCGCACCTACGTTCAATATCCTAGTTCCACGCGGACCTTAGCAAGGT
south1           ATACCATTATTAACCGCACCTACGTTCAATGTCCTAGCTCCACATAA--TACCATAAGGT
south2           ATACCATTATTAACCGCACCTACGTTCAATGTCCTAGCTCCACATAA--TACCATAAGGT
north1           ATACCATTATTAACCGCACCTACGTTCAATGTCCTAGCTCCACATAA--TACCATAAGGT
north2           ATACCATTATTAACCGCACCTACGTTCAATGTCCTAGCTCCACATAA--TACCATAAGGT
Grey1            ATCCTATTATTTATCGCACCTACGTTCAATATTACAGGCGAACATAC-TTACTAAAGTGT
                 ** *   **** * **************** *   **    **            *  **

Capped1      122 GTTATTTAATCCATGCTTGTAGGACATATTAATAACCATTCTAGTCAGTA-TTACTCAC 182
Capped2          GTTATTTAATTCATGCTTGTAGGACATACCAATAATTACTCTAGCCAAC--TTATTCCC
south1           GTTATTTAATTCATGCTTGTAAGACATACAAGCAGTATGTCTTACA-ACAGTTAACTAC
south2           GTTATTTAATTCATGCTTGTAAGACATACAAGCAGTATGTCTTACA-ACAGTTAACTAC
north1           GTTATTTAATTCATGCTTGTAAGACATACAAGCAGTATGTCTTACAGACAGTAAACAAC
north2           GTTATTTAATTCATGCTTGTAAGACATACAAGCAGTATGTCTTACAGACAGTAAACAAC
Grey1            GTTAATTAATTAATGCTTGTAGGACATAATAATAACAATTGATGTCTGCA--CAGCCGC
                 **** *****  ********* ***** *  *  *     *             *    *

Capped1      183 ACTACAC-----CGTAAAC----CGCAACTATACCTGATCAAACCC----CCCCACCCCC 242
Capped2          ACCACGC-----CGTAAAC----CGTAACTATACCTGATCAAACCC----CCCTACCCCC
south1           ACAACGCACCCTCGTTAACACTACAAAACCGCAACAAATTTATGCCAAACTCCCCTCCCC
south2           ACAACGCACCCTCGTTAACACTACAAAACCGCAACAAATTTATGCCAAACTCCCCTCCCC
north1           ACAACACACCCTCGTTAACACTACAAAACCGCAACAAATTTATGCCAAACTCCCCTCCCC
north2           ACAACACACCCTCGTTAACACTACAAAACCGCAACAAATTTATGCCAAACTCCCCTCCCC
Grey1            TTTCCACACAGACATCATA-----ACAAAAAATTTCCACCAAACCC---CCCCCTCCCCC
                     * *       * *         **         *   *  **     **   ****

Capped1      243 CATCTCCGATCTTCATCCAAAAACCCACTCTTGCCAAACCCCAAAAAACAAAAGTCTT-A 303
Capped2          CATCTCCGATCTTCATCCAAAAACCCACTCTTGCCAAACCCCAAAAAACAAAAGTCTT-A
south1           CATCTCCGACCTTTCCCCACAAATCCACTTTTGCCAAACCCCAAAACACAAAAGCCTTTA
south2           CATCTCCGACCTTTCCCCACAAATCCACTTTTGCCAAACCCCAAAACACAAAAGCCTTTA
north1           CATCTCCGACCTTTCCCCACAAATCCACTTTTGCCAAACCCCAAAACACAAAAGCCTTTA
north2           CATCTCCGACCTTTCCCCACAAATCCACTTTTGCCAAACCCCAAAACACAAAAGCCTTTA
Grey1            CGCTTTTGGCCACAGCACTTAAACACATNTTTGCCAAACCCCAAAAAACAAAGAACCCTA
                 *   *  *  *      *  ***  **   **************** *****   *   *

Capped1      304 ATAC—-ATCCGGTCAGAGTCTACATTTTCATCTTTTGGGTGTGCACAACTCCAACTGCCA 364
Capped2          ATAC--ATCCGATCAGAGCCTACATTTTCATCTTTTAGGTGTGCACAACTCCAACTGCCA
south1           ATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTTTAGCTATGCACAACTTCAACTGCTA
south2           ATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTTTAGCTATGCACAACTTCAACTGCTA
north1           ATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTTTAGCTATGCACAACTTCAACTGCTA
north2           ATCC--ACCGGGCCAGAGCTCGCATTCTCATCTTTTAGCTATGCACAACTTCAACTGCTA
Grey1            ACACCAGCCTAACCAGATTTCAAATTTT-ATCTTTTGGCGGTATGCACTTTTAACAGTCA
                 *       *    * **      *** * ******* *   *   **  *  *** *  *

Capped1      365 TTCCCTCAA  373
Capped2          CTCCCTCAA
south1           TTCCCTCAA
south2           TTCCCTCAA
north1           TTCCCTCAA
north2           TTCCCTCAA
Grey1            C-CCCCCAA
                   *** ***
```

Appendix 7: Hybrid Photodocumentation and Sample Collection

Location by Topo Sheet and ID on Topo__________________________
Date:________________
Group Number:_____________________
Number of Individuals in Group:___________________

Langur #	Age	Sex	Photo No& Film Roll	Sample ID

Visual description of individuals in group, use dorsal and ventral schematic drawings:
Langur #__________: Age:_________Sex_________



Description:____

Chapter 3: Land Use, Management, and Conservation of Golden Langur Habitat

Introduction: "Tragedy of the Commons?"

Hardin's seminal paper "The Tragedy of the Commons", published in *Science* in 1968, continues to fuel debate on common property resource management even today. In it he argued that open access resources where "everyone born has an equal right to the commons" lead ultimately to total abuse and ruination of the commons. Hardin, a "genetically trained biologist" and then professor of biology at the University of California, Santa Barbara, develops a rational and stimulating argument to defend his claim. Certain problems, like the commons problem and the exponential growth in global human population, have no technical solutions and cannot be solved by simple changes only in the techniques of natural sciences such as "farming the seas or developing new strains of wheat." Hardin argues that fundamental changes in human values or ideas of morality are necessary to address such problems. Without making Hardin sound draconian, he ultimately reasons that such problems can be addressed only through "mutual coercion mutually agreed upon."

The problems of conservation biology and sustainable development could, by a similar extension of logic, be classified as "problems with no technical solution." This has become an accepted truism by now and my central question in this section "Can local people manage their forests and common property resources on their own without government interference?" may fall in the same category. Specifically, my question will study the threats to golden langurs and their habitat and the potential for local community management of forests in golden langur habitat in central Bhutan. More than 50% of golden langur habitat falls outside of protected areas (Wangchuk, 1995) and in close proximity to villages. Banning the multiple use of forests in such areas is not a feasible option. Local communities have always shared the forests with the golden langurs and also effectively managed them until the nationalization of forests in the 1950s.

Goal

My hypothesis that "local people will manage community forests effectively and on a sustainable basis ensuring long term survival of endangered species," could be tested through what Feeny (1992) calls "natural experimentation." By this he means that ethical considerations of human experimentation would prevent conducting laboratory-like experiments to test the hypothesis. One can only collect data before or after a certain policy change or phenomenon happens through "retrospective or prospective data collection" as Feeny (1992) refers to it. Human experimentation such as letting village A manage their own forests, leaving village B under full government control, and in village C banning access to forests may seem scientific but may not be ethical or adequate.

Explication rather than experimentation may provide more understanding under such circumstances. I attempt then to elucidate the problem from a historical, social, political, and economic perspective on land use in the study area rather than coming up with a technical solution since such a solution is elusive and perhaps nonexistent. This explication is, in my opinion, crucial to answering the question raised above in the introduction of "how to conserve the golden langur" and other endangered species in

Bhutan. A fundamental change in attitude rather than the relentless and elusive quest for technical solutions, as the government is presently in the throes of doing, is necessary.

This represents a paradigmatic shift (sensu Kuhn, 1996) not only in government policy-making but also in the way of doing conservation science. This section then is devoted to exploring the details of what Bourdieu (1984) calls the habitus, the lived environment and experience or the "relationship…established between practices and situation" of the local people in the study area with whom the golden langur intimately shares the common property resources. By this I see the local people as agents "structuring" their social space rather than passive recipients of development aid and conservation policy. In short, understanding the relationship between the people and their environment and endangered species is essential for sound conservation practice. This "depth" understanding of "how it works for them" can emerge by a detailed analysis of how the forests (langur habitat) have been used historically by the people, what changes impinge on their management, and the implications these have on the survival of endangered species. Such a view is essentially, as E. P.Thompson (1994) wrote, "history from below." Reading Bhutan's Land Act, or Forest Act, or for that matter, land tax registers from the mid 18th century, would perhaps lead to a "history from above" perspective, reflecting only the desires of what the rulers wanted from the ruled and not necessarily actual practices on the ground.

Hardin provides a compelling theoretical framework for analyzing common property resources management. He starts by asking and then rejecting Bentham's question (1969) whether "the greatest good for the greatest numbers" is achievable. He shows that this is both a mathematical (cannot maximize two or more variables at the same time) and biological (maximizing population does not maximize goods) impossibility. In short, everyone born cannot have equal access to common property resources. It then is essential to have judgment criteria for allocating the resources optimally and for deciding what the greatest good is. If left to the individuals themselves in the hopes that decisions reached individually will be the best decisions for an entire society, or following Adam Smith's "invisible hand" optimality criterion, the tragedy of the commons will be realized faster than one can say "Adam Smith." Economists term such events as market failures when the invisible hand does not work and supply and demand factors are unable to allocate resources efficiently (Kahn, 1995). One such category of market failure has to do with public goods such as Government Reserve Forests in Bhutan.

Possible solutions to the allocation or commons dilemma, according to Hardin, are to "sell them off as private property [or]… keep them as public property, but allocate the right to enter them." Allocation, according to Hardin, may be done by lottery, on the basis of wealth, merit, auction, on a first-come, first-served basis, or on some agreed upon standards.

How then have the local people in my study area resolved the commons dilemma? By all indications they had a system that worked until government took over the management of the community forests and pastures in the 1950s (Wangchuk, 2000) and systematically nationalized all forest land as government property. Such a move has resulted in tragic environmental degradation in many parts of the world as documented by Messerschmidt (1986) in Nepal, Feeny (1988) in Thailand, and Gadgil and Iyer (1989) in India. Ostrom (1990) succinctly summarizes the situation:

> Nationalizing the ownership of forests in Third World countries…has been advocated on the grounds that local villagers cannot manage forests so as to sustain their productivity and their value in reducing soil erosion. In countries where small villages had owned and regulated their local community forests for generations, nationalization meant expropriation. In such localities, villagers had earlier exercised considerable restraint over the rate and manner of harvesting forest products. In some of these countries, national agencies issued elaborate regulations concerning the use of forests, but were unable to employ sufficient numbers of foresters to enforce those regulations. The foresters who were employed were paid such low salaries that accepting bribes became a common means of supplementing their income. The consequence was that nationalization created *open access resources* where limited-access *common-property resources* had previously existed.

Clearly then Bhutan, like the countries above, chose nationalization under the conditions that Hardin describes as relying on administrative law and bureaucracy to "spell out all" the rules and regulations when it took over the management of the forests. Yet the language of bureaucracies in Bhutan is "lack:" lack of capacity, lack of infrastructure, lack of technology, lack of adequately trained staff, lack of funds, etc. to enforce these regulations. Conditions are ripe for limited-access common-property resources to become "free for all" open access resources (Ostrom, 1990). Endangered species lose the protection inherent in traditional community managed systems. They become wards of the state with a great deal of lacks.

A Previous Case Study

What exactly was the system used by local communities prior to nationalization? According to Hardin the "the social arrangements that produce responsibility are arrangements that create coercion." He calls these arrangements "mutual coercion, mutually agreed upon by the majority of the people affected." In the case of community property in Bhutan, these social arrangements, prior to nationalization, were strict customary laws that were "mutually agreed upon by the majority of the people affected." The rights to enter and use common property such as forests and pastures were negotiated arrangements called *luso,* or village customs. The important point here is that these arrangements are local, negotiated, open, democratic, and controlled by the villagers themselves. Nationalization, on the other hand, resulted in an upward concentration and transfer of power in the hands of the government and specifically the Department of Forestry (DOF). Hardin views such an arrangement as being subject to "arbitrary decisions of distant and irresponsible bureaucrats." Customary law is overridden by administrative law which, in the absence of an independent judiciary and civil society in Bhutan, reigns supreme. It is little wonder then that most school children in Bhutan want to be "civil servants" when they grow up to partake in this bounty of arbitrary power and the privileges that ensue.

I present below a brief synopsis and details of the tension between local democratic norms and state objectives. Specifically, the role of enforcement and state control of natural resources *vis-a-vis* that of community ownership and management is an emerging issue as described above. The prevailing academic argument today favors community forestry and management of forests by the local people, the argument being that if people own a resource, they are more willing to conserve it as opposed to government forests where ineffective state control can lead to forests that are "free for all" open access resources (Ostrom, 1990). Given this paradox, the current approach of the DOF is to regulate all resource use by the people. Is regulation the answer? Will the government ever be in a position to achieve its ideal of complete, total, and thorough enforcement and regulation? What are other feasible alternatives? How have the economic dynamics changed since the advent of modernization in the late 1950s? Does the control of forest resources by the DOF result in the protection of Bhutan's forests given market forces and high timber value since the 1950s? What would happen if these restrictions were lifted? Will Bhutan's forests head the way of Nepal's? Or will the communities, if the forests are handed back to them, do a better job at managing Bhutan's forests?

I had the unique opportunity to try to answer the above questions during a six week field attachment with a territorial division of the DOF in September-October 1999 in western Bhutan. I observed and participated in the daily functioning of the division and its three ranges. Using participation-observation research methods I kept daily field notes, which are analyzed and presented below. I also talked with the people coming to the DOF offices and asked their opinion of the procedures and alternatives they thought might work better. We discussed traditional forest resource management practices in comparison with the existing system. Given that I was also seen as a forestry official, their answers may not have been as candid as they wished. To overcome this, on weekends I visited villages under the division and talked informally with the people.

Since my own ancestral village is from the area, the network of kin and acquaintances greatly facilitated informal discussions.

Forestry is still one of the largest revenue earners for Bhutan. Prior to 1950, forestry was not developed and its contribution to the national exchequer was non-existent. Historically, the state depended on taxation of the rural populace for support. The tax-paying peasantry's labor and produce were strictly regulated and an elaborate taxation system existed. With planned development and the advent of modernization, the state's focus shifted from taxes to natural resource use such as forestry and hydropower. The common people welcomed the lifting of the tax burden, however, they had to contend with new market forces. For instance, in the study area the people said that when the first road into Bhutan connecting India and Bhutan was constructed and towns were built, local elites from their villages misused timber from the community's forest and sold it on the market. These combined factors resulted in the government launching the erstwhile Department of Forestry in 1952 and the eventual nationalization of all forests by 1969. In place now is an elaborate and complex system governing use of forests. For instance I counted about eleven procedural steps and approvals a villager must obtain before he or she is allocated house-building timber or firewood. Also, the bureaucracy covers every aspect of timber and other resource use allocation - preemptive measures foresee all potential for misuse by the public and regulatory mechanisms are made on this basis. There is also a "protection ranger" and his staff who "polices the police" and cracks down on misuse by DOF staff. I was at times struck by how small the rangers' office was on the landscape below the mighty Dzong (fort) and immense mountains and yet how large it seemed in terms of wanting to control everything that went on in the forests.

Figure 3.1 The Chamgang Forest Ranger's Office is the small wooden structure at the base of the Semtoka Dzong (fort)

Prior to the 1950s each village had its own forest or *Ri*, and village forests in west Bhutan were often situated on slopes above the villages, carefully demarcated by streams and ridges or the erection of boundary pillars (*laptsa* or stone cairns) between adjoining forests. The villagers did not need permission to collect timber and firewood from their village forests. However, others were strictly excluded and trespassers were fined and grain compensation collected from encroaching neighbors. In most cases the villagers resolved disputes internally, or a *chipon* or village leaders would visit the transgressor and mediate a suitable outcome. Sometimes a forest tax or *rithray* was collected to allow for certain use rights to neighbors such as permitting limited grazing of cattle or collection of timber. This *phaju-bhuju* or "ancestral" system was resorted to even by the state when asked to adjudicate in certain disputes unresolved at the village level.

From a tenure perspective, the villagers as a community owned the forests. Besides this basic understanding and the protection of certain sacred groves inhabited by *tsen*, *rigamen*, or forest spirits there were no complex rules governing community forestry use. Local elites took advantage of the changing situation in the 1960s when the first vehicle road was built connecting India to Bhutan. A few people profited from the village forests at the expense of the community when they misused timber from community forests and sold it on the market. Consequently, some of the poorer villagers interviewed said that the existing system of government regulation was preferable since those with *bju*, *kha*, and *neagkap* (money, talk, and ideas) would grab the forest if it reverted to the community. Others however, welcomed the idea and said it would reduce the problems they had with the DOF bureaucracy and make their lives much easier. Some elderly villagers voiced concern that the forests would be quickly denuded if reverted to community ownership. Forest rangers however had the opposite perception - that the villagers would simply "lock up" community forests and deny timber and fuelwood to other Bhutanese. However, another senior forestry beat officer noted "we can't guard each and every tree in the forest."

Objectives

Given this complex scenario, the objectives that follow are designed to answer the questions raised above through a detailed analysis of the forests (langur habitat). I begin firstly with a biophysical assessment of the habitat and quantify available habitat for golden and capped langurs. The threats and land use pressures on the habitat of the langur in Bhutan are also assessed in detail. Next I turn to a socio-cultural assessment of historical and current land use practices that impinge on the management of langur habitat. Finally, I present an integrated analysis of the biophysical and socio-cultural aspects of langur conservation in Bhutan. Understanding the relationship between the people and their environment and endangered species is essential for sound conservation practice. Recommendations for conservation management of the langurs of Bhutan are made based on the threats assessment.

Land Use Pressures and Available Golden Langur Habitat

Assessment of Threats and Land Use Pressures

Despite the protected status of about 50% of the golden langurs' habitat within the boundaries of the Royal Manas National Park, Jigme Singye Wangchuck National Park, and Phipsoo Wildlife Sanctuary, almost all of their habitat, both in and out of the parks, is used by the local people of Zhemgang, Trongsa, Sarpang, and Tsirang districts (Figure 3.2). Land use types include subsistence farming, forest grazing, and forest product use such as timber, firewood, and a variety of non-timber forest products by local communities. Commercial timber harvesting operations are also conducted by the Forestry Development Corporation. Other large impact activities include vehicle road construction, mega-electric power line grids passing through langur habitat, and urban growth and development along the border towns with India. To understand clearly the pressures of these land use activities, it is necessary to:

I. Quantify habitat available to golden langurs

Surveys in golden langur habitat show that all broadleaf forests below an altitude of 2,400 m are regularly used by the langurs (Wangchuk 1995). In summer langurs have been seen at higher elevations, close to 2,800 m in Chendebji. However, this may only represent a short seasonal visit. Core habitat therefore consists of forests classified as warm broad-leaved forests between 1,000 m to 2,400 m, and subtropical forests between 200 m and 1,000 m (Grierson and Long, 1983) between the Puna Tsang Chu (Sunkosh river) and Chamkhar / Mangde / Manas rivers. In this area north-facing slopes and shady areas such as ravines and gorges are dominated by mixed broad-leaved forests. South-facing slopes that receive more sunlight are dominated by Chir pine (*Pinus roxburghii*) stands.

II. Quantify types of land use in langur habitat and measure impacts.

Several towns and villages under the districts of Zhemgang, Trongsa, Sarpang, and Tsirang fall within this prime golden langur habitat. Agriculture is the most prevalent land use along with forest grazing of cattle. Other activities such as commercial logging, road building, and urban development have commenced since the start of planned socio-economic development in the 1960s. During the surveys in 2002, a 37 km road (called the Dakpai-Buli Road) passing through prime langur habitat was under construction. The road connects the villages of Tali, Kikhar, and Buli with the Zhemgang – Gelephu highway. This provided an opportunity to measure the impact of the road on the golden langur population in the area and its habitat.

The available habitat consisting of broad leaf forests below 2,400 m can be mapped and measured and likewise land use pressures, in terms of land use types under each of the categories mentioned above, can be measured. Knowing prime habitat available minus the land under use will provide baseline data of habitat available to golden langurs and will be the basis for understanding threats and pressures faced by the langurs. Any discussion of the conservation and management of the forests that form the habitat of the langurs can only take place within this context.

Also, knowledge of detailed species composition of the mixed warm broadleaf forests and preferred foliage species will shed more light on the habitat requirements of the langurs. A habitat profile or physiognomic structural classification of habitat types by vegetation height will be developed to this end. Classifying vegetation into height classes such as top canopy, middle and understory will also provide information on the preferred class by the langurs, especially with reference to the other sympatric primate species, the Assamese macaque (*Macaca assamensis*). Resource partitioning between the langur and macaque, if present, will be highlighted by this exercise.

The Dakpai-Buli road construction will reveal the impacts of an intensive development activity in prime habitat. Both direct and induced impacts can be studied to see effects on langur habitat.

Methods for Quantifying Habitat and Land Use

Geographic Information System (GIS) software was used to map the field data collected during surveys in langur habitat between 1994 to 2003. Digitized forest cover and land use data from the Land Use Planning Database (Ministry of Agriculture, 1995), gathered from Landsat images, and ground truthing during the surveys provided the bulk of the information required. ArcGIS 8.1 software (ESRI, 2002) was then used to calculate area under various land use types and forest cover. The following ArcGIS logic commands were followed:

1. Show area of broadleaf forests below 2400 m minus agricultural areas (*chuzhing, pangshing, tseri, kamshing*) and settlements between the Puna Tsang Chu river

and Chamkhar/Mangde/Manas rivers. Calculate this area in square kilometers. This is the available golden langur habitat. However, since the broadleaf forests of the Chamkhar river basin, on both the west and east banks is exclusively inhabited by capped langurs, this area adds to capped langur habitat and is deducted from golden langur habitat.

2. In golden langur habitat calculate area under various land use categories. Show *kamzhing* (dryland agriculture), *tseri* (shifting cultivation), *chuzhing* (terraced rice paddy farming), and *tsamdo* (registered forest pastures).
3. Calculate areas of coniferous forests, scrub forests, horticulture orchards, landslips/open eroded areas, marshy areas, rock outcrops, water spreads and settlements.
4. Calculate area of forests between 1,000 m and 2,400 m (warm broad leaf) and area of forests between 200 m and 1,000 m (subtropical).
5. Repeat the above procedure to calculate available habitat for capped langurs in east Bhutan. Capped langurs have similar habitat requirements as their sister species, the golden langurs. All broadleaf forests below 2,400 m in areas east of Chamkhar/Mangde/Manas river is suitable habitat. In addition broadleaf forests on the west bank of the Chamkhar river basin are also exclusively used by the capped langurs. Broadleaf forest in this area was also calculated as available habitat for capped langurs.

In addition to the Land Use Planning data another set of data from the Renewable Natural Resource (RNR) nationwide census (MoA, 2000) was reviewed to quantify types of land use in langur habitats and countercheck GIS results. The RNR census, conducted by the Ministry of Agriculture in 2000, gathered data on land use classification, land tenancy, livestock numbers, and household food-grain security among other variables.

Qualitative data on land use were collected through informal interviews with villagers while visiting the villages during surveys. A questionnaire on land management designed to understand traditional and current land use and habitat management practices was also informative, especially on issues related to land used for shifting cultivation. The questionnaire is elaborated further in the sections that follow.

A questionnaire to assess land use issues and attitudes towards community-based management was also developed (Appendix 8).

Methods for Determining Habitat Profile and Forage Species

A habitat profile or physiognomic structural classification of habitat types by vegetation height was done by classifying vegetation into height classes such as top canopy, middle and understory. Canopy trees were typically XX m in height. Warm broad-leaved forests were surveyed by walking four 2 km long transects along forests on north facing slopes in the warm broad-leaved zone. The transects were selected along the census route used in 1994 (Wangchuk, 1995). Trees constituting the top canopy, middle, and understory were recorded to the species level where possible. Shrubs, climbers, and herbs were also recorded to the species level when possible and to the genus level with more difficult taxa. To standardize the height classification, all woody plants less than 2 m tall were called shrubs. Shrubs were then used as a reference point for classifying trees as understory, middle, and top canopy. The following two references, Flora of Bhutan (Grierson and Long, 1983, 1984, 1987, 1991) and Flowers of the Himalayas (Polunin and Stainton, 1984) were used in the field. Because the objective was to get a habitat profile and representative species composition of the flora and not a diversity or density index, the transects were chosen on a non-random basis, laying them in representative areas. During the field surveys, trees and shrubs in which langurs were seen feeding were noted and leaves, buds, and flowers (when present) were collected and pressed for later identification. Both the scan and focal animal sampling methods (Altmann, 1974) were used to observe langurs while foraging to note plants and plant parts being eaten. Sighting locations of langurs and Assamese macaque (*Macaca assamensis*) were recorded by the habitat strata in which they were observed.

Results : Habitat, Land Use, and Threats

Available Habitat

Figure 3.2 shows the warm broad-leaved forests below 2,400 m and subtropical forests, the amount of suitable habitat available to the three langur species of Bhutan. Settlements and agricultural areas have been excluded and are shown as gaps interspersed among the green. The continuous sections of white above the green are alpine areas or forests where langurs do not occur naturally. Protected areas (PAs) are shown outlined by dark green and hatched. The three PAs of interest, Royal Manas National Park (1,023 km^2), Jigme Singye Wangchuck National Park (1,730 km^2), and Phipsoo Wildlife Sanctuary (266 km^2) together protect about 50% of the golden langurs' habitat. The forests available to golden langurs are shown highlighted in yellow outline, both in and outside of protected areas. This is about 4,782 km^2 of potential habitat. However, about 1,307 km^2 is unsuitable due to natural factors (coniferous forests, rocks and cliffs, landslips) and human use (agriculture, settlements). Agricultural land, consisting of 646 km^2 , is the single largest land use category. Coniferous forests consisting largely of chir pine forms the next largest land classification which is not suitable as golden langur habitat. This is about 9.46 % of the total land area in golden langur range in Bhutan. Another 4.3 % of the land is either used as orchards and settlements or are otherwise unsuitable habitat such as eroded landslips and rocky areas. Warm broad-leaved and subtropical forests cover an area of 3,475 km^2 or 72% of the total land area in golden langur range. This area then should be prime habitat for golden langurs. However, 386 km^2 is demarcated as Forest Management Units or logging areas.

Figure 3.2 Map showing langur habitable broadleaf forests, protected areas, and logging areas (forest management units).

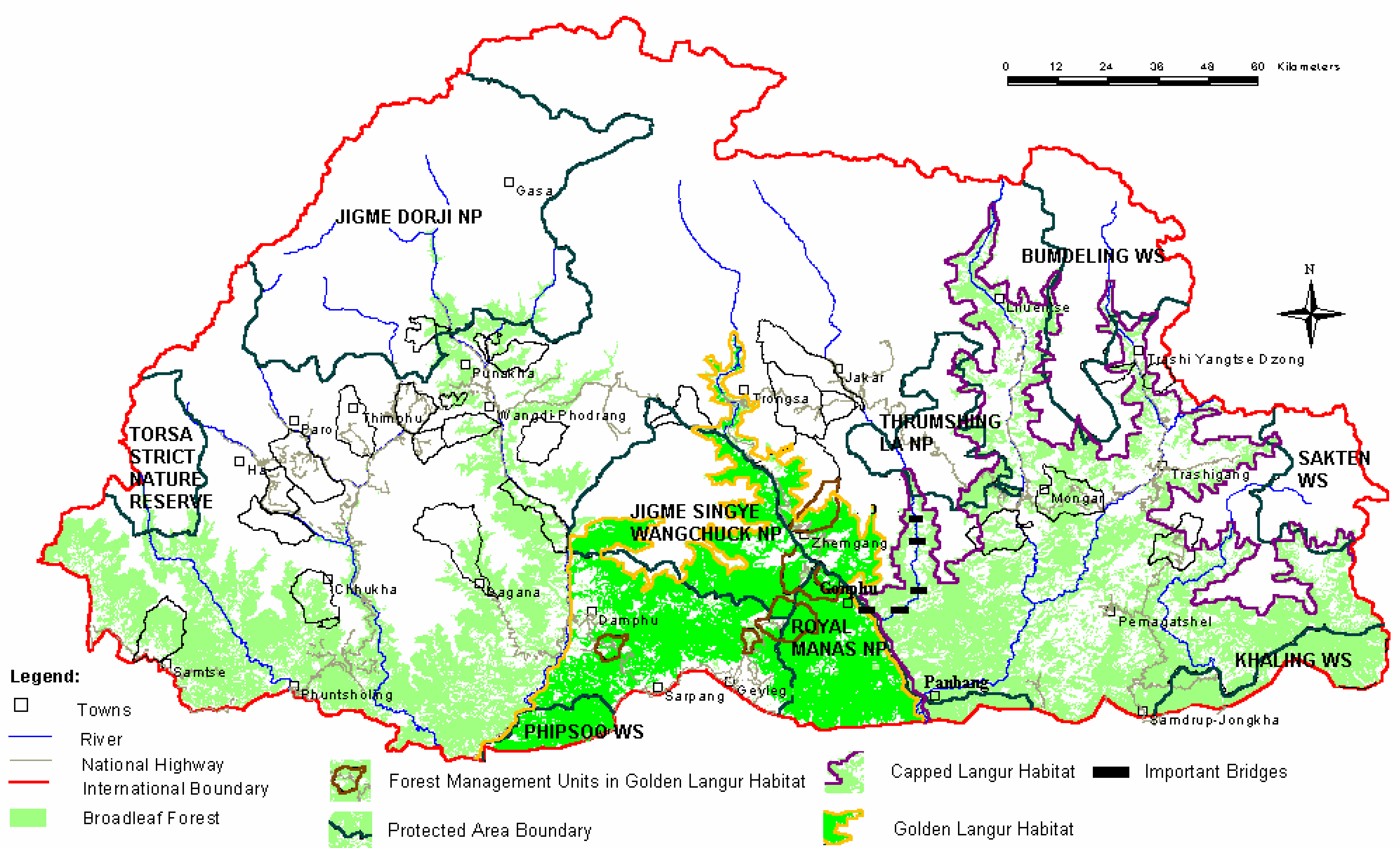


Table 3.1 Land Use and Available Habitat in Golden Langur Range

Golden Langur: Land Classification and Habitat			
Land Classification	**Area(km^2)**	**% Land Area**	
Dryland farming/Kamzhing	138.85	2.90	
Mixed Cultivated Land	245.76	5.14	
Shifting Cultivation /Tseri	133.23	2.79	
Rice farming /Chhuzhing	128.40	2.69	Total Agricultural: 646.24 km2 or 14%
Broadleaf Forest	3475.38	72.67	3675.38 - 200 (Chamkhar west bank) = 3475.38
Coniferous Forest	452.32	9.46	
Forest Plantation	25.59	0.54	
Scrub Forest	37.54	0.78	
Horticulture Orchards	0.60	0.01	
Horticulture plant	8.66	0.18	
Landslips/Open Eroded Areas	5.96	0.12	
Marshy areas	0.64	0.01	
Rock Outcrops	34.93	0.73	
Water Spreads	61.45	1.28	
Natural Pasture	29.51	0.61	
Settlement	3.44	0.07	
	Area (km^2)	%	
	4,782.27	**100.00**	**Total potential habitat**
	1,306.89	**27.33**	**Degraded or unsuitable**
	3,475.38	**72.67**	**Available habitat**
	386.00	**8.07**	**Selective timber extraction (FMU*)**
	3,089.00	**65.00**	**Prime habitat**

* Forest Management Units

In total then about 3,089 km^2 of broad leaf forest is available as core habitat for golden langurs in Bhutan. Of this 836 km^2 is in the subtropical zone between 200 to 1,000 m while 2,253 km^2 is in the warm and cool broadleaf zone between 1,000 to 2,400 m. This has special significance for the new subspecies of golden langur described from north Bhutan (Wangchuk et al., 2003). In essence then it can be assumed that the new subspecies has an area of close to 2,300 km^2 of habitat while the southern subspecies has about 836 km^2 of available habitat in Bhutan. The southern subspecies ranges into Assam India also where an additional 1,255 km^2 (Srivastava et al. 2001**)** of habitat is available.

Collection of firewood, rural house building timber, non-timber forest products (NTFP), and forest grazing take place in this core habitat in the north and the south. It is difficult to gauge impacts of these activities since no studies have been conducted so far. Estimates by the Forestry Resources Development Division suggest that of the annual 8 million cubic feet of timber and firewood used nationwide, 6 million cubic feet is extracted from "un-managed" forests by rural populations (FRDD, 2003). The other 2 million is extracted from FMUs. However, it may be noted that despite this figure, local communities have been using forest resources since habitation of the area and with minimal impacts suggesting that traditional lifestyles were sustainable. Still, increasing population and a market economy are altering traditional lifestyles and increasing pressures as discussed earlier. Bhutan's conservation policy does not deny traditional communities living inside PAs of any of their user rights. In essence then there is no difference regarding land use by local communities inside and outside of PAs. Only newer activities such as FMUs are restricted inside protected areas. Therefore there is no difference in land use pressures and quality of prime habitat inside of protected areas *vis-a-vis* prime areas outside of PAs.

Capped langur habitat

Table 3.2 shows habitat available to capped langurs in Bhutan and land use classifications in their range. Capped langurs have a larger total potential habitat than golden langurs, about 6,968 km^2. However, agricultural use is also much higher in their range, about 1,465 km^2 or 21% of potential habitat is used for permanent and shifting cultivation, which is more than double the amount of agricultural land in golden langur habitat. Coniferous forests, mainly Chir pine, constitute 9.14% of the area while another 4.75% is pasture, landslips, and rock. This leaves a total of 4,535.24 km^2 of broad leaf forests as available habitat, about 65% of the total land area. Of this, 1,389 km^2 is in the subtropical zone between 200-1000m, and 3,145 km^2 is in the warm broad leaved zone between 1000-2400m. However, Table 3.2 shows that 526 km^2 is under FMU management where selective logging takes place. Almost all of this is in broad-leaf forests. This leaves about 4,000 km^2 as core capped langur habitat or 57.5% of the total potential habitat. However, rural house building timber, firewood, forest grazing and NFTP extraction takes place in this core habitat also.

Table 3.2: Land Use and Available Habitat in Capped Langur Range

Capped Langur: Land Classification and Habitat			
Land Classification	**Area (km^2)**	**% Land Area**	
Dryland Farming/Kamzhing	468.22	6.72	
Mixed Cultivated Land	321.78	4.62	
Shifting Cultivation / Tseri	598.45	8.59	
Rice Farming / Chhuzhing	77.00	3.16	Total Agricultural: 1,465 km^2 or 23%
Broadleaf Forest	4,535.24	65.08	
Coniferous Forest	637.11	9.14	
Forest Plantation	3.32	0.05	
Scrub Forest	131.59	1.89	
Horticulture Orchards	0.96	0.01	
Landslips/Open Eroded Areas	11.17	0.16	
Marshy areas	0.11	0.00	
Rock Outcrops	76.38	1.10	
Water Spreads	43.17	0.62	
Improved Pasture	0.75	0.01	
Natural Pasture	59.39	0.85	
Settlement	4.15	0.06	
	Area(km^2)	%	
	6,968.79	**100.00**	**Total available habitat**
	2,433.55	**34.92**	**Degraded or unsuitable**
	4,535.24	**65.08**	**Available habitat**
	526.00	**7.55**	**Selective timber extraction (FMUs)**
	4,010.00	**57.50**	**Prime habitat**

Discussion: Habitat, Land Use, and Threats

The findings of the land use pressures and threats on the habitat of the golden langur are discussed and recommendations made for potential mitigation measures. Each threat ranging from agriculture and shifting cultivation to forest grazing, and timber harvesting is discussed. Emerging threats due to more recent developments such as hydropower projects and power transmission grid lines are discussed. The impacts of road construction are discussed in a later section.

Agriculture

Agricultural land, consisting of 646 km^2 , is the single largest land use category in golden langur range. This is about 14% of the total potential habitat for golden langurs. Of this about 80% of agricultural land is under permanent cultivation consisting of terraced paddy land for irrigated rice growing (*chhuzhing*), dryland (or *kamzhing*) un-terraced land for crops such as maize, buckwheat, and barley that are dependent on the monsoon rains and do not require irrigation. The remaining 20% of the agricultural land is used for shifting cultivation or *tseri*. Table 3.1 shows the details of land use and available habitat for golden langurs. Interestingly, comparing these data to the RNR census data of 2000 (MoA, 2000), only 392 km^2 of land is registered as agricultural and pastures. This discrepancy may be due to the Land Use Data being based on satellite image photo interpretation and the RNR census being a compilation of land records from the *Thram* (land ownership titles registered with the authorities). Dorji (1993) found a similar discrepancy with regards to alpine pastures that are visible on satellite images. The images showed 12% more alpine pastures than are recorded in the land registers. Recent cadastral surveys and land measurement by the government are in agreement with the satellite images and almost all land owners are finding that they own land in excess of what is registered in their *Thram*. Land owners are having to buy these excess land to reconcile the discrepancy between actual and registered lands.

Since langurs do not depredate the traditional crops grown by farmers, agricultural areas do not provide additional nutrition or "habitat" for the langurs. Likewise, the farmers do not hunt, trap or directly harm the langurs since they are not an agricultural pest. However, the great dependency of the people on the forests has an indirect impact on the langurs. Impacts range from collection of firewood, felling of trees for house building, collection of non-wood forest products, to grazing of cattle.

Tseri, Shifting Cultivation

Shifting cultivation land is shown to occupy about 135 km^2 of the area in golden langur habitat or 20% of the total agricultural land**.** This figure could be higher since the majority of people in the area are dependent on it for subsistence. Since fallow *tseri* land appears as forests on satellite images as the fallow period is normally 7 to 8 years and thick vegetation has regenerated in the fallow land by then, it is possible to account *tseri* land as forests. *Tseri* land is available for langurs during fallow periods. For instance in the village of Radi in Zhemgang three groups of langurs were sighted in shrubs and trees growing in fallow *tseri* land around the village.

The village of Radi is largely dependent on *tseri* and crude estimates show that about 2000 hectares of land is needed to sustain the 21 household village with a population of about 110 people. This is about 100 hectares per family. The Radi people say that agricultural productivity is much higher in *tseri* lands, as much as three times higher, than in permanent dryland *kamzhing* fields. This goes to show that *tseri* is a highly productive and viable agricultural system as long as populations are kept in balance. Large amounts of forest land are required to sustain a relatively small population. This fact is clearly noticed by the three villages of Shingkhar, Womling, and Thisa, largely dependent on terraced paddy fields and located on the opposite side of the river from Radi. People there commented that Radi cultivated land equal to or more than all of the three villages combined although the population of the three villages was almost 10 times more than in Radi. The household numbers and agricultural land data are from the RNR center located in Shingkhar village.

The officially registered *tseri* land for Radi village is only 29 hectares and shows the large disparity between *tseri* land registered by the people and actual on the ground usage (2000 hectares). Part of the reason is that the smaller the registered land size, the smaller the land tax. Also, people are not permitted to own more land than a fixed ceiling of 25 acres (10 hectares) as per the Land Act of Bhutan.

The dependency on *tseri* land even varies between neighboring villages and is not consistent in the golden langur habitat. For instance while Radi showed a high reliance on *tseri* for subsistence, its larger neighbors of Shingkhar, Womling, and Thisa with a total of 185 households cultivated about 186 hectares of paddy fields (about 1 hectare of terraced paddy fields per family) compared to Radi's 8 hectares. It is interesting to note that a hundred times more land is required to sustain a population on *tseri* compared to terraced paddy farming.

Shingkhar and Womling people said that they have reduced farming of their *tseri* lands since it had become difficult to guard crops against wild boar (*Sus scrofa*) since the mid 1980s. Boar populations in Bhutan experienced an explosion in the mid 1980s after wild dogs (*Cuon alpinus*), a major livestock predator, were almost eradicated in the early 1980s by poisoning by livestock owners. Recent studies show that the re-emergence of wild dogs is helping curb wild boar numbers and allowing farmers to reuse abandoned fields (Wangchuk, 2004). It is interesting to correlate higher human populations with more intensive agricultural farming practices such as terraced paddy fields and lower populations with extensive systems such as shifting cultivation.

However, the village of Langdurbi, south of Shingkhar and Radi is almost entirely dependent on *tseri* even though Langdurbi has a higher population than Shingkhar and Womling. The explanation provided by the people of Langdurbi was that irrigating rice fields would be a major problem since the "water was down in the ravine and land was up on the slopes." Indeed Langdurbi lands were situated on the slopes above the Bortay Gang river, a tributary of the Chamkhar river. But still there are several streams flowing down Thrimjang Peak, located well above Langdurbi into the Bortay Gang river. These could be tapped as irrigation water. However, massive amounts of labor would be required to build the terraces and convert *tseri* land to paddy fields. Even though Langdurbi people said they viewed their neighbors to the north who cultivated terraced rice fields as fortunate and blessed, there was no interest in actually emulating them. Rather, when on Dec 17, 2002 a live radio broadcast of the King's National Day speech recommended that *tseri* practioners should be given land elsewhere since they lived in abject poverty, Langdurbi people were ready to go to Thimphu to appeal such a recommendation. The true reason behind their dependence on *tseri* may be a socio-cultural and agro-ecological system that is fully evolved for *tseri* and ill equipped for paddy cultivation. Paddy cultivation would require not only huge initial investments of labor and resources but an annual workload that is at least 4 times as demanding as work on *tseri* land. Langdurbi people had a well managed system of communal farming of *tseri* lands. Four or five families pool their labor together and cultivate the land in certain parts of the forest. The land may belong to only one of the families. The following year they move onto another area and work on another group member's land. The labor contribution is equally divided and so is the harvest at the end of the season. Langdurbi *tseri* land covered huge tracts of forest, roughly about 300 km^2 with some *tseri* land situated all the way east near the border with Mongar district, 3 days walk from the village. Thus in Langdurbi, *tseri* is currently a viable agricultural practice due largely to the availability of huge tracts of forests. Should the situation change such as increase in population, then conversion towards more permanent systems is likely.

People of a neighboring village, Zelambi, envied the people of Langdurbi for the huge forest areas they had at their disposal to use for *tseri*. Zelambi people owned only *kamzhing* or permanent fields around the village which they had converted from *tseri* land a few years back. Continuous use without a fallow period naturally resulted in their lands turning into *kamzhing*. This was because Zelambi did not have much *tseri* or forests to start with. A huge amount of forests above the village belonged to a person in Bumthang district who brought his cattle down to graze in the winter. Zelambi people explained that they tried to build an irrigation canal to convert some of their land into terraced paddy fields, however, the porous nature of the soil in the area resulted in the water seeping away before reaching the fields. Zelambi people would have clearly preferred *tseri* since *kamzhing* land, if not fertilized generously with cow manure, crops do not grow at all. Labor investment in *kamzhing* lands is also intensive and crops require not only fertilizing but up to three weedings per season and constant guarding against wildlife. *Tseri* land on the other hand produced three times the amount in the first year of cultivation with labor only involving the initial burning and subsequent guarding of the fields from wildlife. *Tseri* lands are used for two or three years and then left fallow for 7 to 8 years.

This goes to show that *tseri* is a highly productive and viable agricultural system as long as populations are kept in balance. Large amounts of forest land are required to sustain a relatively small population. In general all over Bhutan, the ecological systems determine primarily what kind of farming is practiced. There is no one hundred percent *tseri* farmer or rice farmer in such a system. Rather it is a continuum, with even the largest rice farmer practising *tseri* or shifting cultivation for certain crops such as sorghum, maize, mustard, and most importantly for growing rice seedlings which are later transplanted into the *ari* or paddy fields. Likewise the most swidden of farmers still maintain permanent fields of maize and wheat around their homes, and if there is relatively flat land available, terraced rice fields. Bhutan being a completely mountainous country, any bottom land is coveted and if the altitude permits, made into terraced rice fields. In west Bhutan's broader river valleys, most floodplains are made into terraced rice fields or *chhushing* (which literally means water-field). The farmer will also in many cases own *kamshing* or dry fields that are permanent plots on steep hillsides used for wheat or crops other than rice. In many cases the farmer will also own *tseri* or literally "burnt forest field". With the country opening up to the outside world and to economic development in 1960, the political economy of the country has changed especially in terms of adopting prevailing global discourses on environmental conservation. This has lead to calls from international conservation organizations for "phasing out tseri." At the policy level, the Forest and Nature Conservation Act of Bhutan, again with heavy input from western environmental lawyers, calls for the phasing out of *tseri*. This is clearly a concern for tseri farmers since they believe that if this policy is enforced then they will not have much to eat. At another level, development has produced a large disparity in standards of living between urban towns and rural villages. The spread of primary education to the remotest corners has exposed villagers to the possibility of "modern" lifestyles, improved healthcare and education. This has resulted in rural to urban migration with fewer people left to farm the land. Added to this is the sudden population explosion of wild boars (*Sus scrofa*) within the last two decades to which farmers all over Bhutan lose significant amounts of their crops. A recent survey showed that swidden farmers lost more than 70% of their produce since the type of edge habitat in the forest is preferred by wild pigs (Choden and Namgyal, 1996). The compounded effect of inadequate farm labor and the boar epidemic has resulted in partial swiddners abandoning their *tseri* lands and concentrating on guarding their permanent fields from boars, such as in the villages of Shingkhar and Womling.

In east Bhutan in capped langur habitat where the human population is much higher than in the golden langur area in central Bhutan, *tseri* cultivation is practiced beyond a threshold permitted by geophysical conditions such as slope angle, soil depth, rainfall intensity and agronomic practices such as frequency and methods of cultivation and types of crops grown. Erosion and landslides are common in some places while other villages face fuelwood and water shortage. With increasing population and subsequent fragmentation of land holding the farmers have no option but to reduce the fallow period in order to produce more from the same plot of land and to cultivate steep areas.

A compounding effect is a government policy whereby *tseri* land legally reverts as Government reserve forest if no cultivation is carried out for more than 12 years. To strengthen tenurial security, this policy needs to be reviewed. For instance, during a survey in 2002 some *tseri* land which had remained fallow for more than 11 years was being cleared in the village of Digala even though the owners were only did not have any intention of doing so simply to avoid losing their land. The policy then encourages people to cut down forests on their land. A recent social forestry rule allows owners to register such forested *tseri* land as private forests. However, in Digala people were unaware of the rule.

Several recommendations can be made regarding management of tseri lands. *Tseri* or slash and burn agriculture is seen by many as a destructive practice to be stopped. However, as discussed above, the negative aspects of shifting cultivation manifest only when a certain threshold or carrying capacity is crossed in terms of human population. In golden langur range traditional *tseri* lands are viable habitats for golden langurs during fallow periods. This is a better situation than *tseri* land that is converted into permanent agricultural fields or to cash crop orchards. Also, traditional *tseri* practitioners are adept at using fire as a tool. A fire line is first cut around the plot of land to be cultivated. The first fire is started from the top of the plot and encouraged to move downhill. When this has reached about half way down the slope, another one is started from the bottom of the plot. Rarely do the fires burn out of control.

Rather than banning *tseri* outright, a more feasible management system is needed since firstly people are dependent on *tseri* for subsistence and even though the law banning *tseri* was enacted in 1995 (FNCA, 1995), there is little enforcement. However, another law whereby the government confiscates *tseri* land left fallow for more than 12 years (FNCA, 1995), is strictly enforced and needs serious review. People are forced to clear their *tseri* forests before this deadline is reached even when they do not intend to or need to do so. Consequently many forests that could revert to full growth are rarely allowed to do so due to this law. A more sensible option is to provide security of tenure by not confiscating the land left fallow for more than 12 years. Recent moves to encourage private forests are a better option. This new rule allows land owners to register their fallow *tseri* land as private forests and owners have the right to use forest products from such registered lands (FNCR, 2003). Registering the land and demarcating the private forests will also provide better information for the Department of Forests and prevent illegal encroachment into government reserve forests. At the moment, as pointed out earlier, in extreme cases the land registered in the land records is about 60 times smaller than what is actually cultivated. Proper demarcation and accurate measurements and records will thus prevent encroachment into government forests and restrict people to the10 ha land ceiling. New areas opened up to *tseri* can be detected and prevented if better information is available through such demarcation practices. Combined with the demarcation and conversion, some of the tseri within the 10 ha ceiling can be converted to permanent terraced paddy fields. As noted earlier, even though paddy fields require more labor they can support up to 100 times more people per unit area. As populations increase, conversion to permanent agriculture seems to be a natural progression. Conversion to dryland un-terraced farming is not beneficial either to the farmers or to the environment. Such denuded areas on steep slopes are quickly eroded. However, lack of irrigation facilities leads to dryland farming. Government assistance with irrigation canals and conversion to terraced farming will benefit farmers as well as prevent erosion.

Forest Grazing

Warm broad-leaf and subtropical forests in golden langur habitat are grazed either by migratory cattle from Bumthang district or resident cattle in Zhemgang, Trongsa, Sarpang, and Tsirang. Roder (2003) estimates that about 59% of livestock fodder needs in Bhutan are met from free range grazing inside forests. These forests are legally classified into government reserved forests, forest registered as grazing *tsamdro*, and fallow shifting cultivation forests. For our purposes, all three are potential golden langur habitat and treated as such. Table 3.3 shows that about 96,000 head of livestock including cattle, horse, sheep, goats, and buffalo are present in these districts (MoA, 2000). The amount of fodder required from forests in terms of livestock units (LU) is also shown in Table 3.3. Dorji's (1993a) livestock unit conversion factor (LUCF) was used to convert the livestock population into LUs. This results in a total of 60,458 livestock units grazing in golden langur habitat. Each LU requires about 1.1 metric tons (MT) of fodder a year (Dorji, 1993a). About 40% of this is met from crop residues and fodder trees planted by the farmers around their fields. The rest comes from forests. This amounts to 66,504 metric tons of vegetation eaten from golden langur habitat every year. While livestock browse on edible shrubs and graze on grasses and forbs growing in the understory, broad-leaf trees are lopped by herders and leafy branches fed to the animals.

Table 3.3 Grazing Pressure in Golden Langur Habitat

	% Adult	% Young	Total Pop.	Adult Pop.	Young Pop.	LUCF Adult	LUCF Young	Livestock Units (LU)
Cattle	60	40	75607	45364.2	30242.8	1	0.35	55949.18
Equines	70	30	4339	2603.4	1735.6	1	0.35	3210.86
Sheep/Goats	50	50	16227	9736.2	6490.8	0.1	0.05	1298.16
							Total LU	**60,458.2**
							Fodder /LU	1.1 MT/year
							Total Fodder	**66504 MT/year**
							% Forest Fodder	59%
							Total fodder from forest	**39,237 MT/year**
							km^2/LU	0.0324 km^2/LU
							Total area required	**1,957 km^2**

In terms of area requirements to sustain the livestock population, Dorji (1993a) estimates that each LU requires about 0.0324 km^2 of forest. This amounts to 1,957 km^2 of forests that are required to sustain the livestock population. This represents about 52% of the total of 3,745 km^2 of habitat available to golden langurs, including the FMU forests where cattle are permitted to graze. However, grazing is dispersed over the entire distribution range of langurs and not concentrated in particular localities. So it cannot be assumed that half the forest is unavailable to langurs. Often one notices cattle grazing in the understory while langurs are feeding in the canopy. However, although there is clear resource partitioning between the arboreal langurs and livestock, indirect impacts such as effect on forest regeneration and altered species composition due to grazing (Norbu, 2002; Roder 2002; Miller, 1986; Sangay, 1997) have a direct impact on the langurs. Norbu (2002) observed that because of grazing pressure, 74% of all seedlings regenerating in a grazed area in warm broadleaf forests were pioneer species, of which *Symplocos* spp. dominated the seedling pool. Seedlings of primary and secondary species are low in numbers since they are "highly palatable to the grazing animals, making them susceptible to the wandering cattle" (Norbu, 2002). Also, Roder (1997) found that grazing by cattle in mixed conifer and broadleaf forests reduced the number and density of broadleaf species by about 12 % while at the same time conifers increased by about 14 %. The long-term impacts of such altered species composition and reduced regeneration have not been studied for broad leaf forests in Bhutan. One can only assume that given the available data, grazing reduces the carrying capacity of available habitat for the golden langurs.

Roder (2002) also estimates that nationwide, about 400,000 livestock transfer nutrients annually in the range of 2000 metric tons of single super phosphate fertilizer from the forest to agricultural fields in the form of manure. In golden langur habitat, the livestock population, about one fourth of the national total, thereby would transfer about 500 tons of phosphate by way of grazing in the forest during the day and returning to villages and agricultural fields to be tethered during the night. The large number of livestock in golden langur habitat clearly has an impact both on the forest and on the farming system.

Dorji (1993b) estimates that there was a 31% increase in the population of cattle between 1973 to 1990 due largely to the introduction of animal health care. Cattle numbers increased from about 150,000 to 400,000 by 1990. In 2000 the population remained at levels from 1990, close to 400,000 (MOA, 2000). This seems to indicate that cattle numbers have reached their carrying capacity perhaps due to both density dependent and density independent factors.

Modern veterinary care was started with the advent of planned development in 1961 in the country. It is interesting to note that there occurred a drastic increase in total cattle population during the period from 1973 – 1987, after the introduction of animal health care. Prior to introduction of animal health care, diseases such as rinderpest, anthrax, hemorrhagic septicemia, and gid took a high toll on livestock numbers and perhaps maintained the population at sustainable levels.

About 50% of the cattle in golden langur habitat are migratory and graze during the winter months from September through May (Ura, 2002). The cattle owners live in Bumthang, an alpine district to the north with cold winters. The local breed of cattle, Siri (*thrabam*) and *jatsham* (a cross of the wild cattle *Bos frontalis* or Mithun and Siri) need to migrate to warm broadleaf and subtropical forests in the winter. They spend only four months, June-August, in their summer pastures in Bumthang. A majority of the *tsamdro* or forest grazing pastures in golden langur habitat is owned by people in Bumthang. This creates much resentment from the resident peoples in Zhemgang and Trongsa, districts in the lower altitudes where golden langurs live. Local people are made to pay a fine, usually grain compensation, should their cattle wander into Bumtap-owned forest pastures. Also, when the cattle from Bumthang arrive in Zhemgang in September, crops have not been harvested yet and there is little local people can do when the migratory cattle move into the fields and eat the valuable crops. There has always been a colonial attitude from the Bumthang people towards the people of Zhemgang, or *Khenpa* as they are called. Bumthang was the cultural and political centre of Bhutan where Buddhism was first established in Bhutan. The capital of Bhutan was maintained in Bumthang until the reign of the third king in 1952. The Khengpa's are simple people living off the land, subsisting largely on shifting cultivation and lacking in the high culture and political clout of Bumthang. Ura (2002) writes:

> "a rangeland has to be first claimed from nature by certain means and made fit for grazing. In the traditional lexicon, this process is known as 'creation of rangelands' (*gbrog gsar drup)* involving input of human labour. The creation of this resource by investing human labour is expressed in the phrase 'created by welding knife on the shoulders' (*'gri gnya wa lu 'bag ti drup drup yin'*).Grazing land is carved out of wilderness or forest which is not occupied."

The Bumthang people thus created many such rangelands in the land of the Khengpa people.

The Draft Pasture Policy (1985) aimed to reduce migratory grazing by promoting improved breeds of cattle that do not need to migrate, pasture development in Bumthang and other temperate areas, and by attempting to redistribute pasturelands more equitably. Improved breeds such as jersey and brown swiss and fodder species cultivation have met with some success, however redistribution of pasturelands has not been implemented. The pastureland owners are powerful people who long ago migrated to Thimphu, the present capital, and hold high government posts or others influential positions. The Draft Pasture Policy (1985) has remained just that, a draft. However, it has become a convenient straw man for Bumthang government officials and intellectuals to bash every now and then.

Timber Harvesting

Another large impact use is that of Forest Management Units or timber harvesting areas. Table 3.4 shows that in golden langur habitat about 483 km^2 of forest is under FMU management. This is about 10% of the total potential golden langur habitat. About 20% of the FMUs are in Chir pine forests but the rest are in warm broad leaf forests. Thus about 386 km^2 or 11% of prime broad leaf forest habitat is under FMU management. The FMUs of interest are Wangdigang FMU (97 km^2), Mangdechu FMU (121 km^2), Chapley Khola FMU (109 km^2), Chendebji FMU (7 km^2), Dara Chu FMU (33 km^2), Khosela FMU (104 km^2), and Rongang Chu FMU (15 km^2). For instance the Wangdigang FMU in Zhemgang district in golden langur habitat is largely "warm and cool broadleaved forests and evergreen oak forests…There are about 50 different tree species, *Quercus* spp., *Persea* spp., *Castanopsis* spp. and *Echinocarpus* spp. have the biggest volume and *Symplocos* spp. is the most numerous." (Rinchen and Maatta, 1993). The harvesting system used in this particular FMU was "clear felling with artificial regeneration using local species."

Wangchen (1998), who prepared the Chapley Khola FMU Working Scheme notes "it has always been difficult to get satisfactory natural regeneration in a broadleaf forest so far. Various silvicultural systems like single tree selection, strip clear felling, block clear felling etc. were tried in the past in different temperate broadleaf forests in Bhutan without success in inducing natural regeneration." Wangchen also notes that in recent years demand for timber "has gone up manifold due to launching of more development projects."

Recent work on impacts of logging in oak forests report that the growing stock of oak forest in FMUs that supply oak firewood to urban areas has declined by 10% annually. Also, the rate of natural regeneration is 48 % lower in FMUs relative to oak forests where there is no extraction (SFD, 2003). As a result the Department of Forestry issued a notification (No. SFD/ADM/6-1/543, dated 2 August, 2003) banning the use of oak firewood in urban areas (Kuensel August 2, 2003, Vol. 18 No. 30).

Nationwide, the total area of FMUs amount to 3,161 km^2 or 12 % of Bhutan's forests (Table 3.4). Of this, 2,384 km^2 representing 75% of FMUs are located in mixed broadleaf forests while only 777 km^2 or 25% is in the conifer zone although half of Bhutan's forests are coniferous. Yet the Forestry Development Corporation ironically faces great difficulty in selling the hardwood timber from broadleaf forests once they are harvested (DFS, 2002). The main reason is the low demand for hardwood in the country and higher preference for coniferous species by the construction industry. Coniferous timber has a proven track record of not warping, shrinking, or cracking while hardwoods have not been used extensively in the construction industry and there is little information available to architects and engineers who were initially mostly from India, brought in for government mega projects such as dam construction. This is all the more ironic since local people in the villages know exactly which hardwood species perform well for flooring, roofing, beams, pillars and so on from hundreds of years of experience utilizing the hardwood timber. As a result there is a shortage of conifer timber and a glut of broadleaf timber on the market. And even though the government banned the export of timber from Bhutan in 1999, 70% of hardwoods are disposed of in the Indian market, sometimes sold at much lower than the reserve price. In some cases the hardwood timber is left to rot in the timber depots for want of buyers. Despite this low demand, the production (logging) of hardwoods in broadleaf forests continues at unprecedented levels simply to meet the production targets prescribed in the management plans for the FMUs.

A recent study (Pradhan et al., 2004) showed broadleaf forests, in a random sample, have 55 species of trees, compared to 20 in mixed conifers, and 1 in pine forests. Likewise, broadleaf forests in a random sample had 255 species of shrubs while mixed conifers had 39 shrub species and pine forests only one. Biodiversity is much higher in broadleaf forests than in conifer forests, which often are monocultures of blue pine, fir, or chir pine. Coupled with poor regeneration, the removal of preferred tree species for langurs such as *Castanopsis indica*, *Persea* spp., *Michelia* spp., by harvesting creates areas that have little or no value as golden langur habitat. Clearly then, the policy of operating 75% of FMUs in broadleaf forests needs to be reviewed given that there is no market and that broadleaf forests have high biodiversity value. Meeting timber needs from coniferous forests and limiting FMUs in broadleaf forests is a desired alternative. Conifer FMUs could be managed as tree farms by investing in thinning, and other silvicultural practices. Presently, FMU expenses involve only extraction costs and little is invested in managing the forests. An argument often made against banning FMUs in broadleaf zones is that local timber needs of people living in broadleaf zones should be met locally. This is an understandable situation and only limited FMUs should be operated to meet local demand. However, export-oriented FMUs in broadleaf zones should be banned. Another alternative would be to subsidize transportation of timber from conifer zone to broadleaf zone for local needs in this zone and ban FMUs in broadleaf zones completely.

Also, despite a policy of maintaining 60% forest cover at all times for the country, of the declared 72% forest cover, 8% is degraded scrub forest (BAP, 2001), leaving only 64 % as true forest cover. Since 12% is being harvested as FMUs, only 52% forest cover will be maintained, thereby breaking the 60% forest cover policy.

FMUs in recent years however, have moved away from clear felling to selective logging with provisions for endangered species such as golden langurs, but no monitoring reports are available so far.

Table 3.4: Forest Management Units (FMU) or timber harvesting areas in Bhutan (Source: Forestry Resources Development Division, FRDD, 2003)

	FMU	Dzongkhag (District)	Code*	Area (km^2)	Impacts
1	Bhangtar	Samdrup Jonkha	1	120.23	Capped Habitat
2	Chamang	Mongar	1	7.00	Capped Habitat
3	Chamgang-Helela	Thimphu	1	0.01	Conifer
4	Chamgang-Helela	Thimphu	9	46.83	Conifer
5	Chaple khola	Sarpang	1	109.10	Golden Habitat
6	Chendebji	Trongsa,Wangdue	1	6.58	Golden Habitat
7	Chendebji	Trongsa,Wangdue	9	90.56	Mixed Broadleaf
8	Chhangaphug	Thimphu	1	4.47	Conifer
9	Chhangaphug	Thimphu	9	77.06	Conifer
10	Daifam	Samdrup Jonkha	1	97.46	Capped Habitat
11	Dara chu	Tsirang	1	32.79	Golden Habitat
12	Dawakha	Punakha	1	5.89	Mixed Broadleaf
13	Dawathang	Bumthang	9	175.36	Mixed Broadleaf
14	Dongdi	Trashi Yangtse	1	8.82	Capped Habitat
15	Dongdi	Trashi Yangtse	9	39.75	Mixed Broadleaf
16	Dungna	Chhukha	1	7.60	Mixed Broadleaf
17	Dungna	Chhukha	9	0.64	Mixed Broadleaf
18	Gidakom	Thimphu	1	3.22	Conifer
19	Gidakom	Thimphu	9	106.28	Conifer
20	Gyelposhing	Mongar	1	2.22	Capped Habitat
21	Gyetsa	Bumthang	9	164.96	Conifer
22	Haa-East	Paro, Ha	1	0.01	Conifer
23	Haa-East	Paro, Ha	9	71.11	Conifer
24	Haa-West	Ha, Chhukha, Paro	1	0.56	Conifer
25	Haa-West	Ha, Chhukha, Paro	9	94.57	Conifer
26	Jilegang	Punakha	1	10.40	Mixed Broadleaf
27	Kamichu	Wangdue	1	85.65	Mixed Broadleaf
28	Kamichu	Wangdue	9	1.20	Mixed Broadleaf
29	Karshong	Bumthang	9	47.14	Conifer
30	Khaling-Kharungla	Trashigang	1	55.51	Capped Habitat
31	Khaling-Kharungla	Trashigang	9	45.27	Mixed Broadleaf
32	Khosela	Trongsa	1	104.84	Golden Habitat
33	Khosela	Trongsa	9	128.39	Mixed Broadleaf
34	Khotokha	Wangdue	1	0.41	Mixed Broadleaf
35	Khotokha	Wangdue	9	93.39	Mixed Broadleaf
36	Korila	Mongar	1	128.55	Capped Habitat
37	Korila	Mongar	9	9.85	Mixed Broadleaf
38	Lingmethang	Mongar	1	95.73	Capped Habitat
39	Lingmethang	Mongar	9	10.06	Mixed Broadleaf

	Table 3.4 Continued				
	FMU	Dzongkhag (District)	Code	Area (sq km)	Impacts
40	Mangdechu	Trongsa, Zhemgang	1	121.88	Golden Habitat
41	Menchuna	Thimphu	1	9.31	Mixed Broadleaf
42	Menchuna	Thimphu	9	6.87	Mixed Broadleaf
43	Metapchu	Chhukha	1	72.95	Mixed Broadleaf
44	Metapchu	Chhukha	9	32.50	Mixed Broadleaf
45	Nahi	Wangdue	1	34.20	Mixed Broadleaf
46	Nahi	Wangdue	9	41.79	Mixed Broadleaf
47	Nangladang	Samtse	1	120.77	Mixed Broadleaf
48	Nangladang	Samtse	9	12.41	Mixed Broadleaf
49	Paro-Zonglela	Paro	1	23.78	Conifer
50	Paro-Zonglela	Paro	9	137.74	Conifer
51	Rimchu	Punakha	1	20.17	Mixed Broadleaf
52	Rimchu	Punakha	9	24.43	Mixed Broadleaf
53	Rongangchu	Sarpang	1	14.97	Golden Habitat
54	Shengana	Punakha	1	36.86	Mixed Broadleaf
55	Shengana	Punakha	9	31.75	Mixed Broadleaf
56	Tsangpochen	Trashi Yangtse	1	10.94	Capped Habitat
57	Tsangpochen	Trashi Yangtse	9	30.47	Mixed Broadleaf
58	Tseza	Dagana	1	56.97	Mixed Broadleaf
59	Tseza	Dagana	9	138.34	Mixed Broadleaf
60	Wangdigang	Trongsa, Zhemgang	1	55.69	Golden Habitat
61	Wangdigang	Trongsa, Zhemgang	1	37.65	Golden Habitat
	* 1 = Below 2400m	**Total FMU area**		**3161.93**	
	9 = Above 2400m				
		FMU area in Golden Langur Habitat		**483 km^2**	
		FMU area in Capped Langur Habitat **FMU in Conifer Zone** **FMU in Mixed Broadleaf Zone**		**527 km^2** **777 km2 (25%)** **2,384 km2 (75%)**	

Results of Species composition and Forage Surveys

Surveys in the broad leaf zone showed that species on the north facing slopes consist mainly of *Schima wallichii, Nyssa javanica, Albezia lebbek, A. procera, Lithocarpus sp. Castanopsis, Callicarpa arborea, Macaranga peltaformis, Erythrina* sp. *Engelhardia spicata, Daphnephyllum* sp., *Todadalia* sp., *Alnus nepalensis, Entada gigantium, Duabanga grandiflora, Persia* sp. *Frond* sp. *Raphidophora* sp., *Cycas spinolosa, Hedychium* sp., *Pterospermum* sp., *Sterculia* sp. and other species that are classified as warm broad-leaf mixed forest by Grierson and Long (1983). As already mentioned, south-facing slopes were mainly Chir Pine (*Pinus roxburghii*) and occur in pockets in the surveyed areas. Table 3.5 shows the species composition of the different layers of vegetation present in golden langur habitat. Langur sightings were most frequent in the canopy: 58% of groups encountered were seen in the crowns of large tall trees either feeding or resting. Another 22% were seen in the middle story; the understory and shrubs were equally utilized. Except at mineral salt licks where langurs were seen eating the soil, they were rarely observed on the ground. When alarmed, langurs always fled up to the safety of tall trees. It may be noted that preferred logging tree species in FMUs are the tallest trees yielding the highest volume of timber.

In contrast, *Macaca assamensis*, the Assamese Macaque, were mostly seen in the understory, shrubs, or on the ground (78%), and the rest of the time (22%) were seen in the top canopy largely feeding on fruiting trees. When alarmed they almost always fled out of trees to the ground and sought cover in thickets and undergrowth.

Table 3.5 Species composition by canopy layer.

Top canopy	Middle storey	Under storey	Shrubs	Climbers	Herbs
Lithocarpus elegans	*Bauhinia* sp.	*Murraya exotica*	*Murraya koenigii*	*Cissampelos pareira*	*Campalandra* sp.
Castonopsis indica	*Ficus semicordata*	*Antidesma* sp.	*Holmskoida sanguinea*	*Thunbergia* sp	*Elatostema* sp.
Duabanga sp.	*Macaranga* sp.	*Putrangiva* sp.	*Laportia* sp.	*Rubia cordifolia*	*Balsam* sp.
Engelhardia spicata	*Ailanthus grandiflora*	*Gmelina* sp.	*Adhatoda vasica*	*Calamus* sp.	*Pilea* sp.
Mangifera sp.	*Brassiopsis* sp.	*Debregeasia* sp.	*Advacata diverica*	*Smilax* sp.	*Comilina* sp.
Albezia sp.	*Vitex* sp.		*Piper* sp.	*Piper* sp.	Orchid sp.
	Morus laevigata				Grass sp.

Table 3.6 shows the species that were foraged on by golden langurs. It might be noted that the most frequently eaten plant parts were leaves of large trees. When fruits were available langurs and macaques were seen feeding together in the same tree but on different sections of the tree, each species staying within their own groups.

Table 3.6 Forage species

Species	Habit	Local Name	Parts eaten
Albezia procera	Tree	Sershing	Leaf
Cordia myxa	Tree	-	Leaf
Dendrocalamus sp.	Bamboo	Baa=Dz, Soshing=sha	New shoots
Lithocarpus sp.	Tree	Shakorshing=sha	Young acorn
Morus laevigata	Tree	Tshende=dz, Sengdeng =sha.,Sengleng=Khen	Leaf
Castonopsis sp.	Tree	Sokeyshing=dz,sha	Leaf
Mangifera sp.	Tree	Amshing=sha, Am=dz	Leaf / fruit
Cissampelos pareira	Climber	Jingroo=sha	Leaf
Callicarpa arborea	Tree	Thulshing=sha, khalemashing=khen	Leaf
Thunbergia sp.	Climber	-	Leaf
Ficus semicordata	Tree	Yangru-chokmu=sha	Leaf
Ehretia laevis	Tree	-	Leaf
Holmskoidia sanguinae	Shrub	-	Leaf
Grewia oppositefolia	Tree	Ratsushing=sha	Leaf
Quercus glauca	Tree	Thom=dz, thongpushing=sha	Acorn
Vitex sp.	Tree	Gushing-zemu=sha	Young leaf /shoot
Sterculia sp.	Tree	-	Pod

Language Key:
Dz: Dzongkha, Khen: Khenkha, Sha: Sharchopkha

Trees are of particular importance for the golden langur since it is a specialist leaf eater with a sacculated stomach and a special genetic adaptation - a duplicated gene region coding for RNASE1B enzymes, effective in acidic stomach environments (Davies and Oates, 1994; Zhang et al. 2002). Golden langurs for this reason do not prey on agricultural crops such as maize, rice, and wheat simply because they cannot digest them. However, recent reports from Zurphay in Zhemgang tell of golden langurs entering orange orchards and preying on the oranges. Oranges were introduced as a cash crop within the last 30 years in the region and presents a new challenge for the langurs.

Population estimates of golden langurs: Census 1994 and 2003

A census of Golden Langurs , locally called Raksha, was conducted in the Mangde Chu Valley in November 1994. Till then, in Bhutan, despite several evaluations of biodiversity and conservation efforts, estimates of population status were not available. For sound conservation policy and activities, estimates of the population size of this endangered species are needed. In November 2003, the same census was repeated along the same transect using the same methods to evaluate trends.

Census Methods

The census was conducted in the Mangde Chu Valley in Central Bhutan in the districts of Trongsa and Zhemgang during the month of November, 1994 and 2003. Ten 4 km census transects were selected nonrandomly based on the existence of ancient trails in the sample area. However, the selection of the sample area where the transects were located was random. This was done by a lottery whereby ID numbers of all the topographic sheets (1:50,000) of the estimated distribution range were put into a basket and randomly drawn. The first ID number selected was used as the sample area (sheet no. 78 I/11). However, selection of the transects within this area was done systematically. This does introduce a certain amount of bias (NRC, 1981) but was the only feasible alternative. For instance, when transects were selected on a random basis using compass coordinates, some fell on sheer cliff faces where as others bisected the Mangde river in areas where there are no bridges. More than 60% of the random transects fell in such infeasible terrain. The other 40% roughly coincided with the footpaths that stretched from Surgang to Tingtibi (Figure: scan topo sheet 78 1/11).

The use of trails as transects on the other hand proved feasible since firstly, the trails, being small footpaths used only occasionally by villagers, did not destroy the surrounding vegetation. There was continuous canopy cover on both sides of the footpath and edge effects were avoided. Only in chir pine forests was the canopy open along the footpaths. Secondly, the topography of the Mangde Chu area is such that the footpaths traversed most of the heterogenous habitats in the valley. The only one not included was the high altitude alpine forests above 2500 m. Since the highest altitude at which Golden Langurs were recorded during our surveys was 2,200 m near the Trongsa Dzong, the alpine forests can be safely ignored.

The line transect sampling followed the method adopted by Sugiyama, who successfully used line transect to survey Hanuman Langurs (*Semnopithecus entellus*) in India (Sugiyama, 1964; 1965; Sugiyama and Parthasarthy, 1979). The line transect had the advantage of covering the heterogenous habitat of the study area. The census line transect began at Surgang in Trongsa district on the other side of the Mangde river from the vehicle road. The transects covered a distance of 39 km in length and ended in Tingtibi in Zhemgang.

The maximum perpendicular distance from the transects to a Golden Langur troop was used to estimate transect width. Thus all troops sighted along the transects were within this distance. This distance was doubled in order to cover both sides of the transects. To calculate the censused area, the total length of the transect was multiplied by the doubled maximum perpendicular distance. Transect walks were done from 7 am to 5 pm every day and the approximate walking pace was about 1 km per hour. Frequent stops were made during which the surrounding area was scanned for Golden Langurs. Whenever a troop was sighted, about 20 minutes was spent counting the number of individuals in the troop, estimating the perpendicular animal-to-transect distance and animal-to-observer distance, sexing the individuals, recording their initial activity, the sighting time, and weather conditions. Comments on behavior and habitat were also recorded. The census was conducted over a period of seven days, the time taken to walk the transect at the pace mentioned above.

The basic formula used for estimating the density of Golden Langurs was (adapted from NRC, 1981):

$$N/A = n/a$$

Where N is the estimated population of Golden Langurs, A is the total distribution range of Golden langurs, n is the number of animals seen in the sample area, and a is the sample area.

The equation above can be rewritten as:

$$N = nA / 2 (lw)$$

where N is the estimated Golden Langur population, n is the number of Golden Langurs seen in the sample area, A is the census area, l is the length of the transect line, and w is the strip width variable. The sample area a = 2 (lw) in order to cover both sides of the line transect.

The habitat was described on a qualitative basis, taking care to note dominant vegetation types along the transects and key plant species used for foraging and roosting.

In November 1994 a troop of 15 individuals at Surgang was followed for four days to observe behavior, home range size, interaction with other troops, and interaction with Assamese Macaques (*Macaca assamensis*). Attention was also paid to activity and movement cycles to evaluate activity budgets. Both focal animal and scan sampling (Altmann, 1974) were used to make the above observations. The troop was also tracked for an entire 24 hour day.

Field surveys were made to verify Golden Langur distribution in the following districts: Trongsa and Zhemgang in November 1994, Pemagathsel and Trashigang in January 1995, Punakha and Wangdue Phodrang in March 1995, Tsirang, Sarpang, and Dagana districts in April 1995 and the Chamkhar river basin in December 2002. Methods included trekking along natural dispersal barriers such as the Puna Tsang Chu/Sankosh and Drangme Chu/Manas rivers and questioning villagers on the presence or absence of langurs. Actual langur sightings were recorded and mapped.

Results

In November 1994 a total of 127 individuals in 19 troops were sighted along the 39 km transect. Using the maximum perpendicular distance as transect width, an area of 58.5 km^2 was covered as the sampling area a:

$$a = 39 \text{ km} \times 2(0.75 \text{ km}) = 58.5 \text{ km}^2$$

This resulted in an estimated density of 2.1 Golden Langurs per km^2 in the sample area:

$$\text{Density} = 127 \text{ golden langurs} / 58.5 \text{ km}^2 = 2.1 \text{ Golden langurs/km}^2$$

Using this figure and the distribution of *T. geei,* the total population in Bhutan can be extrapolated. For instance, Golden Langurs were never observed above 2,300 m and they did not use chir pine (*Pinus roxburghii*) forests. Chir pine forests grew on south-facing slopes whereas broadleave forests ideal for *T. geei* habitat grew on north-facing slopes in the Mangde area. Our distribution surveys show that Golden Langurs do not occur west of the Sankosh river and east of the Chamkhar / Mangde / Manas river system. Thus all pristine broadleave forests below 2,300 m and falling between the two river systems should hypothetically be able to support Golden Langurs. This area was roughly estimated at about 2,000 km^2 in 1994. Calculations using the basic formula given above estimates 4,341 Golden Langurs in Bhutan:

N = 127 golden langurs * 2,000 km2 / 58.5 km2 = 4,341 golden langurs

During the November 2003 census 130 individuals in 18 troops were sighted along the 39 km transect. Using the maximum perpendicular distance as transect width, an area of 60.5 km^2 was covered as the sampling area a:

$$a = 39 \text{ km} \times 2(0.77 \text{ km}) = 60.5 \text{ km}^2$$

This resulted in an estimated density of 2.14 Golden Langurs per km^2 in the sample area:

$$\text{Density} = 130 \text{ golden langurs} / 60.5 \text{ km}^2 = 2.14 \text{ Golden langurs/km}^2$$

By November 2003, all areas of golden langur distribution had been visited and surveyed. As such better estimates of the total size of the range were possible as discussed above in the habitat section. Currently, it is estimated that an area of 3,089 km^2 can be classified as prime golden langur habitat after the complete and exhaustive (and exhausting) surveys. Due to this revised area the population estimates of golden langurs in Bhutan after the November 2003 surveys is estimated at:

$$N = 130 \text{ golden langurs} * 3{,}089 \text{ km}^2 / 60.5 \text{ km}^2 = 6{,}637 \text{ golden langurs}$$

This is a substantial increase and is due solely to more accurate estimates of the distribution range of golden langurs.

The habitat in the census area consisted of alternating warm broadleaved and chir pine forests. The warm broadleaved forest is "essentially a type of subtropical forest" that occurs between 1,000 m to 2,300 m (Grierson and Long, 1983). The forest type was dominated by evergreen and deciduous broadleaved tree species. Some of the species commonly used by langurs to forage and rest in were *Engelhardia* spp, *Altingia excelsa*, *Schima wallichii*, *Castanopsis* spp., *Quercus* spp., Dichroa febrifuga, Ostodes spp., and a variety of tree and shrub species belonging to the Fabaceae.

Langurs preferred to forage in deciduous trees that were budding. Such trees mostly grew in more open areas that received more light. They were also seen foraging in leguminous shrubs. Contrary to reports of Golden Langurs being entirely arboreal (Ghosh and Biswas, 1974), langurs were sometimes seen on the ground. For instance, several troops were seen eating mineral salt on exposed cliffs. Golden langurs urinated and defecated when they encountered potential danger and prepared to flee. The feces of langurs, depending on what plants they have been foraging on, can be wet or dry.

In 1994 the average troop size of Raksha in the study area was 7.1 individuals per troop with a standard deviation of 2.8. In 2003 the average group size was 7.2 with a standard deviation of 2.0. In 1994 an all-male troop of 5 males was seen in Becheling. They seemed to be sharing the same home range with a larger bisexual troop of 11 individuals led by an alpha male. Perhaps the all-male troop consisted of subadults driven out from the bisexual troop by the alpha male. Although earlier reports maintain that Golden Langurs are not territorial, observation of the Surgang troop revealed that the troop foraged within a range of 4 km^2 and avoided the troops at Becheling. However, the Surgang troop was sympatric with a troop of macaques. No hostile interactions were recorded between the two species.

The typical activity cycle of the Surgang troop can be broken down as follows: foraging and moving about from about 8 a.m. to 11 a.m, resting from about 11 a.m. to

2.30 p.m, foraging and moving from 2.30 p.m. to about 5 p.m, and roosting during the night. There was no particular tree used as a regular roosting tree. Tall trees that provided good cover were generally used. Sometimes the troop spent the night in the tree that they had been foraging on during the evening and resumed feeding on the leaves of the tree when they started activity in the morning. On cloudy days the troop was active even during the regular resting period.

The average distance between troops sighted along the transect was 1.1 km with a standard deviation of 0.96 km. Troop sightings were most frequent in the mornings followed by evenings. Troop sightings were lowest during the afternoon. For instance, of the 19 troops encountered in 1994, 10 were seen during the morning between 8 to 11 a.m., only 3 were encountered between 11 to 2.30 pm and 6 were seen in the evening between 2.30 to 5 p.m.

Discussion

The density of 2.1 individuals per km^2 in 1994 and 2.14 in 2003 suggests the existence of a healthy and stable population in Bhutan. The 2003 census with more accurate estimates of the distribution range of golden langurs revealed an estimated 6,637 golden langurs in Bhutan. However, the almost pristine quality of the habitat in the census area must be taken into account when using this figure for extrapolation. Such a high density of golden langurs may not occur in other areas since habitat, especially in the south, is highly degraded due to human population pressure. In the study area, the human population was small and the damage to forests from agricultural practices is limited.

Contrarily, troops were encountered less frequently on the other side of the Mangde Chu where the Trongsa- Zhemgang-Gelephu highway is located. Repeated censuses that cover the entire distribution range of Raksha, including disturbed areas, need to be conducted to get more accurate figures.

In Assam India (Srivastava et al. 2001) estimated a total of 1,064 golden langurs in 130 groups. They also recorded rapid habitat loss in Assam. More than 50% of golden langur habitat in Assam, India was lost between 1988 and 1998 (Srivastava et al., 2001). India's exploding human population of more than a billion people with a density of 770 people/km^2 is the main reason behind this loss. While habitat pressure is being felt in Bhutan too, it nowhere matches the gravity in India. Bhutan's small population size of 700,000 people and a density of 23 people /km^2 are low compared to India. Clearly then the forests of Bhutan will be the last bastion of golden langur habitat should populations in India be driven to extinction. Presently, about 86 % of the golden langur population survives inside Bhutan.

Habitat loss is steadily increasing in the census area too due to the construction of a logging road starting in Tingtibi. The road has advanced well within the Jigme Singye Wangchuck National Park. Even though the main species logged is chir pine, valuable habitat is destroyed by the unsustainable methods. Logs are cut and rolled down steep hillsides through broadleaved forests. This results in the loss of both vegetation and topsoil. Incidentally, no langur troops were sighted in the areas where logging was being conducted.

The troop size of golden langurs in Bhutan was estimated earlier to range from 2 to 12 individuals (Subba, 1989). Troop sizes in the census area fell within this range with a few that were larger. The Surgang troop of 15 individuals exhibited a behavior that perhaps can be explained by optimal foraging theory. The troop during the day broke up into two smaller groups of 7 and 8 individuals respectively. In one group, no infants or juveniles were seen whereas the other group had both and was lead by a male. However, in the evenings they roosted together in the same tree. The troop may have divided to access food resources better. Throughout the period that they were followed the troop, both the groups, stayed within a range of about 4 km^2 . They remained within earshot of each other and the separation distance varied between 100 m to 700 m. Also, they never encountered the Becheling troop about 2.5 km from Surgang. A natural boundary consisting of a steep cliff face seemed to act as the territorial boundary. The Becheling troop too never ventured near this boundary. In fact this troop had learned to cross the suspension bridge at Becheling to the other side of the Mangde river where they spent the morning foraging bout. More detailed studies may reveal the true nature of langur territoriality. Earlier studies report that Raksha are not territorial since their home ranges overlapped (Ghosh and Biswas, 1974). However, in *S. entellus*, Sugiyama (1965) confirmed aggressive interactions between troops in encounters at the borders of their home ranges.

Methods for measuring Impact of the Dakpai - Buli road construction

Census of langurs along the Dakpai-Buli road construction was done to monitor the impact of the road construction activities. The same methods used for the 1994 census were used in 2002 along the road construction alignment. Any langurs sighted from the road, using a pair of binoculars, were recorded. The perpendicular distance from the langurs to the road was measured and recorded.

Impacts on vegetation on either side of the road were done by selecting 28 transects (one per km of completed road construction at time of survey) perpendicular to the road and measuring the distance before vegetation conditions returned to normal. Normal in this case meant forest floors without soil and rock debris cut from the road formation and or thrown by blasts from explosives. Also, the density of trees (more than 10 cm dbh), after a certain distance from the road cutting, became consistently high or regular, increasing from zero at the midpoint of the formation cutting. This distance was also measured. Induced impacts in terms of timber removal, both legal and illegal, can only be estimated at this time. Also, other impacts such as clearing of land for cash crops and other development can only be estimated based on experiences elsewhere in golden langur range where roads have been built earlier.

Estimates of Population Viability along the Dakpai – Buli Road, Zhemgang

The Dakpai – Buli road traverses prime habitat of the golden langur. Alternating warm broad leaved and chir pine forests provide ideal habitat for golden langurs in the temperate north. Some of the species used by langurs to forage and rest in along the road construction site were *Engelhardia* spp., *Altingia excelsa*, *Schima wallichii*, *Dichroa febrifuga*, *Castanposis* spp, *Quercus* spp., *Ostodes* spp, and a variety of shrubs and trees belonging to the Fabaceae. All of these occur in healthy stands along the Dakpai – Buli road.

Summary of Golden Langur Population Status Before Road Construction

The 1994 census in Zhemgang in prime habitat in warm broad leaved forests similar to the Dakpai- Buli stretch provides the baseline status for golden langurs. This provides important baseline data for comparing populations before, during, and after road construction. For the first time a valuable monitoring opportunity to study effects of road construction on this endangered species is available.

As a reminder the results from the 1994 census are as follows:

A total of 127 individuals in 19 troops were sighted along the 39 km transect. Using the maximum perpendicular animal-to-transect distance as transect width, an area of 58.5 km2 was covered as the sampling area. This resulted in an estimated density of 2.1 golden langurs per km^2.

Status of Golden Langurs During Road Construction Phase

Despite two surveys along the Dakpai – Buli road, only 1 troop of golden langurs consisting of ten individuals was sighted along the entire 37 km stretch. This is a marked reduction compared to conditions before road construction activities. Even if a conservative estimate of area (37 km [L] * 0.5 km [B] = 18.5 km^2) is used, this results in density estimates of (10 golden langurs / 18.5 km^2 = 0.54 golden langurs per km^2. This represents about a 75% reduction in population estimates of the golden langur.

The reasons for the large decrease in relative density could be manifold but all can be associated with the road construction activities. The more benign and short-term effect could be that the noise from explosives and heavy machinery may have created a zone that langurs avoid. The erstwhile troops could have moved to other ranges away from the noise and possibly return after the cessation of construction activities. However, because golden langurs are highly territorial, movement into other troops' home ranges may have caused territorial disputes with resident troops. If so a troop takeover normally results in killing of the weaker alpha male and infanticide of all his progeny by the invading alpha (Hrdy, 1980).

A more negative and long-term effect could be that loss of habitat from the road construction activities may have reduced the carrying capacity of the area. Golden langur mortality due to direct and indirect effects such as increased diseases and competition for home range and forage may have permanently altered population dynamics.

In terms of direct clearing of forests, rock and soil debris were found on an average as far as 204 m from the midpoint of the road formation cutting on the downhill slope and none on the uphill slope. On steeper slopes the debris reached as far down as 540 m while on gentler slopes the debris reached between 20 to 30 m.

Average tree density in forests well away from the road (at least 4 km) and in relatively good condition were found to be 231 trees / ha. The distance from the midpoint of formation cutting before tree density reached normal was on average 488 m on the uphill side and 609 m on the downhill side. This results then in a swath roughly 1,097 m or 1.1 km wide that is affected along the road. This results in an impacted area of 1.1 km * 1 km = 1.1 km^2 per kilometer of road built. Trees on the downhill side were injured or killed by rock debris while on the uphill side many slid down the steep formation cutting. Also, on both sides, clearing of trees along the road alignment seemed to have the greatest thinning effect. For instance, on average, a distance of 20 m was kept cleared of any trees on the uphill side from the edge of the road.

Direct clearing impacts then can roughly be estimated at 1.1 km^2 of forest cleared per km of road built. On the Dakpai-Buli road since the total length is 37 km, roughly 40.7 km^2 of prime habitat has been lost.

Induced impacts can only be estimated at this time. As the area is opened up, logging areas are created for supply of timber to urban areas, sawmills, wood based industries, and other users. For instance from the Wangdigang area near Zhemgang town (about 15 km away from the Dakpai-Buli road construction site) 15 ha of hardwood forests were harvested for construction of the National Assembly building in Thimphu in 1988 and another 30 ha for veneer production at a factory in Gedu in 1984 (Rinchen and Maatta, 1993). The factory has since gone bankrupt and closed down. Illegal removal of trees can also play an important role since there are no forestry personnel or check gates posted at the road head in Dakpai where the road joins the Zhemang – Gelephu highway. Since the Dakpai – Buli road area does not fall inside a protected area, it is likely that future demand for timber will be met from the area. Other induced impacts, seen along the Zhemgang highway, can be conversion of forests into cash crop orchards, especially orange orchards. Also, fallow shifting cultivation land is converted into permanent settlements and agricultural lands along roadsides. The effects of such activities are gradual deterioration of habitat over the years and reduced langur density.

In golden langur habitat about 850 km of roads have been built so far. Using the estimates from the Dakpai – Buli road construction activities, this amounts to roughly 1000 km^2 of forests cleared to build the roads in Zhemgang, Trongsa, Tsirang, and

Sarpang districts since the mid 1960s. More roads are planned for in the future. The planned Panbang to Gonphu road, 77 km long, will traverse the entire length of the Royal Manas National Park and open up pristine langur habitat to markets in India.

Another significant road is the planned 64 km Gyelpozhing-Nganglam road, which will open up pristine capped langur habitat in east Bhutan. In addition another 202 km of feeder roads and farm roads connecting remote settlements to highways and urban areas is planned during Bhutan's ninth five-year development plan (2002-2007).

Roads have a significant impact on langur habitat. However, roads are the number one priority of the local people since they can bring in much needed development facilities such as hospitals and schools and help to lift living standards from poverty levels. Many of the planned roads pass through sparsely populated areas and service only a few settlements. For instance the Panbang-Gonphu road through the Royal Manas National Park will benefit only a few local communities consisting of about 11 villages with a rough population estimated around 1200 people. The road will create a direct link to roads and markets in India from the interior of golden langur habitat. The benefits of the road to the local people are obvious. However, the purpose of a national park is defeated when the needs of people are prioritized over that of conservation. A solution may be to relocate people from the interior and resettle them outside the park. Adequate and attractive incentives such as replacement land, housing, livestock, farming machinery tools, seeds, and investment schemes, may offset the loss of land and houses in the interior. International conservation agencies could finance such activities to create true wilderness areas inside of protected areas. Otherwise Bhutan's protected areas remain protected only on paper and not in reality. If roads have to be built, feeder roads from highways to villages should be preferred over construction of major roads that open directly to markets in India.

Historical and Current Land Use Practices and Forest Management

This section looks at the land use and land tenure system in place prior to nationalization of forests in the study area. This is closely related to the land use pressures and threats and will provide the necessary historical context for better understanding of the problem. In general I will explore historical land use patterns and how these have changed in order to predict future trends.

Many tend to view the era prior to 1960 in Bhutan as a medieval and feudal time and this of course has implications on how the forests were managed. If a feudal system akin to the European models existed then the land owners would have been feudal lords and the forests managed as enclosed fiefdoms. However, my own earlier work reveals a more complicated situation (Wangchuk, 2000). A tax-paying peasantry, individual farmland ownership, and community owned forests and pastures rather than fiefs, fiefdoms, and feudal lords was the norm in Bhutan. This question has to be clarified for the study area in Zhemgang in central Bhutan to understand present practices and make sound policies for the future. Based on the brief synopsis in the case study above and findings of earlier studies (Wangchuk, 2000), a second hypothesis that historical land management and tenure was private and communal ownership rather than feudal can be made.

If historically people have owned and successfully managed their private and public property to bequeath to the 21^{st} century near pristine forests and ecosystems, doubts about the "capacity of villagers" to manage their forests can be dispelled. However, the associated concerns that modernization and a monetized economy raise need to be addressed.

There is much confusion today as to the land use system in Bhutan prior to 1960. When one looks at the experiences of the day to day lives of the farmer, questions as to what exactly was happening arise. Was Bhutan a feudal society prior to the advent of modernization? Or was the land tenurial and distribution system more akin to a tribal organization? How did the current land use and natural resource management systems in Bhutan come into being? What were the forces of change impacting on land tenure? What role did the farmer play in the land and forest management decision historically?

I will attempt to answer these questions by an analysis of the social and ecological history of Bhutan. For analytical purposes the study is divided into two parts. The first part will look at currently practiced systems which will be compared to the period roughly between 1930 and 1960[1]. This will constitute a comparative analysis both in space and time. Feudalism as practiced in Europe will be looked at and compared to the land use systems in Bhutan prior to the advent of modernization in Bhutan which is generally dubbed as "feudal".

The second part of the analysis generates some clues to the questions that arise in the first part. It is an attempt to look back deeper in history and find the "origins" of the land use and forest management systems that they practiced prior to state formation in the 1600s. The nation state of Bhutan came into existence only in the mid 1600s prior to which the region consisted of "one valley kingdoms" ruled by hereditary kings, chiefs, or lamas (Aris, 1979). It is assumed that by looking at the deeper, older layers of Bhutanese land use history, current systems can be better understood. It is hoped that such an

[1]1960 is the year that the first motorable road into Bhutan from India was built. Also, the first five-year development plans were initiated which have profoundly changed the daily lives of the people. The period before it is regarded as the "olden" days by some and "feudal" by others. 1930 is selected as the other cut off date since the events related later by informants all occurred later than this date. It does not imply any significant change in the socio-economic and political system in the country.

approach will alleviate some of the confusion and bewilderment that exists today and is often reflected in the ambiguous and weak forest and protected area conservation policies.

The land user, the farmer or *minap*[2], will be viewed as an actor among a multitude of kings, chiefs, and priests. For these actors, ecological, social, political, and economic forces are constraining structures. Also, rather than viewing the farmer as a passive victim of history, the role the peasant themselves played in structuring the land use system, by resisting and strategizing against the constraints will be explored (Scott, 1985). This approach is inspired by several scholars (Baviskar, 1997; Burch, 1997; Isaacman, 1996; Siu, 1986; Worby, 1995) who have looked at resource management experiences of the people at the nexus of political, historical, social, economic, and ecological systems. By doing this however, I do not mean to romanticize resistance, as Baviskar (1997) citing from Marx (1852) makes clear:

> "...people make their own history, but not of their own free will; not under circumstances they have chosen but under the given and inherited circumstances with which they are confronted..."

Attempts to balance and play off the tension between constraints and resistance will be made in the analysis.

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[2]The word minap today is loosely used to refer to any one from a rural area. It has acquired the equivalent meaning of 'hill billy' but historically peasants were referred to as minap which literally means person in the dark or ignorant person. As far as the Buddhist clergy, who coined the term, were concerned the peasants were ignorant of the meaning in the sacred texts written in chokay or classical Tibetan and unavailable to the illiterate peasants.

Part I: Was Bhutan Ever a Feudal Society?

Many western scholars studying Bhutan (e.g., Rose, 1970, Aris, 1987; Aris, 1996) label the period prior to the rule of the third king (1952) as feudal Bhutan as opposed to modern Bhutan. They generally assume that Bhutan was a feudal society much like Europe was in the Middle Ages before the Enlightenment. In Bhutan's case the enlightenment is thereby implied to have dawned with modernization. This view is largely accepted as an historical fact by both Western and western educated Bhutanese scholars. This pre-modern, "dark age" is seen as a stage from which Bhutan just recently emerged to embrace modernity. High-modernist discourse of social systems and states progressing and developing along a trajectory are implicit in such views.

Ura (1992), in a comparison of what he terms "the medieval period and feudalism" to "modern" Bhutan, employs such an analytical framework. He summarizes the main differences as

> “...the evolution of Bhutan from a non-market to market organization, from customary self-subsistence economy to a planned trading economy, from theocratic and absolutist regimes to a modern form of government, and from a state whose ideology was the support of religious orders to one with a commitment to the socio-economic development of the country.”

I argue that under scrutiny the above distinctions show that pre-modern Bhutan was certainly different from present day Bhutan but do not qualify the labeling of Bhutan as feudalistic either in the "general or technical" sense (Goody 1971).

If on the other hand the intent is to label the political and economic system in pre-modern Bhutan as repressive, backward, primitive, etc., then it is less complicated if said so directly rather than calling it "feudal." Such usage confounds rather than elucidates views of pre-modern Bhutan. Goody (1971), in critiquing the use of 'feudal' in the African context writes that:

> "...as adequate an analysis [is done] without introducing that concept [feudalism] at all. This ...approach seems preferable as a procedure. It is simpler; it minimizes the inevitable Western bias; and it helps to avoid the assumption that because we find for example, vassalage, we necessarily find other institutions associated with it in medieval Europe. It is just these supposed interconnexions which comparative study has to test rather than assume."

Why then have so many scholars assumed Bhutan to have been a feudalistic society? Certainly there were elements of oppression reminiscent of feudal Europe. However, as shown below the tenurial system and property rights can hardly be labeled as feudal in Bhutan. Perhaps it is a result of scholars preferring a high-modernist ideology that sees feudalism as preceding modern societies. Such scholars are bounded by this evolutionary framework and as Goody writes "...the Western European starting-point heavily influences the outcome of the analysis."

Another compelling explanation for Bhutan to be labeled as "feudal" may be that western scholars who study Bhutan have been trained as Tibetologists. They look to Tibet for causal explanation of not only historical events in Bhutan but also the country's entire socio-cultural systems in general. This is understandable in light of the fact that there was heavy religious and cultural influence on Bhutan from Tibet. In fact the country's unifier and founder, Shabdrung Ngawang Namgyal, was a refugee reincarnate lama from Tibet. However, this does not mean that Tibetan systems were transplanted root stock and barrel onto Bhutan[3]. Rather a hydridity between "roots" and "routes" (Clifford, 1997) of rooted cultures and cultures on the move offer a more complex understanding. This is further explicated in Part II below.

My main aim here is to problematize both the "high-modernist" European evolutionary model and the "Tibetan model." Instead I offer a counter narrative based on the experiences of farmers in Bhutan. Due to the recentness of the introduction of development, most middle-aged and older Bhutanese peasants today lived through the transformation. As such there is a wealth of knowledge, undocumented and mostly in peoples' memories. As Isaacman (1996) writes, accessing this is to create space for alternative perspectives and as Worby (1990) explains, observing the problem with a different "conceptual lenses" can reveal new insights and answers.

What is feudalism?

I first start with a working definition of feudalism as understood in Europe and then compare this to the situation in Bhutan between 1900 and 1960. Defining feudalism is a much debated topic since several scholars use it to mean many different things even in the European context. Bloch (1961), however, is seen as authoritative and offers the following definition at the conclusion of a 500-page book describing feudal society in Europe:

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[3]Even in the case of the first North American English colonies, Virginia and Massachusetts, important differences emerge between England and the colonies, and between the two colonies themselves. Differences were largely due to the purpose of the colony, whether for capitalistic agricultural production of tobacco or for settlement, and most importantly on the relationship with the Native American tribes in the respective areas.

> “A subject peasantry; widespread use of the service tenement (i.e. the fief) instead of salary...supremacy of a class of specialized warriors; ties of obedience and protection which bind man to man; fragmentation of authority; and in the midst of all of this, survival of other forms of association, family and State.”

Applied to pre-modern Bhutan, there is a subject peasantry in the sense of being subject to heavy taxation in kind and labor by the state. State authority was increasingly fragmented after the death of the first Shabdrung, the monk statesman who unified Bhutan after 1616. This fragmentation seems to be the basis for Aris (1994) to describe Bhutan as fiefdoms ruled by regional governors under limited authority of the center. However, there never was service tenement or the existence of a class of specialized warriors.

This becomes clear when we consider Peters’ (1997) explicit division of feudal Europe into a tripartite society consisting of the clergy, knights, and peasants. In particular he highlights the importance of the knights and lords to feudal Europe: "knighthood bound the men of war together and contrasted them with the men of work...These individuals often combined the social status of high birth with old royal titles of service (count, duke, viscount) and landed wealth that enabled them to attract and bind subordinates to them by oaths of vassalage...they assumed control of...public legal and financial powers which made the aristocracy...private lords and public authorities." Bhutan never had a knighthood but rather a "church bureaucracy" (Carrasco, 1959) to administer public legal and financial matters. According to Duby (1980), it is only when the "rights of government (not merely political influence) are attached to lordships and fiefs that we can speak of fully developed feudalism."

On the issue of a "subject peasantry" and land tenure, Bhutan clearly had a system vastly different from feudal Europe. I argue that rights in property have always been held in private by the peasantry. In feudal England there were estimated to be about a thousand lords who shared the landed property amongst themselves (Peters, 1997). By contrast Bhutan had only about 5000 serfs all of whom were emancipated in 1959 by the third king (Karan, 1963). Karan (1963) writes that the third king "...freed the 5000 slaves giving them choice of remaining with their masters as paid servants or accepting land from the government and setting up as farmers." Most established new villages, such as at Kabji Petari in west Bhutan.

The serfs, or more correctly slaves (*zasen*), were descendents of slaves captured from India on Bhutan's southern border. Some were also occasionally bought by wealthier peasants from traders. Most were attached to monastic lands that the slave families cultivated. Some of their descendents to this day continue to farm land owned by the central monk body, but as sharecroppers.

This has often been confused with the entire peasantry being labeled as serfs and a feudal model used to explain the rest of society. Rose (1977) writes "The traditional landholding system in Bhutan was feudal...tenancy which was the norm earlier in most of Bhutan has been much reduced in scope...what is more important perhaps is that the character of the tenancy system has changed...more often than not now it is families that are already landholders in their own right." In short Rose tells of a revolutionary change not only in the land tenurial system but the entire society at large. He does not explain the factors behind this purported revolution but assumes that they occurred based largely on an erroneous reading of the existence of slaves, tenancy, and elites in the traditional system.

The vast majority of peasants were tax paying private citizens, either owning private lands or sharecropping for wealthier families, monasteries, or members of the new royal family (at least after 1907). They are even today referred to as *minap*, loosely translated as "ignorant people" or "people in the dark" but nevertheless free. Some were *drap* or serfs in the true feudal sense, attached to estates of the handful of hereditary nobles "*choje*" or lords of religion in central and eastern Bhutan. Ura (1995) explains their situation: *drap* worked without any payment on the master's land in return for a piece of land allocated by the master for their own use...*drap* families did not pay any tax [to the state] because they were only answerable to the master." It is important to keep in mind that they constitute a notable minority to the free peasants. Others were *zasen* or slaves as explained above. Ura distinguishes them from the *drap*: "*zab* [*zasen*] were in a worse situation: they worked entirely for the master who gave them only food and clothes."

Thus a potpourri mixture of landholding systems existed at the same time between the *minap, zasen*, and *drap*[4]. The important point to keep in mind is that the slaves and serfs constituted only about 5 % of the total population at the time of their emancipation in 1959 (Karan, 1963).

[4]Ura (1995) refers to them as *drami*.

The Burden of Tax

Most of the free *minap* were wretchedly poor and yet heavily taxed by the government. In east Bhutan, some are said to have fled to Arunachal Pradesh in India to escape this heavy tax (Aris, 1980). In west Bhutan a strategy by the peasants was to not divide the household since taxes were assessed by household. *Kheaps* or taxpaying households also had many *zurpa* families attached to them. The *zurpa* or "side" families did not pay taxes but provided help to the *kheap*. In many cases *zurpa* were married children of *kheaps* or other relatives. This worked to the advantage of both *kheap* and *zurpa*. Aris (1994) writes of the attempts by the second king in 1935 to change this arrangement "...it was also discovered there existed a whole class of indigent, untaxed, and landless citizens called *zurpa*, literally 'those who live on the side'." Aris misreads this and goes on to write these landless people were made to "fill up the vacant tax estates." These "tax estates" may have been private lands of monasteries and powerful elite. The *zurpa* were recorded as 'landless' in the tax registers, because the land they owned was undetected by the state or at least not detectable to the authorities (Scott, 1998).

Below is an excerpt of an interview with Ap Tshering of Lunana, a pastoral village on Bhutan's northern border with Tibet. Ap Tshering explained *Zurpa* to me as those unable to pay taxes, while *kheap* were seen as wealthy enough to do so. In the village then *zurpa* had lower status than *kheap*. In a twist, when the government today doles handouts per household, number of registered households mysteriously multiply overnight. For instance the following is paraphrased from an interview with Ap Tshering (1995):

"In the old days when we were taxed heavily, many people in Lunana were unable to pay the taxes and stayed as *zurpa*. They of course had their own houses, land, and yaks but did not pay taxes. Instead they helped us *kheap* by providing labor when needed and when they needed to be spelled out during hard times, we provided what we could. We had *bju* [wealth] but they had *buong* [breath][5] Today it is quite the reverse. The government gives poorer families gift yaks and these are made to households without many yaks to begin with. Many people, even though they live in the same household, register their children or relatives under new households and obtain these gift yaks and add to their herds. Of course the *gup* [headman] is aware of such practices but records the new households anyway since his own household does it too."

Another informant, Lopon Kinley (1995) of Ramena village, a monk in his late fifties, recalls from his childhood days, the immense loss felt by the yak herders at the time of taxation.

"The *boeds*[6] would come to our village, *pata ben* [sword] at their sides. They did a *pu-yig* and counted each family's yaks and then demanded butter and meat taxes on this basis. Some of the harsher *boeds* would point out live yaks and demand they be slaughtered for the *sha thray* [meat tax]. It did not matter if the selected ones were milching *bjim* [females] or *zhuli* [seed stud yaks], as long as they were fattened enough. I remember my mother crying and pleading with the *boed* but to no avail. Of course some

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5Refering to larger yak herds and property of *khepas* as compared to *zurpa*, who owned smaller yak herds and land.

6Attendants of the regional governors recruited from the peasantry themselves.

boeds were kind and did not force the issue. The lifting of the *sha thray* and *ma thray* [butter tax] by the third king was a great boon for the welfare of the *mi-sayr* [public]. It was the kindest *kidu* [welfare] granted to us *bjops* [yak herders] by the government."

Until the late 1950s yak herders paid taxes in meat and butter. The meat often came from animals that otherwise would not be slaughtered, as shown above, since doing so cut into the capital stock. This reduced a herd's capacity to maintain itself and to grow. The amount of tax was determined by animal census or *pu-yig* when representatives from the central government would count each family's holdings and tax them accordingly. However, this was changed to a light monetary tax system with the families reporting the number of animals they own. The animal censuses were dropped since the tax per animal was nominal and the census expensive. People thus report much lower numbers than they actually own in order to evade taxes. The change in the tax system freed the pastoralists from central government control to a certain extent.

Thus taxes were a heavy burden on the people and it was only during the third king's reign that they were alleviated. Depending on the agro-ecological zone people lived in, they paid taxes according to what they produced. For instance, as shown above in Lunana and other alpine regions, taxes were paid in yak butter and meat. In the lower farming valleys, taxes were paid in rice, maize, or wheat. In addition peasant households also had to render labor services such as transporting these goods to the centers of administration in the monastic fortresses or the *dzong*. Aris (1994) describes efforts even by the second king to reduce the tax:

> "Wherever possible it was also decided to reduce the taxes themselves, both those paid in kind and those rendered in the form of labor services ...Previously it seems that every household had to supply firewood and hay to the *dzong* along with various other commodities that varied from district to district. For instance, in eastern Bhutan "tax cloth" had to be paid. Practically all of this type of tax was abolished. The need to supply free transport services was also adjusted, and for the first time these began to be paid for."

Thus as another informant Aum Thinley Bidha says: "We had to pay taxes from the *Utse* [gold roof] of the *dzong* all the way down to the *tari* [stables]." (A metaphorical reference to a system where the entire state administrative apparatus was supported by the taxes of peasants[7].) However, it was only after 1952 that taxes in kind were completely abolished, thereby lifting a great burden off the peasantry. Today only nominal token taxes are collected in monetary terms and these "rural taxes" collected from the peasantry only account for about 1% of total government revenues, leading Bhutan's Ministry of Finance to declare Bhutanese as the least taxed people in the world (RGoB, 1996).

Under heavy taxation, evasion tactics were common practices by the people. For instance, many older tax-paying Bhutanese today recall several tactics used. One method was to soak the hay tax overnight in water, then cover this wet hay with an outer layer of dry hay and weigh it in at the *dzong* the following day. Also, in terms of grain tax, since unhusked rice was collected, in many cases peasants mixed in *shupa* (chaff) with the

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[7]Some may argue that this is evidence of a feudal society (Weber, 1947), but if we look at the United States tax dollars similarly support the entire state apparatus. Yet no one would call the US a feudal society.

actual kernels of grain. Grain was not weighed but measured according to volume of a measuring container, the *drey*.

Disputes among peasants themselves over transporting goods to the dzong were also common. Aum Thinley Bidha, head of her household, of Wang Simu village recalls such a dispute from her tax paying days:

> "We were performing our annual *choku* to appease the dieties. The monks were in the alter room and performing the rituals while the kitchen and *yoeg* [living room] were packed with guests invited for the *choku*. The guests had just been served tea when the *gup* came charging up the stairs and shouted that I had failed to transport the share of my load to the *dzong*. He went on to say that he had deposited the loads outside my house and expected immediate delivery. I said that I might be a *morem* [a single women, usually widowed] but was not a fool since I had taken care to deliver all my loads before the start of my *choku*. The *gup* was furious and advanced towards me and I was also furious. It was inauspicious for him to disturb my *choku* and insult me in front of the guests. The next thing I knew, I had the *gup* pinned under the crook of my left arm and I was pummeling him with my other hand. The *gup's* own relatives were amongst the guests but did not come to his aid since they knew too that he was trying to pass on someone else's load onto me."

Needless to say the loads disappeared from her doorstep. It is also with regards to Aum Thinley Bidha that I present as evidence of private property ownership by the peasantry in Bhutan. In a following section I present a summary of a dispute over her *phazhi* or ancestral property. For now I turn to the Tibetan model and deconstruct its use in explaining land use systems in Bhutan.

Can Bhutan be explained by Tibet?

In *Land and Polity in Tibet*, Carrasco (1959) looks in detail at the "system of land tenure as related to political organization" in Tibet. What is of great relevance for the present purpose is that it is one of the few studies that compare land use systems in Tibet with what he calls the "Lesser States" such as Sikkim, Ladakh and Bhutan. Other Tibetolgists have assumed that land distribution and tenure in Bhutan can be explained by the Tibetan model, notably Aris (1994) writes: "the land itself was divided into provincial units and sub-units, and each was given its own administrative designation on a Tibetan model." Turning to Carrasco (1959), Aziz (1978), and French (1990), a very different picture between Bhutan and Tibet emerges. Carrasco concludes his analysis on Bhutan by writing:

> "In comparison with other Tibetan states the most remarkable trait was the absence of hereditary landed estates as the main source of income for the officials, and the apparently greater social mobility within and into the official class. In this respect the officialdom of old Bhutan closely resembled the monk officials of Lhasa but without a class corresponding to the lay nobility of Tibet."

Although there has been a disproportionate amount of attention focused on the handful of *choje* and other landed hereditary nobility[8] in Bhutan, the vast majority of peasants lived a life closer to that described by Carrasco. It is important to keep in mind that until the instituting of the monarchy in 1907, the ruling class was non-hereditary. Bhutan's numerous civil wars are wars of succession simply because there was no hereditary ruling family along which the secular regentship and powers were passed. After the Shabdrung's death was revealed in 1705 and until 1907, Bhutan was in a "perpetual cycle of conflict" with very few secular rulers, the Druk Desi, being able to serve the full three-year term in office (Aris, 1994). Many were assassinated and still others were exiled. The most ruthless and conniving emerged as the most powerful. Since there was no hereditary ruling elite, very often peasants starting as lowly court attendants, stable boys, and messengers managed to find their way to the top.

In Tibet, "the underlying right of ownership to all of the land in Tibet was in the person of His Holiness the Dalai Lama...all land grants were conditioned on the continued goodwill of the government toward grantee." (French, 1990). Peasants were attached to estates directly administered by the state, to estates owned by nobility and monasteries, or farmed small plots on which they paid "a sixth part of the field" as taxes (French, 1990). Also, peasants could not vacate these lands without permission and in the case of not having an heir who both inherited the land and the tax obligation, peasants adopted children to fill in for them (Aziz, 1978). Among the "three classes of commoners" described as agriculturists, traders, and itinerants such as artisans, Aziz writes of the agriculturists as: "...all are tax paying tenant farmers, working holdings

[8]Ura (1995) mentions the following nobility to whom people paid taxes during the reign of the second king: "the king, the Elder Queen, the powerful aunt of the second King,...and Lame Gonpo Dasho Phuntso Wangdi."

leased from the government or another landlord." In short there were no private-property owning peasants. The nobility too is hereditary including the men of religion, *ngag-pa* or hereditary priests (Aziz, 1978). These priests own estates farmed by tenants. Aziz explains the aristocracy of Tibetan society as *ger-pa*, "the term *ger* means private, designating the exclusive property rights members enjoy as private landlords."

The situation in Bhutan is very different; there is no *ger-pa* or *ngag-pa* class. The agriculturists worked their own private land as tax-paying subjects. Monks were recruited from the peasantry as were the government servants[9]. This is not to say that there was no social stratification in Bhutan. The basis of stratification was different, it was not hereditary, and was not determined by the quality of tenancy or land holdings; in Bhutan rather it was quantity of land owned that determined one's social position. This of course depended on several factors but was open for manipulation. Another important distinction is that in much of Bhutan, land inheritance is through the daughter, a matrilineal system, where as in Tibet it was patrilineal. Carrasco concludes his analysis on land and polity on Tibet by writing:

> “In comparison with European feudalism, Tibet offers great similarity in a few fundamental traits such as the importance of labor rent, the granting of land in return for services, and the close connections of rights over land with political functions...Tibetan landed estates as units of production resemble the manor, and as rewards for services are comparable to the fief, while the home lands of an estate correspond to the lord's demesne...”

[9]Usually recruited as children, they start "work among the lowest menials...fetching firewood and water" designated as "*tozen*, literally, 'food eaters'" and work their way up to *zingap* or attendants in general, to *changgap* or personal attendants to the governor, to junior chamberlin, to chamberlin, and sometimes to the governorship itself (Aris, 1994). The founder of the present monarchy, Jigme Namgyal, rose through the ranks in a similar way although his final ascendancy depended on "tactics of blunt coercion" (Aris, 1994).

Suffice is to say that while Bhutan and Tibet have many similarities, fundamental differences remain and the Bhutanese land tenurial system cannot be explained by Tibetan models.

Current Practices

In a comparison of three villages in three different ethnic zones in Bhutan, Sangay Wangchuk (1998) summarizes the current land use practices in Bhutan. Citing Ura (1995) he writes that after 1953, the distinction between private and public property was made official or legalized through the passage of the *Thrimshung Chenmo* or Supreme Laws. "The official recording of agricultural land after 1953 separated private and community property rights...prior to this, property rights were loosely defined." This can be understood as the State making the country more "legible" for easier control. Previously, customary law regulated land use practices. Currently, this customary law has been overlain with various national legislations such as the Land Act (1978), Forest Act (1969), and Livestock Act (1980). However, this does not mean that customary laws have disappeared. At the local level, customs or *luso* still determine everyday life decisions in many significant ways. For instance, village sacred groves and forests, though not distinguished from other forest by state laws, are protected by customary law. E.P. Thompson (1991) offers a rich description and analysis of agrarian customs in England during the 18th century (after the collapse of feudalism):

> “Agrarian custom was never fact. It was ambience. It may be understood with the aid of Bourdieu's concept of "habitus" - a lived environment comprised of practices, inherited expectations, rules...norms, and

> sanctions...Within this habitus all parties strove to maximise their own advantages. Each enroached upon the usages of others."

In Bhutan, such a habitus is also the nexus where customs meet formal laws and are negotiated, contested, used and abused by the local actors. Thus to acknowledge the existence of only one system is to deny history to a rich process. For instance, to look at the Forest Act and to assume forest usage existing on the ground as legislated in the Act would be an incomplete picture.

However, the general effect of the legislations resulted in private property being measured, recorded, and titled in a systematic way. The *sathram* or land record title was issued to all peasants for the first time. This can be misinterpreted as the granting of private property and instituting a change in land tenure practices from a feudal to private property relationships. It is important to keep in mind that these activities are state schemes at rationalization and ordering. In *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, Scott (1998) shows the need for states to simplify the complex in order to exert control. Consequently, the schemes should be seen as an exercise in "administrative ordering" and making legible a complex society. Today the effort continues with the use of more sophisticated cadastral equipment, and computerization of the entire land records of the country into a database.

Today then, citizens hold their property in private, and they have the paperwork to prove it. My contention is that this is a reflection or result of a long history of land tenurial systems where property rights always were held in private. To look at the 1950s and say that the land tenure system changed from feudal to private, simply because of the issuance of a few documents is to dehistoricize the issue.

If anything, peasants lost rights over common property resources such as forests and pastures with the enactment of the Forest Act. Sangay Wangchuk (1998) explains:

> "The enactment of the Forest Act in 1969 whereby all forests became the property of the state, had a profound impact on the tenurial system. However, this did not have an immediate effect on forest resource use by the local communities, as the state did not have adequate machinery to implement the provisions of the Forest Act. Therefore the informal tenurial relationship continued. Over the years...the state's enforcement of the respective laws has increased. This process has lead to the widening of the gap between the state who owns the resources, and the local communities who use the resources."

Likewise all pastures also became state property with yak herders renting the pastures from the government and paying a *chotham* fee or token license fee. However, the *chotham* is as legitimate as a land title for the holders since the government did not redistribute the pastures after passing the Act. Existing pasture distribution patterns were maintained and registered in the *sathram* of the original owners. In a few cases however, the government has intervened to distribute the pastures but in terms of rights in what Gluckman (1965) explains as "people own rights, not objects." Consequently it becomes possible for "several groups or persons [to] hold different kinds of rights in the same piece of land while it is devoted to a particular kind of use" (Gluckman, 1965). Layers of rights are then possible and a clearer understanding of pasture use rights can be gained.

In 1960, after the Chinese take over of Tibet, several Tibetan refugee families fled into the northern border region of Bhutan, some with several hundred yaks. This was concentrated in the Lingshi area since the high mountain passes from Tibet are easiest to cross both in terms of the condition of the trail and the shortness of distance. Since the available pasturage were all "owned" and leased out, the government and Lingshi people devised a system of use rights called *Khatsa-Tintsa* (NCS, 1996) to accommodate the refugee families and their yaks.

Pasture "owners" with fewer livestock shared use rights with refugee families with yaks who held *khatsa* or "surface eater" rights. The former held *tintsa* or "depth eater" rights with the pasture still being registered in their sathram. However, the advantage for the *tintsa* was that obligations were also divided. The license fee was halved and so were labor contributions for development activities[10]. Another example is *masa* or communal pastures for which in actuality, rather than being an open access resource, use rights are held by several families. This group of families shares all the benefits as well as the taxes and obligations. Ura (1993) describes other use right arrangements in communal pastures in two other areas of Bhutan.

Returning to rights to land in general, Gluckman's (1965) explanation of "rights to land are an incident of political and social status" in tribal societies has some resemblance to the system in Bhutan. Although peasants have rights to sell, exchange, and alter their land, if the state requires it for a road, airport, or school, the land can be taken from them.

[10]Such labor obligations are termed *shabto lemi* and the government now pays for the labor and the labor is restricted largely to development activities benefiting the labor contributors.

And even though compensation is paid or alternative land allocated to the peasants, the state having the highest "political and social status" can ultimately acquire peasant lands.

It is in this context that I turn to Aum Thinley Bidha's story. Although this happened prior to 1960 and the start of development, the fundamental land tenure of peasants is the same as today. It offers a markedly different perspective on land tenure as seen by Tibetologists "trapped" by the Tibetan model.

Aum Thinley Bidha's Fight

What follows is an account of Aum Thinley Bidha's fight over her *phazhi* or ancestral property. The story was collected in several interviews over a period of three years between 1994 and 1997. I visited her in the village, taped our conversations on a Hi 8 videocamera, talked to her surviving children and other village elders. The story is important since it reveals the dynamics of land tenure in Bhutan during a time when most historians dismiss it as a "feudal" state.

Thinley Bidha was born in 1908 in the village of Wang[11] Simu in west Bhutan. As the eldest and only daughter she inherited the ancestral property from her mother who died at the young age of 29 when Thinley Bidha was only 11. Various maternal aunts served as the *nangi aum* in the household until she took over at the age of 26 after the death of her aunts. The *nangi aum*, variously translated as mother at the core and anchor mother, is as the name suggests, the authority (person?) around which the peasant

[11]The wang have been variously describes as a "tribe" and clan and several explanations as to their origins exist. The most popular is that they came to Bhutan as part of an invading Tibetan-Mongolian army, fell in love with the country, married the local girls and settled down.

household revolves. Although sometimes upstaged by a forceful husband, the *nangi aum* still retains some control since the husband joins the household as an outsider and the property owner is still the wife. The division of labor ideally is that the husband handles the outside work while the *nangi aum* the inside work. Outside work can range from dealing with the state, tax collectors, government servants, performing the labor tax, serving in the militia recruited during times of war, resolving disputes in court, and sometimes going on trading expeditions. Inside work reflects work not only in the house but also all work related to the land such as making decisions about planting, harvesting, and day-to-day work schedules of the land.

Thinley Bidha lost her husband to an illness when she was 43. Her younger brother increasingly took on outside work on her behalf but could not be fully committed since he had married out and was responsible for his wife's household duties also.

In 1947, after she had lost her husband and her younger brother had already married out, a distant relative filed a *labzhi* case against her. Seeing her household as not having strong male representation, the relative took advantage of this to grab not only her valuables but also her property. Without a fair trail, the second king's court granted all the movable valuables such as jewelery to her enemies. The *phazhi* however, she refused to hand over, citing ancestral claims and invoking the protection of guardian dieties. Her brother was taken as a prisoner due to her refusal to move out of the house. By doing so she would have symbolically given up her rights to the land. She was personally threatened with eviction but neither the relative nor the court could do so simply because the land and house were her personal property and everyone in the village acknowledged this ownership. At one point after her brother was taken prisoner, she almost relented but finally sought protection from the queen. Her brother had served as a personal attendant to the queen and with eyes swollen from crying she went to visit the queen. Citing the folk saying "in my house I am king" Thinley Bidha was given a fair trail eventually. Serving as her own *jabmi* or solicitor she not only managed to hold on to her property but also won back her valuables.

Two important points become clear, that the nature of ownership and "legal relations are between persons...a person owns not an object itself but a right to do certain things with or in regard to that object" (Gluckman, 1965). In this case Thinley Bidha's land could have been coerced from her by her enemies but the rights would still have been vested with her as per customary law as acknowledged by fellow villagers. Secondly, if the land was held in a feudal tenancy mode, the case would not have arisen at all. The landlord would simply have reassigned the land to another tenant without so much fuss.

Farmer as Land Owner

What are the implications of this fact that farmers in the past have always made land use decisions themselves, including crucial forest and pasture resources? There is no feudal lord to manage the estate. The state until the 1960s did not intervene in local resource use and management choices. But with increasing legislation and rationalization on a Western model, as recommended by development experts, local resource use is increasingly regulated by the state. Farmers legally lost common property resources such as pastures and community forests through such legislation. However, the state's lack of resources to monitor and enforce the legislation effectively has created space for farmers to continue to manage the resources within certain constraints imposed by the legislation.

For instance, even today as pointed out in the case study at the beginning, customary rights still govern access to village forests. There is clear demarcation between one village and the next by the use of *laptsap*, cairns of stone serving both as boundary markers and village entrance guardian spirits. People from other villages may not collect firewood, timber, or graze their cattle beyond these boundaries. If they do so, they are made to pay compensation and in the case of illegal grazing, cattle are retained until the fine is paid. The fine is used for community activities such as sponsoring numerous village ritual ceremonies in the village monastery. The community forest is held as *masa* or public land on which villagers collectively pay a tax to the state. Thus, village members themselves cannot abuse the resources in the common forests with impunity. There are sacred groves where trees may not be felled. Also, the resource extraction process should not harm a neighbor's property, such as felling trees from near a neighbor's house. Excessive felling of timber for commercial profit would not be permitted unless the whole village benefited. Additionally, some villages enforce a *ridum* or forest closure during certain times of the year. When a *ridum* is in force no one may enter certain parts of the forest since it is believed that the *rigamem* or forest spirits are not to be disturbed during these times. Interestingly, these times also correspond with times when trees and other forest plants are flowering and seeding and disturbances would interfere with the reproduction and growth cycle. These customary regulations are sometimes overridden by state laws that grant permits to collect timber and other resources from a village's traditional common forest, causing much resentment among the villagers. Can farmers regain historical resource use rights? The answer to this is difficult given the new dynamics and market forces in action. There is much to be gained for short-term profit and the fear of losing all control over Bhutan's natural resources has prevented the state from moving towards handing over community forests back to the farmers. However, the important distinction is to be made between open access resources and common property resources. If the latter pattern is legalized then the former is not a threat since rights in the land and resource belong to a village and they are responsible for any decisions they make. With regards to this, Ostrom (1990) debunks Hardin's (1968) myth of tragedy of the commons, which has become an 'accepted way of viewing problems' with common property resources. She shows that these models view individuals as prisoners with constraints imposed on them, which they cannot change. She instead gives the actors in her models agency the ability "to change the constraining rules of the game". Ostrom's model shows alternatives to overcoming the problem of the commons other than privatization and state control. Actors have the ability to negotiate with each other and discuss best strategies for the use of the resource. They then enter into a contract agreed to by all parties, and this results in an equitable sharing of resources on a sustainable basis. From the description of the village forests above, they are far from being open access resources, which are free for all. Rather, strict customary laws govern their use. This is often undermined when outsiders impinge on the rights a village through bureaucratic procedures or with state approval. Thus, rather than protecting and controlling resources, state laws undermine traditional customary laws that are recognized by a village and its members. In effect, they create a situation whereby previously common property resources are turned into open access resources. As a first step, the government can re-recognize customary laws operating in a village forest and stop issuing resource use permits to outsiders from such forests. The village institutions are already in place and are recognized for other purposes such as for *gewog yargay tshochung* or village development purposes. In a very simple process, the village forests can be handed over to the villagers for their own management and use without state interference.

Part II: Origins

In Part I above I have attempted to deconstruct the existing representations of Bhutan as a feudal society prior to the advent of modernization. The question then arises, if not feudal then what? I use different conceptual lenses to answer this question, as Worby (1995) writes:

> "The solution to this puzzle lies less in a changed reality that has suddenly been registered in the 'data' and more in the changing observational and conceptual lenses through which that reality has been viewed and represented."

The different conceptual lenses are analytical tools developed from a multidisciplinary approach. Thought processes from ecosystem and landscape ecology, paleoecology, social history, and political economy are stitched together to present a varied and patched mosaic of lived experiences on the landscape of Bhutan. To the conventional tools of the historian, that of narrating significant events in a temporal sequence, I add spatial dimensions.

"The total effect of austere mountains, rock, and river was that nature had laid out a grand and eternal stage for human action" (Burch, 1997), is the central theme on which this dimension is built. When looking at the early history and origins of Bhutan, most historians write of obscurity and myth and lament the lack of written sources. Aris (1979), in a bold attempt not only gathered existing written Bhutanese and Tibetan sources but also conducted interviews and visited places of historical curiosity to him. The product was a doctoral dissertation and a book titled "Bhutan: the Early History of a Himalayan Kingdom" (1979). Commendable as his work is one might raise questions about what constitutes history. Does it consist only of the collection, analysis, and interpretation of written "primary" sources into a structured narrative? Who's history is it anyway? In a country where even today among an increasingly literate populace, oral traditions are the preferred mode of sharing stories and experiences, dependence on written sources alone is "annoying" as Aris himself admits. Nonetheless, Aris has presented a basic temporal structure, in some places thin and stretched, based on the available written sources. I will attempt to add to this temporal framework some spatial history and "thick description". What dramas did human actors play on nature's stage? By looking at history through the lens of landscape ecology, and adding multi dimensionality, will a more nuanced and fuller picture emerge?

The current model of the origins of the different ethnic groups in Bhutan are that Tibetan people's invaded western Bhutan, pushed out the indigenous people and extended their influence over other indigenous groups in eastern Bhutan. No one claims this model since it is too flimsy and most importantly, unauthenticated. However it has become accepted such that even guide books for tourists visiting Bhutan reproduce this model for popular consumption. The latest one gives the following version (Armington, 1998):

> “The Sharchops, who live in the east of the country are recognized as the original inhabitants of Bhutan. They are Indo-Mongoloid; it is still unclear exactly where they migrated from and when they arrived in Bhutan. The Ngalong are descendents of Tibetan immigrants who arrived in Bhutan from the 9th Century. These immigrants settled in the west of the country...The third group is the Nepalis, who began settling in the south of Bhutan in the late 19th century...Minority Groups: several smaller groups many with their own language form about 1% of the population...”

Scholars have steered clear of such models largely because of their political nature. Obviously, those ethnic groups described as "original inhabitants" can claim more political power while powers of immigrants can be seen as illegitimate and illegal. This "empty land" model which gets filled with various ethnic groups is problematic for several reasons. For one, the area's prehistoric era is completely dismissed. For another, historical complexity is simplified and the forces impinging on the historians themselves are seen as neutral. The "original inhabitants" or the Sharchops are more accurately described as Tsangla. This denomination is derived from being the clan descendants of Prince Tsang-ma of Tibet (Aris, 1979). The Tsangla identity emerged only in the 17th century as a conscious construction of a monk-historian, Ngawang, and his works (Aris, 1979). Meanwhile, the "Tibetans" in the west couldn't be more anti-Tibetan. Several wars were fought with invading Tibetan armies. Ballads, songs, and stories ridiculing the Tibetans became popular. Most importantly, the land tenurial system cannot be explained by the Tibetan model as shown above. Yet the empty land model is unquestioned largely because the Tibetan bias of Tibetologists, which assumes everything in Bhutan came from Tibet, is not challenged. The empty land model is an untested assumption built on another untested assumption. In this light what alternative model can be constructed to explain the land use system in Bhutan? For this I turn to Clifford (1997):

> "...the representational challenge is seen to be the portrayal of local/global historical encounters...one needs to focus on hybrid, cosmopolitan experiences as much as on rooted, native ones. In my current problematic, the goal is not to replace the cultural figure 'native' with the intercultural figure 'traveler.' Rather the task is to focus on concrete mediations of the two..."

Thus instead of the 'empty land' model, I am more comfortable with this representation that introduces a new dynamic to the system, of layered hybridity. Cultural patterns are conveyed and altered along routes of immigration, trade, and war leading to new "roots" or communities and identities. There is no "original inhabitant" existing in a cultural vacuum, unchanged and unique. Rather I "focus on hybrid...experiences as much as on rooted" ones. In this model during prehistoric times, Palaeolithic peoples dispersed from east to west, from the upper reaches of the Yellow River in China to present day Yunnan province and thence east to Bhutan, Arunachal Pradesh, Nagaland, Mizoram, Manipur, Shillong, Myanmar, and as far west as central Nepal[12] (Allchin, 1982; Marshall, 1997; Ross, 1990) . Kosambi (1965) writes: "eastern parts of India...were penetrated by prehistoric people from Yunnan and Burma." The movements of these peoples, how and in what patterns they occurred are explained by Fagan (1990):

> “Population movements associated with *Homo sapiens sapiens*...should not be thought of as migrations, certainly not in terms of the kind of mass population movements that characterize later migrations in human history. These millennia-long population movements were gradual, dictated in large part not by the innate human curiosity of what lay over the next horizon, but by a myriad of complex environmental, climatic, and entirely pragmatic factors...they were short term responses to ever changing local conditions, often triggered in turn by larger global climatic fluctuations throughout the last (Wurm) glaciations...our remote modern ancestors were part of a complex world ecological system that affected all animal species on earth.”

One can then imagine this gradual movement from east to west and later from north and south, adding layers to the previous layers. It also important to keep in mind that if there is movement in, then movement out is also possible. The focus has entirely been on the north to south influence, that of Tibet on Bhutan. But earlier records also show important refugee princes from India seeking refuge in Bhutan, for instance the Sindhu Raja fleeing and establishing a kingdom in the 7th Century. Most historical personalities

[12]Interestingly, faunal penetration from east to west in the Himalayas also extends as far as central Nepal. One such example is the red panda (*Ailurus fulgens*).

arrive as refugees, written sources document their arrival, and their exploits in detail. The sources never mention mass migrations of people as popularly imagined. The idea of mass population movements within a short period of time is problematic. In this empty land scenario, then the Tibetans arriving in west Bhutan would simply have filled up the land and carried on as in Tibet. The land tenurial system should reflect this similarity but it does not. Rather, a more sensible explanation is that singular Tibetans scholars, saints, and princes, arrive in Bhutan as refugees, bring "high Tibetan culture" and religion which is layered onto existing native practices.

Chhoki (1994) differentiates this habitus as the nexus between the "sacred" and the "obscene". The sacred is represented by Tibetan Buddhism which is adopted as the state religion while the obscene is the animistic religion that the people practice in the villages. Chhoki finds the coexistence of the two in a village in west Bhutan, she writes:
"The *nenjorm-pawo* [indigenous ritual specialists] themselves describe their complex as having native origins, in contrast to the monastic tradition which came to Bhutan from Tibet."

The prehistoric and historical landscapes of Bhutan can then be thought of as consisting of mosaics or patches of diverse peoples. This diversity is not only in space across the landscape but also in time and "depth". By this I mean that if we look under one layer of religion, culture, and land use practices, we will encounter other vibrant layers of local practices, as Chhoki's (1994) work makes clear. With this I attempt to build an analytical framework for exploring an alternative explanation below.

Mosaics and Connectivity

Mosaics are perhaps most simply and clearly described by E.O. Wilson (1995) in a forward to Forman's (1995) book "Land Mosaics: The Ecology of Landscapes and Regions:"

> “...the real world consists of finely fragmented habitats. The pieces range from radically altered urban parks and gardens to remnant pockets of the original environment. Across periods, living species arrive, impinge, dominate, yield, and disappear in this kaleidoscope. The vast majority of the inhabitants we never see, because they are too small and obscure: creepy-crawlies, immense in diversity, from insects to fungi and bacteria. All together, they are as important as the towering trees and the birds on which our attention is ordinarily focused.”

This conceptualization of land and landscape as patches or mosaics provides an understanding of the processes occurring on the human cultural and historical landscape in Bhutan. Forman (1995) explains patch as a "particular type that differs from adjacent land." A mosaic then is an aggregated pattern of patches, and within the patches there is internal microheterogeneity as well. Prior to Bhutan's unification (and even today), people constantly "arrive, impinge, dominate, yield," or migrate, changing the nature of the patches. The whole country was what Aris describes as "one valley kingdoms" with fixed and jealously guarded and well recognized borders (*sa-tsam*). On a larger scale these one valley kingdoms may be seen as patches on a complex landscape.

At a continental level, Bhutan is a mountainous frontier land rising abruptly from the Gangetic plains of India and ending again at the edges of the Tibetan plateau. Over the years, refugee kings, princes, priests, and monks fled to the safety of the mountains from north, south, east and west. An ancient name by which the Tibetans referred to Bhutan is *Lho-mon Kha Zhi*, roughly translated as the southern barbarian land of four approaches. So at this larger scale, the plains of India, plateau of Tibet, and mountains and hills of Bhutan may be viewed as three patches across which kings, saints, traders, and lamas moved both in and out of Bhutan as political, economic, and ecological circumstances demanded.

The comings and goings are recorded by Bhutanese, Indian, and Tibetan sources, scantily and in some cases with biased political motives. Patch dynamics can explain these patterns and processes even if the details of specific and particular events are unknown or unrecorded. For explicative purposes, history is thus released from the tyranny of the few and biased written "primary" sources. One can at least imagine what were the general patterns and processes across these landscapes.

By connectivity, I do not mean to impose a totalizing master narrative that unifies this diverse mosaic into a single monolithic understanding of Bhutanese national history. Connectivity in landscape ecology is understood as "how connected an area is for a process" (Forman, 1995), such as understanding how and why species "arrive, impinge, dominate, yield, and disappear" and how the people in these patches interacted with people from other areas. We know that they traded, exchanged ideas, fought, married, formed alliances, proselytized, sometimes destroyed each other, and eventually were unified into the peoples of the nation state of Bhutan. It is the legacy of these actions that is reflected in the land use systems and by extension provides an understanding into the "webs of signification" and into the webs of power relationships that existed.

People as ecological beings

In calling for a "humanist environmentalism" Cronon (1998) laments the nature and culture dualism with which Western societies view the world. He instead espouses a holism in which humans are intrinsically connected by complex webs of linkages and are a part of nature. Cronon (1992) writes:

> “...human acts occur within a network of relationships, processes, and systems that are as ecological as they are cultural. To such basic historical categories as gender, class, and race, environmental historians would add a theoretical vocabulary in which plants, animals, soils, climates, and other nonhumans become the coactors and codeterminants of a history not just of people but of the earth itself.”

This basic realization, though only recently gaining ground in Western thought through the efforts of postmodernist thinkers, has always been the way pre-modern peoples viewed their place in the world and in history. Chief Seattle's call is echoed worldwide and finds common ground with diverse beliefs from Hindu and Buddhist mythology to Dayak swidden cultivators. In a strange way then, the post-modern ideal is a lived reality of pre-modern peoples. Burch et al. (1997) have articulated this concept earlier and by now have developed the Human Ecosystem Model that is applied to urban ecology projects in Baltimore and New Haven and uses the concept of the human ecosystem. In the final section this approach is used to assess the feasibility of community-based conservation approaches in golden langur habitat.

For the task at hand, such a holism and connectivity allows for an ecological interpretation of history or as Worster (1992) writes, using "ecology to help explain why the past developed the way it did...this new history rejects the common assumption that human experience has been exempt from natural constraints."

Landscape Ecology, due to its integrative and spatial nature, is my choice from the various ecologies for the analysis. This provides an alternative way of looking at Bhutanese history because the narrative texts that exist are few and as Aris (1979) writes of one such text, the *Gyalrig*, "...the schematic preoccupations of a local historian can so color his writings as to alter the true order of reality."

The substantive nature of the narratives is not disregarded; they are the 'data' or evidence on which I will rely. However, the cause and effect interpretation is from an ecological and political economic perspective and not from "schematic preoccupations." (Although why Ngawang, the author of the Gyalrigs wrote what he did is of interest.) Narrative, as Cronon (1992) writes, "...succeeds to the extent that it hides the discontinuities, ellipses, and contradictory experiences that would undermine the intended meaning of its story. Whatever its overt purpose, it cannot avoid a covert exercise of power: it inevitably sanctions some voices while silencing others."

Layers upon layers, but still pockmarked

In this section I look first at the larger regional population dynamics of people from pre-historical times to the present. I will then try to explain what the origins of the people and the land use systems of Bhutan are using the regional analysis and spatial landscape patch dynamics. The underlying assumption is as presented of "millennia-long population movements [that] were gradual, dictated in large part...by a myriad of complex environmental, climatic, and entirely pragmatic factors." (Fagan, 1990). By this I reject the idea of local autochthony and instead depend on paleoecological evidence that has more or less established the east to west movement in the eastern Himalayas and the later historical evidence of strong Tibetan influence.

In the absence of written evidence, what the landscape would suggest is that the current identities of the various ethnic groups are a complexity of layers upon layers of history, as described above, and a single "pure" lineage and identity is not tenable for any of today's politically defined ethnic groups. By the same token then, the land use systems are a reflection of these layers and simple labels such as "feudalistic" do not capture the complex nature of land use.

Specifically, Tibetan influence cannot be discounted but neither can they explain everything. One can only conjecture that as Clifford writes "hybrids" are the norm, with Tibetan influences impinging on existing native "tribal" ones and in the mix producing a "uniquely" Bhutanese land use pattern and identity.

Maps of ethnic groups, as spatial representations of areas occupied by various ethnic groups, shed light on this pattern. Three areas are looked at, Bhutan, and immediately east of Bhutan to Arunachal Pradesh and further east to Yunnan in China.

Aris (1979) mapped the area occupied by three major ethnic groups in Bhutan. Grewal (1997) showed the spatial distribution of Arunachal Pradesh's 25 main tribes. Yunnan (Aris, 1992) also reveals a complexity of patches of over 40 ethnic groups. What is striking is that while the whole of Bhutan is spatially occupied by just 3 large ethnic groups, Arunachal Pradesh still has 25 tribes, and Yunnan, while the map shows only the Tibetan influenced tribes, still captures the local diversity. How can this striking difference be explained? Could the more diverse areas be the source and the less diverse areas be the sink areas to which people have migrated? An answer perhaps can be found by looking at Bhutan's languages. In Bhutan today there are 19 languages grouped under four main language groups; Central Bodish, East Bodish, and Bodic language of the Tibeto-Burman family and an Indo-Aryan language (van Driem, 1994). All this in a country the size of Switzerland. van Driem (1994) explains:

> "The linguistic situation in Bhutan is complex. Nineteen different languages are spoken in this Himalayan kingdom, which is only slightly larger than the Netherlands...The population numbers approximately 650,000 and there is no majority language."

The nineteen is a conservative grouping that can be divided further into dialects, literally by the major river valleys that flow north-south through the country. How can this situation be explained? If the analytical framework developed above is applied then one can imagine a "sacred language" made dominant through regional power dynamics and layering onto existing languages. Regional dominant lingua franca such as Ngalop in west Bhutan, Bumthap in central Bhutan, and Tsangla in east Bhutan may have gained ascendancy but not totally wiped out earlier languages. Thus a layer model emerges; there are subordinate local groups, dominated by a larger regional identity such as Ngalop, Bumthap, and Tsangla (the three major ethnic groups of Bhutan), which finally is overlain with a national layer, "Bhutan", extending across the entire country. Even in east Bhutan, popularly believed to be the original inhabitants, as explained above, if we look under the layer of the Tsangla language, various local dialects are discernible such as Dzalakha, Bramelo, Chalikha, Brokket and so on. Needless to say these language speakers are bilingual and trilingual, speaking their local dialect and Tsangla and the national language, Dzongkha. So Aris' (1979) map captured only the top layer of this diversity that is revealed in the linguistic survey.

In the same way then when related to land use systems, one can conjecture that on earlier local land use patterns and systems are layered a regional system, onto which is layered a national system. Thus the evolution of land use systems from tribal to feudal to modern is not supported. Rather, they exist all at the same time but in layers. Looking at the national level, the Land Act and various other legislations would seem to be in effect but digging a little deeper would reveal customary laws governing land use systems. The pattern of connectivity informs that there may certainly have been borrowing and exchanging but the model of one "original" system evolving into a multitude of others is not supported.

Conclusion

In this section, I have attempted to answer questions about the land use system in Bhutan. The first part debunks the popularly held view that land tenure in Bhutan was feudal. I do this by comparing Bhutan to feudalism in Europe and show that there are no similarities between European land tenurial systems during the Middle Ages and between Bhutan. I also look at Tibet, which does have several similarities to European feudalism, "Tibet offers great similarity in a few fundamental traits such as the importance of labor rent, the granting of land in return for services..." as Carrasco writes. I exposit that most western historians of Bhutan have been trained as Tibetologists and they favor Tibetan explanations for Bhutanese phenomenon. Their Tibetan bias has resulted in their labeling Bhutan as feudal, similar to Tibet. By looking at the lived experiences of peasants, as human agents at the nexus of social, political, economic, and ecological forces, one sees a more nuanced and complex picture of land use systems in Bhutan. In summary, rights in land are for the most part held in private although other arrangements existed alongside private property ownership. Monastic estates, and estates belonging to the handful of religious nobility were worked by tenured serfs. However as Aum Thinley Bidha's story shows, for the vast majority of peasants in Bhutan, land was private property.

The implication of this is that farmers in Bhutan have always made land use decisions themselves. There is no feudal lord to manage the estate. The state until the 1950s did not intervene in local resource use and management choices. But with increasing legislation and rationalization on a Western model, as recommended by development experts, local resource use was increasingly regulated by the state. Farmers lost common property resources such as pastures and community forests through such legislation. However, the state's lack of resources to monitor and enforce the legislations has created space for farmers to continue to manage the resources but within the constraints imposed by the legislations. Can farmers regain their historical resource use rights? The answer to this is difficult given the new dynamics and market forces in action. There is much to be gained for short term profit and the fear of losing all control over Bhutan's natural resources has prevented the state from moving towards handing over community forests back to the farmers. However, the important distinction is to be made between open access resources and common property resources. If the latter pattern is legalized then the former is not a threat since rights in the land and resource belong to a village and they are responsible for any decisions they make.

In Part II, I have tried to build an analytical framework for an alternative explanation. Rather than relying on the Tibetan and the empty land models, which are closely linked, I instead build a layer model. In prehistoric times, populations moved east to west in the Himalayas and in later historical times, rather than actual mass migrations, individual luminaries from Tibet and India coming as refugees mostly, brought religious practices and schools of thought which were established in Bhutan. This formed the "high" culture or "sacred" as opposed to the native animist beliefs and practices. Rather than supplanting earlier systems, the later ones were layered onto and integrated with existing practices. In contradistinction to a feudal system, historically land use decisions, especially regarding forests, have been made by the people themselves without major state intervention as is being done today. The past generations of villagers have bequeathed to us a pristine environment and it would be well worth the effort to learn from them and share the burden of managing and conserving Bhutan's natural resources. This is all the more compelling as the capacity of the government to protect the forests is limited, as explored in the next section.

Can the Government Protect the Forest?

Given the scenario so far, that people traditionally managed the forests and that the government nationalized all forests starting in 1952, it is appropriate at this juncture to ask if the government is capable of doing what the people had been doing up until 1952, especially since the I started with the question "Can local people manage their forests and common property resources on their own without government interference?" The answer thus far is a qualified yes. Yet Bhutan chose nationalization under the conditions that Hardin (1968) describes as relying on administrative law and bureaucracy to "spell out all" the rules and regulations when it took over the management of the forests. The advent of modernization of the economy and the country in general necessitated these changes. Natural resources were increasingly tapped as sources of revenue and a "command and control" approach was adopted to control access to forests and other natural resources.

Yet the language of bureaucracies in Bhutan is "lack:" lack of capacity, lack of infrastructure, lack of technology, lack of adequately trained staff, lack of funds, etc. to enforce these regulations. Are conditions are ripe for limited-access common-property resources to become free for all open access resources?

This section then consists of an institutional analysis of the roles, responsibilities, and capacity of the *Department of Forestry* (DOF), Bhutan, in the enforcement of forest protection rules and regulations and Monitoring and Evaluation (M&E) of sustainable forest practices. Since the *Ministry of Agriculture* (MOA), the parent ministry of DOF, has broader mandates for enforcement, monitoring, evaluation, and information management, detailed findings also concern MOA as a whole. Rules and policies governing the protection of forests exist as enshrined in the Forest and Nature Conservation Act of Bhutan, 1995 which is a much revised and updated version of the Forest Act of 1969. Successful conservation of habitats and species hinges on the enforcement of the Act. The MOA and DOF have interpreted the Act as empowering them with the "command and control" approach even though the Act can be interpreted as also empowering local communities with community management of forests. The recent moves towards a written constitution for the nation and devolution of powers to the villages and districts in essence devolves management and protection of local forests to the villages.

This topic is particularly relevant and timely, as there is political will and commitment at the highest levels of the Royal Government of Bhutan (RGOB) to conserve biodiversity as reflected in the many political speeches and policy documents. However, as an institution are the DOF and MOA, as the main actors mandated with "the command and control" of all forests in Bhutan, capable of doing this? If not what are the consequences? What are the strengths and weaknesses of these institutions and what are the threats and opportunities that exist? If the government is incapable of completely enforcing the forest protection rules and regulations, will it not make more sense to recruit the assistance of the people in the conservation of forests? Policy and legislation supporting either scenario exist at the moment. An in-depth study of both options is necessary. Particular attention is paid to the monitoring and evaluation capacity of the institutions since successful enforcement of the rules can be gauged through effective monitoring and evaluation of activities.

The first part of the analysis then deals with the broader setting. To gain a deeper understanding of the institutional functioning of the DOF, the work culture of the Bhutanese bureaucracy needs to be comprehended. The social, economic, political, and cultural context within which DOF functions largely determines the latter's outputs and performance.

Given this background, the existing institutional structure and organization of the DOF with regards to enforcement, monitoring and evaluation are presented in detail. Special attention is paid to the present system's strengths, weaknesses, opportunities, and threats. Analysis of DOF and other departments/divisions of MOA and their role in enforcement is done in an integrated manner emphasizing areas of cooperation and duplication. Special attention is paid to the broader context to bring about integrated approaches to addressing issues.

Finally, recommendations for closing gaps identified in the analysis are presented within the framework of the *Royal Government of Bhutan*'s (RGOB's) vision for the renewable natural resources (RNR) sector and the overall goal of conserving vital habitat.

To understand the institutional functioning of DOF in Bhutan, especially with reference to *Enforcement*, *Monitoring and Evaluation* (EM&E), it is helpful to consider the work culture of the Bhutanese bureaucracy. The social, economic, political, and cultural context within which the DOF functions largely determines DOF's performance and outputs.

In other words how successful is the DOF in performing and executing its "command and control" mandate? How are forest protection activities executed on the ground? What is the success rate? What are the challenges? How is responsibility delegated? How is accountability maintained? Is there transparency in decision making? Most importantly, how do these institutional strengths, weaknesses, opportunities, and threats influence environmental sustainability of forest management practices on the ground? These questions are better answered if viewed within the institutional and cultural context of the Bhutanese government.

Within this background context, the existing institutional structure and organization of the DOF with regards to monitoring and evaluation are presented in detail. The roles, responsibilities, and capacities of the various divisions of the DFS in monitoring and evaluation activities are studied.

The *Ministry of Agriculture*'s (MOA) *Planning and Policy Division* (PPD), the parent ministry of DOF, in theory has the mandate for monitoring and evaluating all MOA's activities, including forest protection and sustainable forestry management. PPD is also responsible for maintaining a central database and an information management system to gauge performance and provide success indicators among other things. The MOA's *Administration and Finance Division* (AFD) carries out monitoring of financial and physical progress. This is linked to the Royal Audit Authority's (RAA's) national level financial management role.

Analysis of these institutions and their roles in M&E activities is done in an integrated manner emphasizing areas of cooperation and duplication. Special attention is paid to the broader cultural context to bring about integrated approaches to addressing issues.

Finally, recommendations for closing gaps identified in the analysis are presented within the framework of *Royal Government of Bhutan*'s (RGOB) vision for the Renewable Natural Resources (RNR) sector and its strategies for enhancing good governance.

"Promoting Efficiency, Transparency, and Accountability"

In 1999, an initiative to restructure the entire RGOB's administration was started under the leadership of the erstwhile chairman of the cabinet and head of government, Lyonpo Sangay Ngedup. A strategy entitled "Enhancing Good Governance: Promoting efficiency, transparency and accountability for Gross National Happiness" was launched. Over a period of three years (1999-2002) this strategy aimed to "rationalize and recommend ways to further strengthen the Bhutanese bureaucracy, its structures and functions, guided by the three pillars of good governance: efficiency, accountability and transparency."

Underpinning the strategy is an assessment of the situation prevailing currently and a vision of the system that would be needed, ideally: "*the current practice of ad hoc and instruction driven action should give way to an effective and purposeful system of planning and monitoring*."

> The above quote can be interpreted as a felt need to shift from a traditional to a modern and rationalized bureaucracy within the Bhutanese context. A central feature would be to promote impersonal standards of performance and compliance, i.e., a change from a typical personalized superior - subordinate relationship, built on trust and loyalty, to a more rationalized system built on functional needs.

The change is seen as a proactive response to the critical and urgent issues that Bhutan will face in terms of organizing its bureaucracy:

- Update and strengthen legislation relating to governance
- Induce professionalism and integrity in the civil and public service
- Restructure and decentralize organizations
- Use information technology as an integral strategy to enhance efficiency and transparency

For example, in the Forestry sector the current system is oriented to measuring inputs (trees planted, seedlings distributed, plans completed) rather than outcomes and impacts (quality of plantations, increasing role of communities in fire prevention, biodiverse areas under effective protection).

In the traditional system, accountability, transparency, and efficiency are predicated by the trust and loyalty between supervisors and subordinates within the hierarchy. Other than the periodic physical and financial progress reports submitted for audit purposes, there is limited monitoring and evaluation of activities. For instance, only in exceptional cases are detailed reports and analyses submitted along with the bare minimums required in audit reports. These reports are submitted sometimes only when the Royal Audit Authority issues an "audit memo" and investigates an activity in detail, or when an "explanation" is requested by a supervisor (which indicates a break in the relationship – the subordinate no longer having the trust of the supervisor).

In the current system, multiple checks and balances exist prior to funds being released for an approved activity but outcome monitoring to determine the impact of these investments is very limited. Project implementers (PI) spend too much time in Thimphu, processing approvals for releases for activities already agreed to in annual work plans and in memoranda of understanding signed between donors and the RGOB. Donor agency funds lie with the *Ministry of Finance* (MOF) yet the PI must initiate release of these funds by writing a new budget report and submitting it to the MOF after receiving approval from their own parent ministry. The MOF issues a budget code that should take only a day, but can take weeks or months if the PI does not personally follow up. Once the codes are sanctioned, then the AFD of the parent ministry is requested to ask for the release of the funds from the MOF. The MOF credits the AFD's bank account with the funds requested and the PI then has to ask for approval of release of these funds from the AFD after technical and financial sanctions are granted by the head of the department.

The PI must constantly follow up with copies of the approvals since the AFD is notorious for misplacing approved documentation. The PI cannot afford simply to write a letter requesting fund release and hope the release takes place on schedule. In many instances the PI's head must personally carry the documents from office to office and desk to desk.

However, once the funds are released there is no monitoring mechanism in place. Apart from the boxes filled out for the annual progress report submitted to the

AFD and the RAA, there is no other M&E mechanism. For instance, if the *Forest Management Unit* (FMU) manager has the trust of the supervisor, then the manager is expected to follow proper management guidelines detailed in the annual operational plan for that FMU. The territorial *Divisional Forest Officer* (DFO) who has the responsibility for monitoring FMUs cannot in most cases do so because of a lack of staff with the professional capacity. Also, the judgment and loyalty of the FMU manager is being questioned should the DFO decide to monitor a particular FMU.

MOA, citing an existing *Royal Civil Service Commission* (RCSC) rule, has recently issued a circular that states that since monitoring activities are limited or non-existent, staff who have been in the same post for more than five years should be transferred to other posts and locations. The circular states that such transfers will prevent staff from unethical practices [13]. This also implies that there is no way of knowing how successful the DOF is in providing protection for the forests of Bhutan under the command and control approach.

Of particular interest to systematizing monitoring and evaluation is RGOB's restructuring of the *Planning and Policy Divisions* of all the ministries to include Monitoring and Evaluation Sections (MES) by March 2000 [14]. The strategy reads that "all ministries must be structured in such a way that there is uniformity in its basic structural components" and that authority and accountability are streamlined. It

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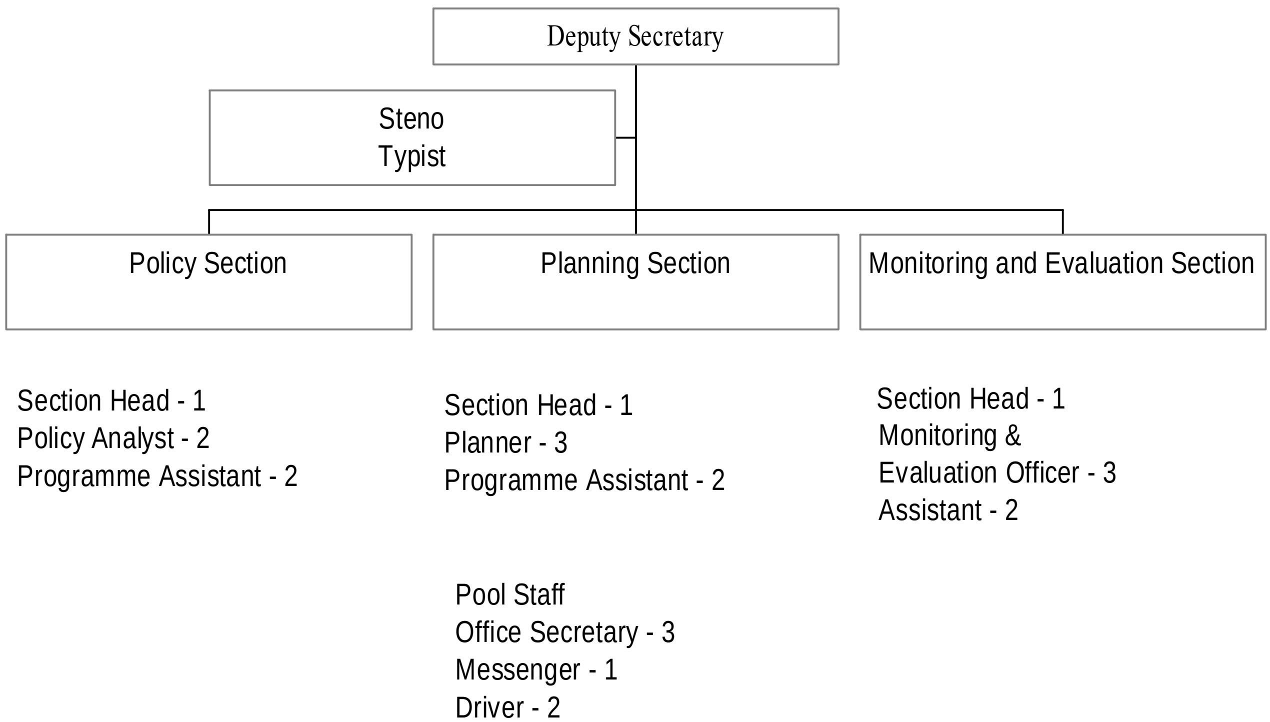
[13] "Rotating agents functionally and geographically" is one among many standard recommendations from organizations such as *Transparency International* and the *Center for Institutional Reform and the Informal Sector* at the University of Maryland. It is generally recognized "that corruption is a problem of sick systems more than it is one of immoral individuals" and creating incentives for positive behavior can be a more efficient method of reducing corruption (raising salaries, improving career paths, etc.) (http://www.inform.umd.edu/EdRes/Colleges/BSOS/Depts/IRIS/IRIS/publications/doc/tkzzann2)

[14] Scheduled for implementation by March 2000, the MOA – PPD is still in the process of restructuring and it is probable that the current Statistical Unit may be upgraded to MES. Plans for filling the positions, budget for staff training, and implementation programs are forthcoming.

also says “with the specification of the extent of administrative and financial powers attached to a post, a clear hierarchy for reporting and well-defined responsibilities in meeting organizational goals will enhance efficiency.

Figure 3.3 below shows the standard organogram for a Planning and Policy Division with a new Monitoring and Evaluation Section.

Figure 3.3: STANDARD STRUCUTURE OF
A POLICY AND PLANNING DIVISION (PPD)



In summary, RGOB's ongoing restructuring exercise will have a direct bearing on monitoring and evaluation of forest protection activities as detailed above through the general change in the style and content of management.

Institutional Organization of the Department of Forestry and Monitoring and Evaluation

The Department of Forestry Services (DOF) presently consists of four divisions and is mandated with the responsibility of protecting and managing Bhutan's forests on a sustainable basis. DOF "provides for the protection and sustainable use of forests…of Bhutan for the benefit of present and future generations." (Forest and Nature Conservation Act, 1995).

DOF has both an environmental conservation and a forest management function. DOF is also the only agency charged with on-the-ground management of Bhutan's forests and protected areas. Other conservation agencies in Bhutan, both governmental and non-governmental, play advocacy, financing, and policy formulation roles [15]. This means that DOF has jurisdiction over 72% of the land area of Bhutan corresponding with the area under forest cover[16].

DOF's role has evolved over the three and a half decades it has been in existence. The department was initially started to harvest the rich timber resources along the country's southern border with India, and was mainly staffed with managers and advisors

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[15] The *Royal Society for Protection of Nature* (RSPN), *World Wildlife Fund* (WWF) – Bhutan Program, Bhutan Trust Fund For Environmental Conservation, Netherlands Development Organization (SNV), Danish International Development Agency (DANIDA), National Environmental Commission etc., are some other prominent actors in Bhutan's conservation efforts.

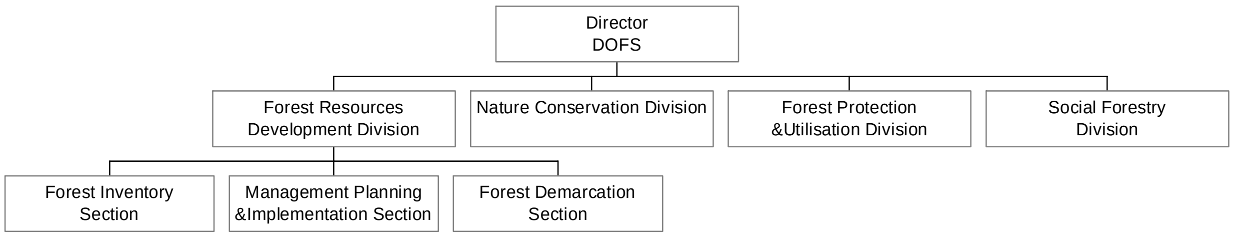
[16] Conflicting roles over mineral rights such as quarrying and mining permits often arise with the Department of Geology and Mines of the Ministry of Trade and Industry.

from the Indian Forest Service [17]. In 1964, the first scientific forest management plans were approved for implementation. In 1980, the harvesting role was taken over by the newly-created *Bhutan Logging Corporation* which was subsequently renamed the *Forestry Development Corporation* (FDC). DOF itself has also undergone several name changes from Department of Forestry to Forestry Services Division in 1991, to Department of Forestry Services in 2000 to back to Department of Forestry in 2002.

DOF's conservation and forest protection role has gained increasing prominence over the last decade as environmental conservation emerged as a key national objective. Below, the roles of the specific divisions of the DOF, especially in relation to monitoring and evaluation, are discussed. Figure 3.4 shows the DOF's latest organizational structure (Sept 2004). The four sections of the *Forest Resources Development Division* (FRDD) are also shown since this division plays the most important role in the monitoring and evaluation of sustainable forestry management activities.

[17] Even today DFOs continue to be trained at forestry institutes in India. Forest rangers are now being trained at the Natural Resource Training Institute in Bhutan. The DFS is presently fully staffed by Bhutanese.

Figure 3.4: Organization of the Department of Forestry (with FRDD elaboration)



The Nature Conservation Division (NCD)

The *Nature Conservation Division* (NCD) is emerging as an important structure mandated with the management of the protected areas network of Bhutan. Currently this consists of 9 protected areas and 8 biological corridors linking the PAs and in total covering about 34% of the country. Only five of the protected areas are actively managed under current projects with future plans to bring all PAs under management. The park managers of the PAs are considered at par with the Divisional Forest Officers (DFO) who manage the territorial divisions. All forested areas outside of the PAs are under the jurisdiction of the territorial DFOs who report directly to the Director, DOF. The five park managers report to the Head of NCD, thereby creating a parallel hierarchy to the DOF/DFO hierarchy. Some staff feel that the sometimes conflicting conservation and logging goals of the DOF are reflected in this parallel hierarchy.

NCD is also a relatively young structure, established in 1993 from the erstwhile Northern Wildlife Circle. In terms of organizational maturity and establishment, FRDD is more advanced with the three functional sections established since 1987 (Figure 3.4). NCD has since 2002 allocated responsibilities to three specialized sections along the lines of FRDD's organization, i.e. Biodiversity Inventory and Survey Section, Management Planning and Integrated Conservation & Development Section, and Species, Research and Monitoring Section (SCREAM).

Specifically, NCD plans to develop M&E activities for biodiversity through the establishment of the SCREAM section described above. A GIS unit, equipped and staffed with two technicians, is currently in place. An Information technology graduate has been trained at the Master's level. Also, an ecologist will be recruited and trained to head the Research and Monitoring Unit soon. Two plant taxonomists and a trainee ornithologist are available for work as and when required.

The Forest Resources Development Division (FRDD)

The *Forest Resources Development Division*'s (FRDD's) main objectives are to ensure a sustainable supply of timber and fuelwood for the people of Bhutan, and to allocate timber for value-added forest-based activities, including activities based on Non-Timber Forest Products (NTFPs)[18].

Since the mid-1960s, DOF has prepared forest management plans that were "devoted to timber harvesting alone" (FRDD, 1999). Starting in 1973 with UNDP and FAO assistance, the scope of the management plans has broadened to incorporate social and environmental concerns. Monitoring and evaluation for sustainable practices emerged as an important management tool. Subsequent projects therefore aimed at improving FRDD's institutional capacity for sustainable management planning and monitoring. By 1987, FRDD was fully functional with staff skills and capacity ranging from GIS, aerial photo interpretation, map production, and data management, to management plan implementation support. FRDD's staffing pattern and organizational structure from 1998 onward shows its relatively advanced state in terms of institutional development *vis-à-vis* other structures.

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[18] The MOA's National Mushroom Centre, The National Women's Association of Bhutan's bamboo handicrafts development and marketing project, the National Institute of Traditional Medicine's herbal medicine production, and the Tashi Group of Companies Rosin tapping activities are some other institutions involved with NTFPs in Bhutan.

FRDD has responsibility for developing management plans. This responsibility is currently handled primarily from Thimphu. However, there are plans under way to decentralize this process and develop the requisite skills at the local level. FRDD's capacity to produce good management plans is recognized. But actual implementation of these plans is still an issue. Decentralized planning may result in better implementation. Each territorial division is envisioned to develop its own management plans by the end of the 9th five year plan in 2006. FRDD will continue to provide technical backstopping.

Despite FRDD's significant resources and capacity, monitoring and evaluation still remains weak with only one Range Officer assigned to this important task even today. There is also increasing pressure from the *National Environment Commission* (NEC) to monitor FMUs better. According to the *Environmental Assessment Act* (EAA, 2000), FMUs are classified in Category A requiring full-scale environmental impact assessments (EIAs). The EAA also states that FMU management plans should serve as the EIA report and the competent authority to conduct the EIA is the FRDD.

The guidelines established by the National Forest Policy (1995) are observed closely by FRDD in preparing FMU management plans and thus meet some of the requirements of an Environmental Impact Assessment. These guidelines are based on the following elements:

- Forests must be managed for long-term sustainable yield with allowable cuts based on inventories and scientific growth and yield studies.
- Forest harvesting should ensure environmental protection by minimizing soil erosion, land degradation, protecting natural drainage, and avoiding permanent changes in the composition of vegetative species.

- Forest roads must be built to strict standards (moderate inclines, adequate drainage, appropriate use of bioengineering to control land slips).

However, the limited monitoring is a weak link in the planning and implementation process that can undermine goals of sustainability as shown in the next section.

Planning, Implementation, and Monitoring

FRDD's planning and implementation activities are summarized in Figure 3.5. Briefly, FRDD inventories forest resources, prepares management plans that are approved successively by DOF's Director, MOA's Secretary and MOA's Minister. The territorial DFOs then have the responsibility of preparing annual operational plans based on the management plan. DFOs demarcate the harvesting areas and selectively mark trees for extraction. They subsequently contract FDC to implement the harvesting protocol (FDC also markets timber through open auctions).

1. DFOs are the "overall responsible officers for the implementation of the management plan" (FRDD, 2000). They form a critical link in the chain of planning, implementation, monitoring, and reporting. Specifically, in terms of monitoring, the physical, financial, and environmental monitoring forms[19], are currently required to be submitted on an annual basis to FRDD. These monitoring forms are meant to be prepared nationwide and not to be limited to the present logging area. The DFOs have the responsibility for scoring the forms after field visits of each FMU in their area.

2. Two training workshops for DFOs and their staff have so far been conducted, one in Thimphu and the other in Bumthang, in the use of the monitoring forms. Some DFOs see the monitoring forms as an added burden to their already heavy responsibilities. Others

[19] "An environmental monitoring and evaluation system for use in FMUs in Eastern Bhutan: Forms and Instructions for their use."

said that between filling out progress reports and forms for the various donors and RGOB's own forms required for the programmatic review of the five year development plans, things get confusing. Yet others said that the FRDD monitoring forms were simplified to the point of losing specific information from particular FMUs. Also, some were not sure what the acceptable cutoff scores were on the FRDD forms[20]. The lack of baseline data to compare current scores *vis-à-vis* historical scores was another issue especially with project related activities. Without a baseline, impacts cannot be clearly attributed to project activities. 2001 was the first time that the forms were filled out in the field and submitted nationwide. However, FRDD admits that the consultant hired to help in designing the forms has not yet provided full instructions for analyzing the reported scores.

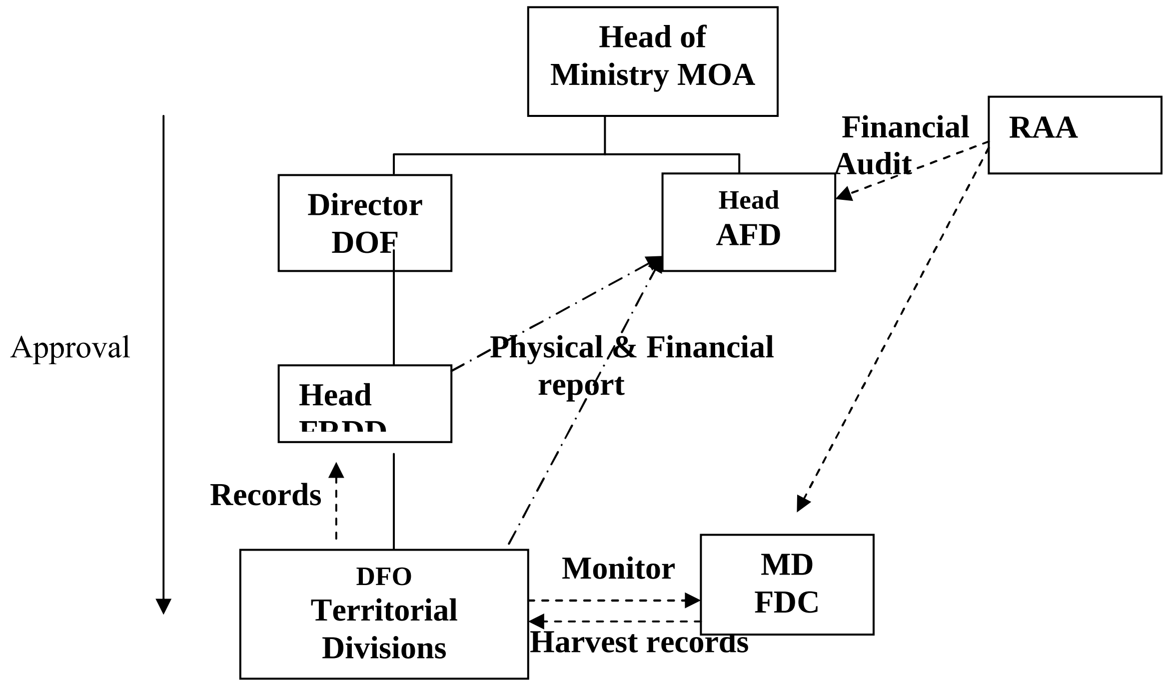
In reply to how DFOs could be more responsive to monitoring and reporting many said that monitoring needed to be accepted as a regular day-to-day task acceptable to the work culture of DOF. This means that the technical aspect of monitoring and evaluation needs to be stressed so that M&E is not seen as a means of judging personal performance of individual managers. Also, some called for more training both to achieve competence and foster acceptance.

Practical benefits of monitoring should be further developed and refined so that DFOs find the output highly useful for their own information and management decisions. For instance, one particular example is the issue of permits for firewood in urban areas. Lack of monitoring prevents DFOs from making confident decisions about the allocation of firewood so they resort to haphazard guesses at the risk of over-exploitation of a

[20] In a nutshell, the monitoring and evaluation forms use scores arrived at after conducting simple measurements along forest roads, cable crane lines, and assessing for wildlife use and human needs.

particular supply area. Information from regular monitoring precise trends, yields, and availability can reduce risky decision making.

Figure 3.5: Approval and reporting in Forest Management



Returning to Figure 3.5, FRDD and territorial DFOs independently maintain physical and financial progress reports that are submitted to AFD which in turn accounts to the Royal Audit Authority. The RAA also audits the FDC directly. Other than the linkage through the territorial DFO, there is no other way of monitoring the activities of FDC, which is primarily a contractor. A memorandum of understanding between the FDC and DOF has been developed to streamline management issues, especially with regards to FMU extraction activities. For instance, if FDC deems an FMU to be unprofitable, it will not operate there even though FRDD sees it as a part of its sustainable management activities. In other words, there is no mechanism or enforcement legislation that requires contractors to meet sustainable forest guidelines.

3. The planned gradual privatization of FDC operations is of particular relevance in this debate. There is a plan for increased use of private contractors to carry out felling, extraction and transportation of timber resources. For instance in Thimphu and Paro winter heating wood is privatized and contractors bid for supply of wood from "forest to door." The experience so far has been mixed with some contractors maximizing profits through unsustainable practices. The lack of monitoring allows such practices to flourish and without increased capacity for monitoring, privatizing is a risky option. Any further privatization should be accompanied by improved monitoring to check unsustainable practices, to identify repeat offenders and to bar non-conforming individuals and firms from bidding on future contracts.

Another mechanism that has been used effectively in other countries is the use of a 'performance bond' that requires contractors to agree to a stringent set of guidelines for extraction and to deposit funds in the bank as a guarantee. If the guidelines are not adhered to, then the funds are kept by the government. Also, repeat offenders are barred from bidding on future contracts.

Rural Timber

Rural timber and firewood supplies are allocated on an individual requirement basis are not planned. DFOs currently manage these supplies directly as and when requests from the rural people are received following processing through the dzongkhag (district) administration. Records of timber allocated are maintained in the registers of the DFO and range offices under their jurisdiction. Within the protected areas, the Park Managers have the responsibility for allocating rural timber requirements. However, only limited use of these records have been made so far for planning and forecasting purposes. This is in part due to the difficulty in retrieving and analyzing the data filed on paper and stored in the various range, division, and park managers' offices. Also, unwillingness on the part of implementers to show their records, and thereby reveal inefficiencies may play a part.

The transfer of rural timber control to the districts from the DFOs may result in even less monitoring. In this regard, there is a proposal (RGOB, 1999) that requires DOF to decentralize sanctioning of rural timber for house construction and firewood to the dzongkhag or district administrations. The proposal reads as follows:

> "The present procedures of sanctioning of both fuelwood and timber for rural housing by involving the gup, dzongkhags, ranger, and DFO, who are at different places, are too cumbersome for the people. The authority to sanction them will be given to the dzongkhag so that the permits can be given from "one window" or the dzongkhag range office."

This of course means that the DOF's authority in controlling forest resource use by the largest consumer, the rural populace representing more than 80% of the total population, will be transferred to the district administrations. Implications for monitoring and evaluation for sustainable management are discussed below.

The DFOs feel that they will not have the full picture about how much and from where timber is being allocated. The present rural timber management, through both formal and informal reports from the range and beat offices to DFOs, allows the latter to have estimates of timber allocation and make decisions accordingly. If the issuance of permits is controlled by the dzongkhag administration, DFOs fear that they may not receive this crucial feedback.

On the other hand, rural people will certainly benefit from having all the paperwork taken care of through a "one-window" approach. Also, an opportunity to decentralize monitoring and evaluation of rural timber allocation exists if the dzongkhag forestry officials are motivated to do so. This is discussed in the recommendation section. The important point is that for rural timber allocation, there is no management planning and this is a huge gap that needs to be filled.

Staff and Infrastructure

Nationwide there are 1,088 full time staff working for the DOF; of this about 70 are clerical and another 150 are in managerial posts. Field staff who should be able to conduct enforcement and anti-poaching patrols and activities number 523 rangers, deputy rangers and forest guards in the territorial divisions and 138 wardens, deputy wardens, and park guards with the protected areas (DOF, 2001). This is about 661 field staff for the entire nation to conduct the "command and control" operations in the field. Since there are about 30,000 km^2 of forests in Bhutan, each field staff on average has to cover an area of about 46 km^2 regularly on their beat. Also, the total population of Bhutan is estimated at 700,000 people (Planning Commission, 2002). This is about 1,059 people per forestry field staff that need to be monitored on a regular basis under the command and control approach.

Since the terrain is rugged and most of the forestry offices are near roads and urban areas, forestry staff rarely are able to cover the entire area they are responsible for. For instance in the Chamkhar river basin of Zhemgang, most villages are 5 to 10 days difficult hike from the Ranger's offices. The ranger and his staff from Zhemgang town therefore are able to make an annual visit in February of each year during which they take care of business. The main activity is the issuance of permits for timber for house construction and firewood to the rural populace. However, another significant activity is the enforcement of forestry rules and regulations. This is done largely through the imposition of fines for illegally felling trees. The people then await the annual visit with a mixture of dread and anticipation; dreaded by those who could not wait for the foresters to arrive and had cut down trees for various purposes (some for genuine reasons such as losing a house to fire and requiring timber immediately to rebuild, others not quite patient enough to wait for the foresters). An agreement is signed every year whereby the villagers inform the Ranger in Zhemgang of the best time to come and "mark" the trees for felling in their village. The villagers had chosen the dry months of winter when there is less agricultural activity. Available time and fine weather are conducive to working in the forest and for seasoning the timber.

The Information Management System of the Ministry of Agriculture and Monitoring and Evaluation

The Ministry of Agriculture has a Monitoring and Evaluation Unit (MEU) concerned largely with national level agricultural data collection and statistical records production. The unit is placed under the Planning and Policy Division to provide support for monitoring and evaluating the programs of all the agencies in the MOA, including DOF. The unit is also supposed to provide services to all departments of the MOA rather than each one having independent RNR information management systems.

The unit is small, with five staff headed by an agricultural economist and currently one is pursuing a graduate degree in statistics. The unit is otherwise well established in terms of having adequate data storage and analyses capacity.

Data collection is done through the use of RNR staff posted in the districts. Questionnaires developed by the PPD are distributed to RNR sector heads in the dzongkhags. These consist of the *District Agriculture Officer* (DAO), *District Forestry Extension Officer* (DFEO), and the *District Animal Husbandry Officer* (DAHO). Each of these officers will have three or more extension officers in each sector posted out in the villages wherever there is an RNR center. An extensive network of people covering all the 20 districts and reaching even the remotest villages is tapped into by the MEU.

The constraints faced by the central MEU are in data entry into their database due to the large amounts of data (sometimes 70,000 questionnaires) having to be processed. Each district is equipped with a single computer which at this moment are not networked to each other or to the central MEU.   In the near future they may have more computers, more people trained in the districts in the statistical software, and the databases networked for easier flow of information. Another constraint is data collection at the grassroots; extension officers are few in numbers and have limited resources; they are typically overloaded with work and are not trained as enumerators.

As already pointed out, the main concern of the central unit is with measuring and analyzing food crops and livestock production data in the districts. The FRDD has had two rounds of meeting with the PPD and the MEU to discuss forestry data collection. Because of the crop and livestock focus of the Unit, the Statistical Unit sees itself as not having the capacity to collect specialized forestry data at the moment. The commercial FMUs and the forms developed for their monitoring and evaluation are seen as specialized functions of the DOF. However, opportunities for monitoring rural timber allocation and conducting simple evaluations are possible.   This is discussed in the recommendations section below.

SWOT Summary

A summary of the observations of the analysis is presented in the tables 3.7 and 3.8 below using the Strength, Weakness, Opportunity, and Threats (SWOT) format citation?. The tables highlight some of the most important points from the observations and analysis so far. The strengths and weaknesses describe the current situation whereas the opportunities and threats show future possibilities. The table is divided into a macro-level and micro-level analysis to highlight issues at a broader (e.g. national level) and specific (e.g. departmental) levels respectively.

Table 3.7: SWOT Summary at the Macro Level

Macro-Level Analysis	**Weakness**	**Strength**	**Opportunity**	**Threat**
Institutional Aspects	1. Limited M&E of activities, M&E is project driven. 2. Work culture equates monitoring with mistrust. 3. Ad hoc data collection 4. Lack of coordination 5. Ad hoc and instruction driven action.	1. Trust and Loyalty relationship fosters efficiency. 2. Political will to create effective and purposeful system of planning and monitoring.	1. Reform exercise of RGOB to strengthen the bureaucracy underway.	1. Lack of monitoring and evaluation could lead to loss of valuable habitat.
Human Resources	1. Inefficient use of available pool of staff 2. Acute need for training 3. Duplication of efforts	A large number of well-trained, knowledgeable, and concerned employees.	1. Deep pool of graduates and other skilled potential workers available	Skilled employees might move to other agencies.
Policies	1. Staff rotation seen as antidote to corruption.	1. National Forest Policy establishes guidelines for management plans centered on sustainability 2. Environmental Assessment Act requires full EIA in FMUs 3. Forest and Nature Conservation Act emphasizes "conservation before profit."	1. Top leadership committed to good governance through efficiency, transparency, and accountability. 2. Decentralization policy can lead to community management of forests and local M&E.	1. Lack of clear rural timber management policy can lead to misuse.

Table 3.8: SWOT Summary at the Micro Level

Micro-Level Analysis	**Weakness**	**Strength**	**Opportunity**	**Threat**
Physical	1. Currently measures inputs (trees planted, plans written) rather than outcomes and impacts		1. Trained DOF staff can act as trainers for physical, financial, and environmental M&E.	
Financial	1. Complicated and lengthy procedures for release of funds creates bottleneck in implementation	1. Trust and loyalty and "transparent society" highlights blatant misuse. 2. Audits regular and mismanagement penalized.	1. Improved monitoring can lead to decreased emphasis on pre-release controls and audits.	1. Lack on monitoring and evaluation can encourage unethical practices and obstruct accountability.
Environmental	1. Lack of M&E creates ambiguity and confusion about existing ecosystem health. 2. Lack of information hinders proper planning and accurate forecasts.	1. Monitoring forms for FMUs developed by TFDP / FRDD and DFOs trained. 2. Harvest records maintained for all legally issued timber permits.	1. Harvest records can be used for management decisions if retrieved and analyzed.	1. Lack of M&E can result in loss of habitat. . .
Institutional	1. M&E not prioritized	1. FRDD long established with streamlined roles and responsibilities.	1. PPD has MEU as part of restructuring activities. 2. MEU of PPD can backstop data analysis, Dzongkhag RNR and communities for role in M&E.	1. Rift in conservation and harvesting goals of DOF.

Discussion

As the analysis above reveals, the DOF is not in a position for complete command and control of all of Bhutan's forests and wildlife. Will the DOF ever be in a position for complete control? In *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, Scott (1998) shows the need for states to simplify the complex in order to exert control. For instance, when scientific forestry was first developed in Germany, diverse, complex and "chaotic nature" was converted into manageable monocultures of single species. Monoculture forestry however resulted in disasters or forest death where entire forests died out. Similarly, for a state to then inflict "full-fledged disasters" on their forests Scott says four conditions are necessary: the "administrative ordering" and simplification of nature and society, a high modernist ideology, an authoritarian state, and fourth a "prostrate civil society" unable to resist the state. To this I would add the need for large amounts of surplus funds at the state's disposal. Fortunately,

due to limited funds, bureaucratic inefficiency, technological limitations and "high modernist ideology" unable to be translated into reality, Bhutan is spared such large-scale disasters even if the state desperately wants to have money, technology, and wants to be modern.

In terms of natural resource management, this means that the State in many third world countries can never completely rationalize and simplify nature or society for easy management. Nature is always complex and confounding, and a common lament of third world countries is the lack of "institutional capacity" to manage nature effectively.

Democratic Resource Management

From field studies in India, Agrawal (1998) identified four essential components for successful management of forests by local communities: "representative and accountable local institutions, regular and open elections within local institutions, local metering, monitoring, and sanctioning, control over resources by community institutions, and federated organizations of community user groups." In this section I look in detail at the capacity of local communities to manage forests. The question here then is "can local people manage the forests?" as a counter question to the one raised above "can the government manage the forests?" Traditionally, local people were the managers and stewards of Bhutan's rich forest resources, however with vastly changed circumstances both in terms of the economy and government policies, an in-depth look at community institutions that currently exist is needed. They are not looked at in isolation but within the local and national political context within which they operate.

Leo Rose, in his seminal 1977 work *The Politics of Bhutan*, observes that there is "no other political system presently extant with which the Bhutanese polity is comparable in either its 'traditional' polity or its process of political development." The new head of government in 1998 and chairman of the elected Council of Ministers spoke of a "unique" political system and democratization process in Bhutan, and former Prime Minister of India I. K. Gujral writes that "the people of Bhutan are fortunate in having as their monarch a man who has attributes of Plato's philosopher-king." (CBS, 1999). Also, in 1977 Rose explained that local village administrations could be characterized as "semidemocratic" and that this "is an important factor in Bhutan's polity, for it explains the broad degree of village autonomy that has long been a feature of the country's political system." In contrast, Rose observed that at the national level, the "decision-making process within the Royal Government continues to be a very narrow one, involving only a small number of officials." This tension between the local democratic village polity and the national government is, in part, the reason for Bhutan's unique political system and contains the potential for genuine democratic development and management of forests by the local people. Pema Dema, a 58-year-old woman from Tamshing in Bumthang, on being elected *chimi* (a people's representative) to the 76th session of the National Assembly in 1998, had this to say: "I am very happy to be here and will try my best to bridge the gap between the government and the people." (Kuensel, 1998).

Building on the framework provided by Rose, the following questions are raised: What is the gap between the people and the government? And what are the necessary and sufficient conditions conducive to a democratic order at the national level, and, as Robert Dahl (1956) writes, in the "individual's behavior system?" I will explicate these questions in the Bhutanese context, using a Dahlian analytical framework: that historical, economic, social, cultural, and political forces act like a "three dimensional web . . . of interconnected strands" (Dahl, 1989) either to facilitate or impede a democratic order and democratic resource distribution, access, and management systems.

Bhutan provides a unique situation where these questions can be empirically analyzed. In various depictions by Westerners and others, Bhutan appears generally either romanticized as a "Shangri-La," a hidden paradise on earth, or vilified as a tyrannical and medieval kingdom. A brief historical analysis will allow us to begin to move beyond this simplistic dichotomy toward a deeper understanding of the politics of resource management in Bhutan.

In landmark National Assembly proceedings in 1998, King Jigme Singye Wangchuck relinquished his role as head of government to the chairman of the cabinet. The cabinet itself was reconstituted with the retirement of formerly appointed cabinet ministers and the election of a new set of ministers by the National Assembly. The Assembly was also empowered with the authority to pass a no-confidence vote on the monarch. These changes were initiated by the King himself and resisted by many in the Assembly, with one member asking, "If it is not broken, why fix it?" To which the King replied, “The future of the country must not be compromised for one individual’s convenience; we must always give more importance to building the institution,” (NAS, 1998).

Given Bhutan's political history, these structural changes are significant. Since the unification of the country by Shabdrung Ngawang Namgyel, who first unified Bhutan into a nation-state in 1616**,** and the creation of a dual religious/secular system of government, the succession of the secular rulers (Druk Desi) was fraught with difficulties. The position was non-hereditary, and no smooth mechanism for succession was ever worked out. The country thus endured constant civil war, plots, and counterplots, and no less than 54 Druk Desis held office between 1651 and 1907. More than half failed to serve a full three-year term, with many meeting "violent death by sword, poison, or it is claimed, by magic” (Aris, 1994).

By 1845, Jigme Namgyel emerged as a powerful player in the intense and vicious game of succession politics. By 1860, he had won the secular rulership and consolidated his hold over the country although it was only in 1870 that he formally assumed powers as the 51^{st} Druk Desi. At his death in 1881, almost the entire opposition had been pacified by force. But it was his son, Sir Ugyen Wangchuck, who reunified the country, using methods that "promoted harmony and consensus." He also mediated a critical dispute between the British in India and Tibetan authorities, for which service he was knighted.

In 1907, the first hereditary monarch was elected unanimously by an assembly of the "abbot, teachers of the monastic community, the ministers of the council of state, regional governors . . . and the headmen of the public of each district." (Aris, 1994). Assembly members or "witnesses" sealed their personal consent to the Contractual Agreement of Hereditary Monarchy; significantly, it read (translation from Aris, 1994):

> "Now therefore a contract has been drawn up in firm conclusion containing a unanimous agreement . . . made evident to all gods and men, that Sir Ugyen Wangchuk, the leader of Bhutan and Tongsa Penlop, has been empowered as hereditary monarch . . . accordingly we the above mentioned lamas and officials, subjects and followers, great and small, shall place our loyalty and render service and honor to the king . . . and to the succession of his royal heirs. If otherwise there should be any kind of accusing talk arising from evilly disposed rumour or false gossip, then such persons are to be expelled from the common fold."

This contract between the ruler and ruled legitimized the authority of the king, and Aris writes that it was a "voluntary undertaking entered into by free negotiation" to end the "incessant feuds" of succession and "above all else to achieving lasting peace."

Under the aegis of this lasting peace, the third king, Jigme Dorji Wangchuck, the "father of modern Bhutan," initiated key processes of democratic institutionalization in 1953 by convening the National Assembly, drafting the *Thrimshung Chenmo* (Supreme Laws), and later, establishing the Royal Advisory Council. Ura (1994) writes that such changes derived from the existence of "an enlightened and progressive monarchy. There was no domestic political compulsion or pressure for reforms. The impulse for reform originated in the monarchy itself."

The reforms have been continued by the fourth and current king, with the most notable ones being the King relinquishing his role as the Head of Government, the National Assembly empowered with the authority to pass a no-confidence vote on the monarch, and the drafting of a written constitution, started in 2002. The same year, two significant acts, the Dzongkhag Yargay Tshogdue Chathrim (District Development Committee (DYT) Act) and the Gewog Yargay Tshogchung Chathrim (Block Development Committees (GYT) Act) were passed by the National Assembly to facilitate decentralization of political power to the grassroots level. One could view these acts as the fruition of a process initiated in 1981 when the King first established the DYTs and individual development plans were prepared for all *dzongkhags* (districts). Considerable administrative and financial powers were given to *dzongkhag* administrations.

Another historical circumstance that has affected Bhutan's political development was that the vast majority of the people privately owned their agricultural land in contradistinction to a feudal system as discussed above (Wangchuk, 2000). The non-hereditary nature of the ruling elite, until the creation of the monarchy, prevented any consequential aristocracy from forming. The absence of an aristocracy and past feudal lords, and villagers empowered with private land ownership greatly fosters the democratic transitions seen today in Bhutan.

Using Dahl's (1989) empirical approach and Rose’s (1977) local-national distinction, this section develops three theses and a critique to explore the meaning of democracy and democratic resource management in Bhutan. I argue that given Bhutan's historical and social circumstances, (1) village society is democratic, (2) the state administration is bureaucratic and authoritarian, (3) the state can be democratized by formalizing customary institutions, and finally, the initial notion that village society is fundamentally egalitarian and democratic is critiqued.

Utilizing a single monolithic explanation, as the Western media is fond of doing, confuses rather than clarifies the forces operating on the politics of resource management in Bhutan. Instead of looking at the country as a single entity, I will instead unpack the layers of existing social and political relationships to present a nuanced description for the "habitus—the liv[ing] environment compris[ing] practices, inherited expectations, rules . . . norms, and sanctions" that constitutes the totality of Bhutan's political context (Thompson, 1991). Finally, the options for democratic transition and decentralized resource management opportunities will be explored. Bhutanese people and society value democratic principles of justice, liberty, and equality, but the philosophical basis and justification for these ideals differ from those in Western Europe and America.

Thesis I: Village Society Is Fundamentally Democratic

If all politics is local and, as Lowi (1969) writes, all social control is local, then the Bhutanese village is an appropriate nexus at which to analyze what the conditions necessary for democratic resource management in Bhutan are. More than 80% of Bhutan's population is rural and lives in villages, and is directly dependent on forest resources. They are the key resource users and stakeholders who can make or break Bhutan's biodiversity conservation objectives.

I argue that village society is fundamentally egalitarian and democratic in its organization and function. As Tocqueville (1969) says, it is the mores in society, even more than laws and physical circumstances, that are ultimately responsible for ensuring freedom. Village society in Bhutan values justice, equality, and liberty. The conditions that Rousseau (1969) sees as necessary for democracy are met in the Bhutanese village, where "people may be readily assembled and where each citizen may easily know all the others."

Tocqueville defines mores as "habits of the heart . . . the different notions possessed by men, the various opinions current among them, and the sum of ideas that shape mental habits." He considers these factors to be "one of the great general causes responsible for the maintenance of a democratic republic." In Tocqueville's opinion, religious beliefs strongly shape mores. Tocqueville observed that two factors favoring democracy in America in the 18th century were the country's "peculiar and accidental situation," meaning its unique history and geography, and the laws of the land. Likewise, Bhutan presents a unique scenario. Buddhism is the major religion and has played a strong role in the country's political history. The United Nations Development Program

(UNDP, 2004) has observed that, "In Bhutan, respect for human rights is enshrined in Buddhist precepts and practice and is in line with the holistic vision of Gross National Happiness." Buddhism's influence on culture and mores is almost total and, as Ura (1994) writes, "Buddhist ideology colours the way in which an individual looks at himself and the world around him." Within Buddhism, a strong ethos of equality, individual liberty, and personal agency occurs. In the words of the Dalai Lama (1999),

> "As a Buddhist monk, I do not find alien the concept and practice of democracy. At the heart of Buddhism lies the idea that the potential for awakening and perfection is present in every human being and that realizing this potential is a matter of personal effort. The Buddha proclaimed that each individual is a master of his or her own destiny, highlighting the capacity that person has to attain enlightenment. . . . The Buddhist world view recognizes the fundamental sameness of all human beings. Like Buddhism, modern democracy is based on the principle that all human beings are essentially equal. . . . Not only do we desire happiness and seek to avoid suffering, but each of us also has an equal right to pursue these goals. Thus not only are Buddhism and democracy compatible, they are rooted in a common understanding of the equality and potential of every individual."

This Buddhist world view permeates the way of life of the villager. His or her beliefs and mores are strongly colored by this world view and become reflected in everyday dealings, transactions, and politics.

Decisions affecting the community are made in the village meeting (*zomdu)*, where at least one representative from each family participates. Because the average village size ranges from 20 to 200 households, the problem of handling the logistics of an unmanageably large village meeting is seldom encountered. Decisions are made once a consensus is reached, and all differing viewpoints are debated. Vociferous debaters wielding well-honed oratory can sway decisions in their favor. Because most Bhutanese villagers are illiterate, oratorical skills (*kha*) are highly valued in their own right and persuasive debaters are respected. *Kha* is valued even more than *yonten* (knowledge). Oration can be seen as a "weapon of the weak" (Scott, 1987) and, in Bhutan, is wielded frequently in the National Assembly, where humble village representatives challenge the policies of powerful government ministers with tact.

The village *zomdu* embodies what Dahl (1990) terms "primary democracy" occurring at the village level. The village *zomdu* is comparable to what Dahl describes as the "*ekklesia* in Athens, the New England town meeting, or the assembly of citizens (*Landsgemeinde*) in a rural Swiss canton [where] quite possibly everyone may speak who really wants to, and so all may feel their viewpoint has been adequately expressed. In primary (or town meeting) democracy, then the citizens may have a well-justified confidence that they really do govern directly themselves, particularly because participation is not confined to the town meeting proper but is interwoven with the totality of community life."

The village in Bhutan is small enough that "participation . . . is interwoven with the totality of community life," which involves a high degree of what Tocqueville (1969) calls "associations in civil life" and what Putnam (1993) would call "norms of reciprocity and networks of civic engagement." Tocqueville (1969) observes:

> "Among democratic peoples all the citizens are independent and weak. They can do hardly anything for themselves, and none of them is in a position to force his fellows to help him. They would all therefore find themselves helpless if they did not learn to help each other voluntarily."

As a community, then, Bhutanese village life is highly interdependent. No villager can survive on his or her own without the cooperation of other villagers. From building a house to sharing farm labor, a complex web of mutual obligations exist. When such reciprocity vanished, villagers traditionally wielded the corrective—and effective—tool of severe ostracism to socially and economically isolate noncompliant households. Closed hearth/closed water restrictions (*chuko miko dum*) were issued, under which villagers agreed not to enter an "exiled" household and the household itself was banned from using the common village spring.[21] Although formally banned by the government, this threat is still evoked, especially against wealthier households that may not feel the need to participate in community obligations and activities as much as poorer households do.

As recently as 1990, I witnessed the issuance of such a threat at a *zomdu* in a Punakha District village over a dispute about maintenance of the village monastery. The villagers had built the monastery themselves, with voluntary contributions of labor and money. From the start, construction was contentious and factionalized. The location of the monastery was hotly debated, as it had to be close enough to all three hamlets

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[21] Such practices have since been made illegal by the government.

forming the 22-household village. A central location was selected, but the owner of the land refused to “donate” it without compensation. Another villager offered a plot of land elsewhere, in exchange. The construction project was headed by a retired headman who was chosen to be the foreman. But in assigning labor contributions, this person was seen as favoring his relatives and, after many heated arguments and accusations, removed from the position. The incumbent headman[22] intervened and mediated the dispute by asking the elected "elder of the public" (*mangi-ap*) to manage the work. He reluctantly agreed because he was nursing a sick mother at home. After the completion of the monastery, the wealthiest family in the village was asked to make the largest contribution toward buying the idols of deities and religious instruments. Villagers each donated an agreed sum of money, which was given to the head of this household, with the understanding that she would contribute the rest—about half of the expenses. After the idols and instruments arrived, the woman was accused of buying inferior products, which she denied. Fed up with the monastery-related problems, the villagers threatened at a *zomdu* to isolate her household by imposing *chuko miko dum.* The woman called on the headman to mediate, who along with a monk-expert on religious items, authenticated the products as being of good quality.

This incident reveals how the village practiced primary democracy in managing its affairs but also was hobbled by inefficiency and the high cost of reaching accord. The monastery took twice as long as necessary to be built, and the process was ridden with disputes. However, everyone had a say, and even though the lengthy *zomdu*s were

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[22]Headmen are elected by a block of villages ranging anywhere from three to 10 villages per block. In this particular case, the incumbent headman was from another village.

viewed as an annoyance, —interfering with heavy, never-ending farm work—people regularly attended them. The fundamental beliefs that everyone had an equal say, that the process be fair and just, that people be held accountable for their actions, and that no one had an inherent right to lord it over the rest were upheld and practiced. Buddhist belief in individual potential and equality plays an important role in structuring such values and mores. In addition, the economic necessity for cooperating and helping one another helps to entrench civil associations and civil society in Bhutanese villages. Putnam (1993) says that such substantive stocks of social capital are necessary to make democracy work.

A more positive example of social capital in action comes from eastern Bhutan. The village of Melphay in Trashigang practiced a simple tradition of labor-sharing. One working member from each household formed part of a work group that serviced each and every household in the village on a rotating basis during the busy maize-planting and harvesting seasons. Every month on the tenth day, for example, Household A would be assured of having a large work force available for planting, weeding, or harvesting crops. If members of a noncompliant household freeloaded or shirked their civic responsibility, the household simply lost the use of this valuable service. The cost of monitoring and enforcing this labor-sharing system was minimal.

The question then arises, can the government tap into the existing wealth of social capital in rural areas to facilitate a national transition to democratic governance of local resources? Let us begin with some structural background. In Bhutan, a *gewog* is a block of villages grouped together by traditional and customary affiliations, and in some cases, by tribal and clan lineages. Some *gewogs*, such as the *Wang Tsho Chen Gyed* (Eight Great Communities of Wang), existed as far back as the eighth century or earlier (Aris, 1979). The GYT or block development committees mentioned above were established in 1991 by royal command to involve the masses in the development process. In 1992, the Home Ministry issued a GYT Act, which was replaced in 2002 by the GYT Act passed by the National Assembly.

Traditionally, each of these *gewogs* or *tsho* (communities) selected a *gup* (headman) to govern them, akin to a tribal chieftain. However, the position was non-hereditary and rotated among the different households. When the Shabdrung established the nation-state of Bhutan in the mid-1600s, he brought these units under the control of regional governors. Thus, *gewogs* have traditionally functioned as the lowest administrative units in Bhutan linked to the state. The establishment of the GYT system was an attempt to bring planned socioeconomic development to the people and involve them in decision-making. In 1991, GYTs consisted of the *gup*, *mangi-ap*, and one *chipon* (village representative) from each village in the *gewog*. The local primary school headmaster served as the non-voting GYT secretary. GYT meetings were held at least three times a year, and their main agenda was to identify and prioritize development activities in the *gewog*. The GYT, as a formal institution, is thus very different from the informal village *zomdu.*

A village *zomdu's* scope is more informal. A *zomdu* can be called at any time by any villager to make decisions that affect everyday life. The GYT is a formal committee that requests development aid from the central government and meets only three times a year. Recently, the GYT's role has been considerably enhanced beyond the function of submitting wish lists to the government. The GYT Act of 2002 and the subsequent *2004 Manual for the Implementation of GYT Chathrim, 2002*, (DSP, 2004) both give GYTs considerable powers, ranging from collection of rural taxes and retention of these funds for village development to implementation of larger government-funded development programs.

One could view the GYT as an extension of the central bureaucracy that has moved into the heart of rural Bhutan in an effort to devolve certain state powers to the local level. However, the gap between the people and the government still exists, even though it has been narrowed. The GYT Act of 2002 provided no checks and balances on the power of the *gup* that might enable ordinary villagers from his *gewog* to challenge his authority. In fact, the power to remove or impeach an unpopular or corrupt headman lies only with the *dzongdag* (district administrator, DA) who, by setting up an "administrative proceeding," (DSP, 2004) can remove a headman. Traditional social checks and balances are losing importance, because the constitutional powers enshrined in the GYT Act of 2002 endow the headman with considerable administrative and financial powers. And local people have lost their traditional power of removing unpopular headmen in the village *zomdu* through consensus[23]. During the 82nd National Assembly in 2004 the *chimis* to the assembly raised the issue of concentration of power in the headman (BBS, 2004). They pointed out that both the administrative and decision-making powers of the GYT lie with the headman. The representatives requested that the GYT follow the DYT model,[24] in which administrative power lies with the DAs and policy decision-making is

[23] A village *zomdu* could agree to impeach a headman and raise it as an issue at the *gewog zomdu*. Usually, unpopular headmen are unpopular in all villages and consensus is arrived at unanimously. Don't split the footnote across pages.

[24]The DYT was empowered by the DYT Act of 2002. Previously, the DA also served as the chairman of the DYT. The DYT Act separates the role of the DA to actual implementation of development plans, while

led by the DYT chair. The National Assembly resolved that this would be discussed at the annual DYT and GYT conference, putting off the issue until the 83rd session of the National Assembly in 2005. It is ironic, then, that decentralization efforts have created powerful bureaucrats at the local level where none existed before. Hopefully, the 83rd session can revert some power to the people themselves and avert the village emperor syndrome experienced in China where decentralization efforts have lead to the creation of powerful local administrators.

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the DYT remains the decision-making body. The DYT chairman is elected from among the *chimi* or headmen from the district. For instance, development plan proposals and budget requests from the GYT are put to the DYT for approval. The DA then studies the technical and financial feasibility of the proposals and submits the plans to the DYT. The DAs can also submit their own proposals for district-wide programs.

Thesis II: The State Administration Is Bureaucratic and Authoritarian

While village organization is fundamentally democratic in nature, the modern Bhutanese nation-state is based on the rationalized Western bureaucratic model. The top-down style of the state differs markedly from the bottom-up model preferred in the villages. Within the hierarchy of bureaucratic organization, villagers inevitably are assigned to the bottom rung, and the *gewog* headman is co-opted as a junior-level civil servant. This, of course, offers the advantage of a very efficient, transparent system of decision-making and financial transaction, in that people in the lower ranks are held directly accountable to higher-ups, but at the expense of direct democracy.

Admirably, funds for development projects flow to villages with little leakage. The World Bank and other multilateral and bilateral donors consider the Bhutan government to be among the least corrupt and most efficient in delivering development services, among recipient states. The World Bank (1996) declares that Bhutan has "a civil service that has traditionally sustained a high level of professionalism and a lack of corruption for which it is well known." The report also summarizes development achievements in Bhutan:

> "Bhutan's small population (estimated at 600,000 in 1991) had a per capita gross domestic product [GDP] estimated at $450 in 1996, one of the highest in South Asia. While there has been no recent systematic survey of living standards, it appears that very few Bhutanese are hungry or homeless. Income distribution is relatively equal. . . . Significant gains have been made in the following areas: improvement of living standards, through stronger and more equitable growth and more efficient provision

of social services; balanced development among regions; and decentralization and community participation."

If one agrees with Dahl's (1989) view that the term "democracy" should be reserved "for a political system, one of the characteristics of which is the quality of being completely or almost completely responsive to all its citizens," then the Bhutan government can be said to be responsive to its citizens, thereby having a necessary condition for a democratic ethos.

However, in what Ferguson (1994) describes as the "anti-politics machine," the state in Bhutan may be "depoliticizing everything it touches, everywhere whisking political realities out of sight, all the while performing, almost unnoticed, its own pre-eminently political operation of expanding bureaucratic state power." Under such a scenario, the structural impetus on the bureaucracy to act as an anti-politics machine directly contrasts with the democratic institutions traditionally prevalent in the villages. Given their large power asymmetries, the relationship between state and village is non-democratic, and the village is pushed to resort to strategies of resistance.

Weber (1946) predicted that states would rationalize bureaucracies to the extent of entrapping citizens in "iron cages." Although such a drastic situation does not exist in Bhutan—constrained as it is by institutional incapacities such as the lack of financial resources, trained people, and equipment such as supercomputer databases, and also perhaps by the traditional Buddhist ethos of tolerance and compassion—the state is nevertheless authoritarian. For instance, the village headman is co-opted by the bureaucracy and answerable to the DA. More important, as Shapiro and Jung (1996) write, there is no loyal opposition to shine "light in dark places, and expose abuses of power." It is rule by administrators, and there is no distinction between the regime and the government.

The government is also vanguardist and paternalistic in assuming that it knows what is best for the people. For instance, an argument frequently extended in opposition to calls for self-governance in the villages is that "peasants are illiterate" and currently not ready for such responsibilities. Given time, education, and increased modernization, the argument goes, villagers may be capable *eventually* of understanding democracy and practicing it. *In this framework,* the agricultural extension agent becomes the "expert," not the farmer who daily experiences and works the land. In this scheme, then, the bureaucracy is not only the source of modern scientific knowledge but also of money and power, and the villagers are considered as children who need to be cared for, with firmness and compassion, and only allowed limited involvement in their own governance.

At the level of the state, then, the idea of governance takes on a very different meaning than at the level of the village. Dahl (1989) writes that primary democracy is not feasible in larger settings such as at the national level because "the greater the numbers, the more the town meeting runs the risk of becoming unrepresentative." Ultimately, such unrepresentativeness can result in the states usurping the voice and decision-making role of the people. Yet, while ultimately, delegation of authority to the state is total, this does not necessarily result in inherent injustices. In fact, as the World Bank and other bilateral donors note, development funds in Bhutan reach intended targets, and the distribution of resources is more equitable than in most countries with democratically elected governments. And, while people might not have the capacity to force government to concede legislatively to their demands, or retain what Orlando Patterson (1999) calls the capacity to exercise positive freedom and power, villagers still have negative freedom in considering their local affairs, whereby the Buddhist ethos of non-interference is upheld. Government officials are ultimately mostly Buddhist and their authority is tempered by this ethos that respects the privacy and fundamental rights of a human; even the most hawkish can be made gentle.

Thesis III: The State Can Be Democratized by Formalizing Customary Institutions

The single most influential action the state can take in democratizing decision-making is to recognize through legislation the village *zomdu* as a legitimate institution. Most significantly, this would give villages financial control over annual development budgets allocated for them, rather than vesting such authority in the headman as the GYT Act of 2002 does. Currently, although villages may demand that development projects be sited within their respective jurisdictions, actual implementation and financial control rest in the hands of either the central government or the district administration and, as of 2002, in the hands of the headman, resulting in a concentration of power and undemocratic power relationships between the state and the village. Legitimizing the *zomdu* and granting it financial control would empower villagers more than would giving them the right to vote for a head of government, an abstract figure far removed from the day-to-day experiences and local concerns of villagers. Having a say in the governance of village affairs through the institution of the *zomdu* would provide villagers with Dahl's ideal situation: primary, or direct, democracy. Unlike in larger nations with populations counted in the millions, the small size of Bhutanese villages actually makes such a proposition feasible.

Thus, the new challenge that arises in the wake of the GYT Act of 2002 is: How can power be devolved to the masses? The simple answer would be to utilize the wealth of social capital that exists in the villages. The examples given above for labor-sharing traditions could be tapped to help implement development projects. The village *zomdu* should be allowed to act as the decision-making body for matters affecting the village, including the management and use of resources from the village forests. The GYT should be required to respect and implement the decisions of the village *zomdu*. What is needed, then, is a Village Zomdu Act, whereby decisions can be formalized, legitimized, recorded, and passed onto the GYT for compliance or implementation. Villagers would retain their traditional decision-making roles and be encouraged to use and further develop the norms of reciprocity and networks of civic engagement, or social capital, that exist in the villages. Putnam (1993), based on his long-term study in Italy, writes that social capital tends to "increase with use and diminish with disuse." So, Bhutan can either "use it or lose it" as the nation marches down the road of development.

Unfortunately, the GYTs have in effect become government development agencies at the local level. While each village seats a representative (*tshogpa*) on the GYT committee, the representatives have no power, even though they have voting rights since only the District Administrator can remove a headman. The GYT Act of 2002 requires *tshogpa* to submit development proposals from the village to the GYT. Then the proposal must go through the GYT, DA, DYT, and finally, the Department of Planning at the central government. *Tshogpa* should be empowered by a simple majority vote on the GYT, to impeach a corrupt and unpopular headman (currently, only the DA has this power). In the absence of a Village Zomdu Act, *tshogpa* should also be able to vote, with a simple majority, for resource management decisions in their respective villages. The central government should be required to approve these proposals as long as they do not violate national laws. Likewise, villagers, through their *tshogpa*, should be allowed to decide on what they want to contribute, both in kind (usually food grains, alcohol, dairy products, etc.), cash, or labor, for village projects. A major drain on villagers' meager income is the frequent "donations" and "contributions" they have to make at the behest of the headman in order to feed visiting government officials, sponsor archery matches, or conduct other activities, not to mention making voluntary labor contributions for government-sponsored projects in their villages or *gewogs*. An added burden from the GYT Act of 2002 derives from the new authority of the GYT and headman to employ private contractors to build schools and clinics and collect cash from the villagers to pay the contractors. In Bhutan, construction is the most corrupt and inefficient industry, and this phenomenon has now been extended down to the grass roots. The *tshogpa* is sometimes simply relegated to being a messenger running between the headman and the *tshogpa's* village, collecting "contributions" and delivering them to the headman.

The state, in all fairness, is influenced by the developmental ideology of "grassroots participation" for "good governance" and development services; in behalf of this, there is now a decentralized three-tier system, from the GYT level to the district, and finally to the national level.

The transition from primary to representative democracy, although initiated by establishing the GYT, DYT, and National Assembly still has a long way to go. This is the crux of the matter. In the villages, what Dahl (1989) calls social checks are relatively effective in curbing despotism; however, these mechanisms are only effective at the district and national levels in controlling extreme forms of arbitrariness. How, then, can power relationships between the state and village be democratized, and how can village and *gewog* leaders be made more accountable to the people?

For instance, in frequent village meetings, villagers make their wishes and preferences clear to the headman and fellow villagers. The headman needs to consider each preference carefully. Being a villager himself, he cannot blatantly act like a tyrant, petty or otherwise, because when his term is over he returns to live in his ancestral village in the *gewog* among the people he administered. At minimum, villagers had this informal control over the relationship between their leader and themselves until recently.

Formalizing village institutions, such as the *zomdu*, headman elections, other public meetings, and mutual accountability, will allow for existing democratic mores to gain legal recognition. What Dahl calls "social checks" would be formalized into "constitutional checks," or institutional guarantees. Specifically, this would require legally limiting the power of the DAs to planning, coordination, and providing technical support for development projects. Actual financial control would shift to village *zomdus,* which would also be empowered to remove headmen from office and challenge the authority of DAs and other bureaucrats. These steps might eventually prove more effective in promoting democratic resource management than would a bloody revolution and mass upheaval and war as was propounded in Iraq by the Superpower Nation. Stephen Holmes (1999) remarks that simply lifting the lid off tyranny will not permit democracy to flourish. Implicit in this understanding is that indigenous institutions favoring a democratic order need to be nurtured more than dramatic forms of change such as those experienced by Russia and Iraq, for example.

In the towns, larger populations, different economic conditions, and salaried employment all hinder the development of civic associations. In fact, other than a few "welfare" associations where people combine resources to help each other cover expensive funeral rites, there is almost no civil association in towns where the new middle class is based. Moreover, under the new rules the educated elite must run as candidates for *chimi* from their ancestral villages where they are registered, if they want representation in the National Assembly. This greatly hinders their participation in civic life: not only do they retain different interests and agendas than their village constituencies, but they are also outsiders to village politics and cannot gain support.[25] In fact, during the local elections for headman and *chimi* in 2002, dismally low voter turnout in some *gewogs* was attributed to a large exodus to Thimphu. Reestablishing the *zomdu* in the towns, whereby neighborhoods would be divided into "villages," with each neighborhood electing not only a head but also a representative to the National Assembly, would allow the educated elite to participate in the development and governance of the country. Civil society organizations aimed at fostering civic participation in towns can also be legitimized. Once officially sanctioned, such organizations should provide a mechanism for citizens to participate meaningfully in national politics, including management of Bhutan's forests. In such new situations, social capital needs to be rebuilt, as "norms are inculcated and sustained by modeling and socialization (including civic education) and by sanctions" (Putnam, 1993). The emerging urban Bhutanese may

[25] Also, urban dwellers cannot run for the post of *gup*, because the GYT Chathrim of 2002 requires candidates to be full-time residents in the village where they are registered for census purposes. Low voter turnout (as low as 10%) during the 2002 nationwide *gup* elections has been attributed to eligible voters having moved away to urban centers.

need to learn that it is not good to chuck your garbage out of your apartment window, as well as to find ways and means of helping each other.

The draft of a written Constitution, a process started in 2002 and already into its sixth round, will soon be distributed to the villages and public for comments and feedback. This may bolster individual rights and promote “positive freedoms” for Bhutanese citizens, including the voiceless, educated middle class living in urban areas. The Constitution will be formally enacted in 2007, coinciding with the monarchy’s centennial in Bhutan.

Critique: The First Thesis Is a Myth

Is the thesis that village society is fundamentally egalitarian and democratic simply a myth, much like the picture of Rousseau's noble savage living in the pristine state of Nature? One could argue that the village institutions I have described function without teeth and therefore do not justify designation of the village as democratic. Besides, the village also fosters traditional hierarchies of wealth and local village elites exercise more influence than poorer villagers. The charge can also be made that I have assumed a harmonious village community, one that ignores power asymmetries privileging local elites such as powerful and tyrannical headmen. Currently, because headmen are paid employees of the state, they often evoke arbitrary powers of the state to implement unpopular development projects requiring labor contributions from the villagers.

These criticisms must be addressed, even if the hierarchies within the village are nowhere close to the power asymmetries between state and village. Village hierarchies are governed by social norms; social checks prevent any single villager from assuming too much power. The small size of the village, frequent meetings, transparency, and practices of "outlawing" noncompliant households prevent arbitrary power concentration. And villagers' dependence on each other for support with farm labor serves as a leveling mechanism. In the Bhutanese village, labor is always in short supply, thus endowing all able-bodied persons, rich or poor, with an equal value.

If local elites in the village can dominate outcomes of decisions made in the *zomdu*, this does not mean that they can get away with ordering blatantly unjust decisions. The *zomdu*, by its very design, is an open forum for participation and negotiation, and all decisions are negotiated settlements, which at times may favor local elites, but at other times can work against them. Rose (1977) correctly observed that "politics in Bhutan is only rarely a winner-take-all proposition." Hierarchies may exist, but village politics is grounded in democratic practices shaped by social, economic, and cultural factors.

At the interface between village and state, or between the people and the state, the relationship is nondemocratic, and this hierarchy is very different in nature. Social checks that are highly effective in controlling concentrations and abuses of power in the village have a limited ability to control power abuses by the state. In this light, one may wonder how villages have maintained, or insulated, their liberties over the centuries. The argument arises that the village, in its relationship with the state, engages in strategic resistance. A whole repertoire of resistance strategies has evolved to counter state authority. In what Scott (1990) calls infrapolitics, an "unobtrusive realm of political struggle," villagers avoid conducting "loud, headline-grabbing protests, demonstrations and rebellions" in favor of the "circumspect struggle waged daily by subordinate groups [that] is like infrared rays, beyond the visible end of the spectrum. That it should be invisible . . . is in large part by design—a tactical choice born of a prudent awareness of the balance of power."

In promoting village institutions, I have embraced the primary democracy of the village, which values justice and equality as much as democracy and where a "substantial stock of social capital in the form of norms of reciprocity and networks of civic engagement" (Putnam, 1993) exists. I favor democratic justice as the middle path toward which the state, society, and the individual in Bhutan should strive. The elements already exist at the levels of the individual and society, from a cultural heritage that cherishes personal agency and potential and traditional village institutions such as the *zomdu*.

Thus the answer to the question raised, "can local people manage the forests" is a qualified yes. I do not advocate direct handing over of forests to local communities without having key institutions and mechanisms in place. As shown here the traditional village customs and practices such as the *zomdu* can be legitimized as formal resource management agencies. An additional need is for strong monitoring and evaluation protocols in place as highlighted in section 5 above. The Department of Forestry would then play only a backstopping role providing support in the creation of community forest management plans and monitoring and evaluating the proper implementation of these plans.

Conclusion and Recommendations

I started by looking at Hardin's "Tragedy of the Commons" which asked how common property such as forests are best allocated. Hardin recommended "Certain problems, like the commons problem and the exponential growth in global human population, have no technical solutions and cannot be solved by simple changes only in the techniques of natural sciences." Hardin argues that fundamental changes in human values or ideas of morality are necessary to address such problems. Hardin ultimately reasons that such problems can be addressed only through "mutual coercion mutually agreed upon." In Bhutan we find two such systems, one that existed prior to the nationalization of forests and was largely customary laws that governed access to resources, and the extant system where government controls the use of forests and forest lands. I then looked at the situation in golden langur habitat in terms of available habitat and explored the various threats that impinge on the survival of the langurs and their habitat. A major threat identified was inadequate enforcement of habitat protection laws largely due to lack of capacity on the part of the enforcement agencies as a detailed analysis of the main enforcement agency, the Department of Forestry, made clear. Despite these emerging threats the population census data from 1994 and 2003 show that langur populations are stable and there is room to address the emerging threats in a reasoned and timely manner. The solution, as shown by the historical analysis on the land use systems and local democratic institutions, is to enlist the support of the main stakeholder, the rural farmer and resource user, comprising 80% of Bhutan's population, as guardians of the forests.

The recommendations that follow are both long-term and short-term in nature to meet the challenges raised above and avert potential disasters. The long-term recommendation closely follows "Bhutan 2020: a Vision for Peace, Prosperity, and Happiness" (RGOB, 2000). Fifteen years from now, will Bhutan's forest management reflect the goals of sustainability, community participation, and economic development in the process of increasing Gross National Happiness and reducing poverty?

The long-term recommendation then is that traditional community forests be returned to local people in the hope that local management will foster ownership and zealous monitoring and evaluation. Blending traditional management with modern tools of scientific monitoring and evaluation, the forests can benefit from both the old and the new management systems. Simply handing over forests to the villages without the vital monitoring and evaluation system in place will be disastrous. A middle path where resources are managed by the people themselves but monitored by the state is recommended. As highlighted above, locally managed community forests functioned well in the traditional system prior to the advent of modernization.

To facilitate the process, community and private forestry rules and regulations as a requirement of the Forest and Nature Conservation Act already exist. The other new tool that can be added to community forests is the experience and knowledge gained over the last three decades of forestry management by the DOF. Specifically, plans that emphasize management based on complete and accurate information need to be developed.

This recommendation then follows the decentralization efforts throughout the government. Despite the potential problems highlighted above, the forests are one step closer to the people. Although strong political will to decentralize community forests to communities is yet to be demonstrated, due largely to concerns of losing control and ensuing degradation, the issue is very much on the table at an institutional level.

The long-term recommendation of community-based resource management can be achieved by combining the old and the new, people power with statistical and data management capacities of the Ministry of Agriculture's Monitoring and Evaluation Unit (MEU). This unit will be supported by the districts' extension officers in the fields, in turn supported technically by Forest Resource Development Division (FRDD).

A clear and detailed strategy for decentralization of forest management is necessary at this juncture. The strategy needs to address precise schedules for handing over rural timber management to communities. Capacity development of the district forestry sectors in terms of human resources, training, and equipment, are important aspects to consider in implementing this strategy. For the moment, it is recommended that staff previously responsible for rural timber marking in the territorial divisions be transferred to the districts (dzongkhags). The dzongkhag forestry sectors will also need leadership from a senior forestry staff at the DFO level. This is a suggestion already made by the task force who formulated the strategy for good governance discussed above[26].

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[26] Even though complaints of inadequately trained human resources are always voiced, in reality, DOF has many capable graduates trained in forestry, without leadership positions, serving in administrative/technical posts that can be filled by rangers or graduates without specialized training - of which there is a glut in Bhutan. Unemployment of educated youth is already a major issue and the recently created Ministry of Labour and Employment has "productive employment" of educated youth as a major mandate.

Under this scenario, FRDD would make rural timber management plans for all the dzongkhags. Initially, these would not have to be as rigorous as commercial FMUs' management plans. But, this will be an improvement over allocating rural timber without any management prescriptions. FRDD resources may be stretched initially with this activity. However, using the dzongkhag forestry staff will lessen the burden and they can be authorized to make their own plans in the near future in accordance with FRDD's decentralization policy.

The dzongkhag forestry sector would prepare annual operational plans and implement the plans. Also, as presently done, records of timber volumes extracted annually would be maintained. Additionally, the monitoring and evaluation of the forests managed by the districts can be undertaken on an annual basis by the staff themselves. The forms already developed for FMUs can be adapted to collect data in forests that are not FMUs. These records can be submitted both to FRDD and PPD's MEU. Simple correlation statistics between the rural agricultural census data (number of households in a district, forecasts of population increase etc.), already maintained by the unit, can be linked with timber requirements, for example. The FRDD can then use these data to prepare future management plans[27].

Community-based forest management is a gradual process in Bhutan. As more forests are managed by local people in the future, a concurrent rise in local government capacity to provide technical backstopping is essential. The process outlined above can provide for this capacity development and facilitate the eventual goal of community-based resource management.

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[27] A detailed study and strategy for facilitating decentralization of rural timber management to dzongkhags is also recommended.

Legislation with both long-term and short-term effects and having a direct bearing on monitoring and evaluation is needed. A national law that requires enforcement of existing rules and regulations, concerning monitoring of projects and programs, will clearly set the stage for monitoring activities. This will ‘institutionalize’ monitoring as a mainstreamed activity. Hence monitoring will not be seen as a means to unearth corruption as it is presently. The cultural stigma of being monitored and not having the trust of superiors, or being disloyal, can be overcome with such a “neutral” legislation applied across the board.

Monitoring and evaluation can also shift the emphasis from pre-release controls of funds by the AFD as highlighted above to post-release assessment. The lengthy and time-consuming intricacies can be reduced if MOF and AFD can be assured of financial regularity through monitoring rather than relying solely on audits. It is recommended that the PPD’s *Monitoring and Evaluation Unit* (MEU) be strengthened. One of the main roles that this section can play is to authorize release of funds based on M&E reports. Financial, physical, and environmental regularity should be maintained with AFD’s policing role transferred to PPD’s MES. Clearly MEU’s capacity will need to be developed with either staff reallocation or new recruitment. Appropriate training will be essential.

Strengthening FRDD’s capacity to monitor and evaluate not only commercial FMUs but especially rural timber and firewood allotment is crucial. A clear strategy for strengthening FRDD’s M&E capacity is a priority recommendation. Also, FRDD’s FMU Monitoring and Evaluation Cell, staffed with only one ranger, should be upgraded to a full section. A graduate with forestry background should be appointed as the head of this section. Specialized training at the Masters level in M&E for this appointee will greatly facilitate capacity building of the section. Use of graduates and other skilled workers to fill posts in this section should be considered. Graduates who opt not to sit for the civil service exams or are not professionally trained as Foresters are excluded by default from careers in DOF. Hiring such graduates should be considered as an option since they already have undergraduate training and short-term training in appropriate fields can greatly add value to their capacity.

This new M&E Section will work closely with the MEU of the PPD, MOA and provide reports for funds release approval. All activities of the Department of Forestry and the Dzongkhag Forestry Sectors with a sustainable management focus will need to have satisfactory M&E reports for approval of subsequent funds release.

Another recommendation is to make full use of the monitoring and evaluation forms developed by FRDD in existing FMUs. DFOs can be made more responsive to monitoring if it is accepted as a part of the institution, as a regular day-to-day task acceptable to the work culture of DOF. This means that the technical aspect of monitoring and evaluation needs to be prioritized rather than as a means of judging performance of individual managers. Providing more training as a means to achieve not only competence but also foster acceptance may be needed. Already trained staff can be used as trainers in the use of the forms at all levels in the dzongkhags and territorial divisions. Table 3.9 below provides a summary of the recommendations

Table 3.9 Summary of the recommendation

	Decentralization of Rural Timber	Strengthen FRDD	RGOB Reform
Policy / Strategy	1. Implement decentralization policy. 2. Develop detailed strategy for decentralization	1. Develop clear strategy to strengthen the M&E capacity of the FRDD.	1. Formulate legislation for monitoring and evaluation. 2. Develop policy and strategy for enforcement of legislation 3. Implement PPD restructuring with MEU strengthening.
Capacity	1. Increase management planning and M&E capacity of Dzongkhags	1. Upgrade the existing FMU Monitoring and Evaluation Cell (staffed with 1 ranger presently) to a full section with a Forestry Graduate as coordinator.	1. Increase enforcement capacity of competent authorities such as the PPD, territorial DFOs and the FRDD.
Human Resources	1. Transfer senior DFO to Dzongkhag. 2. Transfer staff from territorial divisions to Dzongkhag 3. Train staff in M&E and mgmt. Planning.	1. Appoint Forestry graduate at FRDD to coordinate and head M&E activities. Provide graduate level training in M&E to officer. 2. Recruit graduates to fill new posts for M&E. Train graduates in Mgmt. Planning and M&E.	1. Staff of competent authorities trained in M&E.
Coordination / Roles	1. FRDD initially help make rural timber mgmt. Plans for dzongkhags. 2. FRDD train dzongkhag and territorial staff in use of M&E forms 3. PPD, MoA provide technical support for data collection and analysis in coordination with Dzongkhag RNR.	1. The new M&E section will coordinate and provide technical backstopping for M&E in FMUs (territorial DFOs) and rural timber (Dzongkhag Forestry Sector) 2. Work closely with MES, PPD and provide M&E reports for funds release approval.	1. MEU, PPD authorize release of funds based on M&E report. AFD not play policing role as presently done.

Literature Cited Chapter 3

Agrawal, A., 1998. *Community in Conservation: Beyond Enchantment and Disenchantment.* Conservation and Development Forum Discussion Paper, Gainesville, Florida.

Tocqueville, A., 1969. *Democracy in America*. New York: Doubleday.

Allchin, Raymond. 1982. The Rise of Civilization in India and Pakistan. Cambridge University Press, Cambridge.

Aris, Michael. 1979. Bhutan: The Early History of a Himalayan Kingdom. Aris & Phillips Ltd., Warminister.

__________. 1980. Notes on the History of the Mon-yul Corridor in M. Aris Ed. Tibetan Studies in Honour of Hugh Richardson. Aris and Phillips Ltd.

__________. 1987. Views of Medieval Bhutan: The Diary and Drawings of Samuel Davis, 1783. Serindia Publications.

__________. 1992. Lamas, Princes, and Brigands: Joseph Rock's Photographs of the Tibetan Borderlands of China. China House Gallery, New York.

__________. 1994. The Raven Crown: The Origins of Buddhist Monarchy in Bhutan. Serindia Publications, London.

Aziz, Barbara. 1978. Tibetan Frontier Families: Reflection of Three Generations from D'ing-ri. Carolina Academic Press.

Baviskar, A. 1997. *In the belly of the River: Tribal Conflicts over Development in the Narmada Valley*. Oxford India Paperbacks, Delhi.

Bloch, Marc. 1961. *Feudal Society*. University of Chicago Press.

Burch, William, G.E. Machlis, J.E. Force,1997. The Human Ecosystem Part I: The Human Ecosystem as an organizing Concept in Ecosystem management. *Society and Natural Resources*, 10:347-376.

Burch, William. 1997. Daydreams and Nightmares: A Sociological Essay on the American Environment. Social Ecology Press, Wisconsin.

Burch, William. 1998. (In manuscript) Ecosystem Management - some social, conceptual, scientific, and operational guidelines for practitioners.

Burch, William. 1999. Personal Communication, New Haven.

Carrasco, Pedro. 1959. *Land and Polity in Tibet*. University of Washington Press.

Center for Bhutan Studies *"25 Years a King: His Majesty King Jigme Singay Wangchuck 1974 -1999"* (Thimphu: Center for Bhutan Studies, 1999), pp. 8.

Chhoki, Sonam. 1994. Religion in Bhutan I: The Sacred and The Obscene. In M. Hutt and M. Aris eds. *Bhutan: Aspects of Culture and Development*. Paul Strachan - Kiscadale Ltd.

Clifford, James. 1997. *Routes: Travel and Translation in the Late Twentieth Century*. Harvard University Press.

Cronon, William. 1992. A Place for Stories: Nature, History, and Narrative. *J. of American History*, Vol 78 (4): 1347-1376.

Dahl, R., 1956. *A Preface to Democratic Theory*. Chicago: University of Chicago Press.

Dahl, R., 1989. *Democracy and Its Critics* New Haven: Yale University Press.

Dahl, R., 1990. *After the Revolution? Authority in a Good Society* New Haven: Yale University Press.

Dalai Lama, "Buddhism, Asian Values, and Democracy," *Journal of Democracy* 10:1 (1999), pp. 3–7.

Dorji, J., 1993a. Estimation of grazing animal feed requirement in Bhutan. Background paper for Bhutan's National Environmental Strategy. National Environment Commission, Thimphu, Bhutan.

Dorji, J., 1993b. Livestock development and pasture development. Background paper for Bhutan's National Environmental Strategy. National Environment Commission, Thimphu, Bhutan.

Duby, Georges. 1980. The Three Orders: Feudal Society Imagined. University of Chicago Press.

E. P. Thompson, *Customs in Common* (New York: New Press, 1991).

Fagan, Brian. 1990. *The Journey From Eden: The Peopling of Our World*. Thames and Hudson Ltd.

Ferguson, J., 1994. *The Antipolitics Machine: Development, Depoliticization, and Bureaucratic Power in Lesotho*. Minneapolis: University of Minneapolis Press.

Forest Resources Development Division 1999. Forest Resources Management Program. FRDD, Thimphu.

Forman, Richard. 1995. *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge University Press.

Foucault, M. 1980. *Power/Knowledge: Selected interviews and other writings, 1972-1977*. Edited by Colin Gordon. Pantheon Press.

French, Rebecca. 1990. The Golden Yoke: A Legal Ethnography of Tibet Pre-1959. Ph.D. Dissertation. Yale University.

Geertz, Clifford. 1988. *Works and Lives: The Anthropologist as Author*. Stanford Univ. Press.

Gluckman, Max. 1965. The ideas in Barotse Jurisprudence. Yale University Press.

Goody, Jack. 1971. Feudalism in Africa? In George Dalton Ed. Economic Development and Social Change: The Modernization of Village Communities. The Natural History Press, New York.

Grewal, Dalvinder. 1997. Tribes of Arunachal Pradesh: Identity, Culture, and Languages. South Asia Publications, Delhi.

Grierson, A. J., and D.G. Long. 1983. *Flora of Bhutan.* Royal Botanic Garden, Edinburgh.

Gupta, K.K., 1974. Fauna of Orang Wildlife Reserve. *Rhino*. 2: 2 *J. of Kaziranga Wildlife Soc.* 0-30.

Hardin, Garret. 1968. The Tragedy of the Commons. *Science*. 162:1243-8.

Hrdy, S.B. 1980. *The langurs of Abu* Harvard Unversity Press, Cambridge.

Kahn, J.R., 1995. The Economic Approach to Environmental and Natural Resources. Harcourt Brace & Company, Orlando.

Karan, P. P. 1963. The Himalayan Kingdoms: Bhutan, Sikkim, and Nepal. Van Norstrand Company.

Karma Ura, 1994. "Development and Decentralization in Medieval and Modern Bhutan," in *Bhutan: Aspects of Culture and Development*, eds. Michael Aris and Michael Hutt Gartmore, Scotland: Strachan-Kiscadale.

Khajuria, H. 1977. Ecological Observations on the Golden langur (*Presbytis geei* Khajuria) with remarks on its conservation. In *Use of Non-human primates in biomedical research*. M.R. Prasad and T.C. Kumar, eds. Indian National Science Academy, New Delhi.

Kosambi, D.D. 1965. *Ancient India*. Pantheon Books.

Lansing, Stephen. 1991. *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*. Princeton University Press.

Leo E. Rose, 1977. *The Politics of Bhutan* Ithaca, N. Y.: Cornell University Press.

Lowi, T., 1969. *The End of Liberalism: The Second Republic of the United States*. New York: W.W. Norton.

Machlis, G.E., J.E. Force, and W.R. Burch, Jr. 1997. The Human Ecosystem Part I: The Human Ecosystem as an organizing Concept in Ecosystem management. *Society and Natural Resources*, 10:347-376.

Mackinnon, J. 1991. *National Conservation Plan: Bhutan*. Unpublished report for the Department of Forestry, Thimphu.

Marshall, Harry. 1997. The Karen People of Burma. White Lotus Press, Bangkok.

Max Weber, *Max Weber: Essay in Sociology*, ed. by H. H. Gerth and C. Wright Mills Oxford: Oxford University Press.

Michael Aris, 1979. *Bhutan: The Early History of a Himalayan Kingdom* London: Aris & Phillips, Ltd.

Michael Aris, 1994. *The Raven Crown: The Origins of Buddhist Monarchy in Bhutan* London: Serindia Publication.

MoA (Ministry of Agriculture), 2002. Renewable Natural Resources Statistics 2000.

Ministry of Agriculture, Royal Government of Bhutan, Thimphu, Bhutan.

Mukherjee, R. P. and S.S. Saha, 1974. The Golden langurs of Assam. *Primates* 15(4): 327-340

NCS (Nature Conservation Section), 1996. Jigme Dorji National Park Conservation Management Plan. NCS, Thimphu.

Norbu, P., 1998. Working scheme for Chapley Khola Forest Management Unit 1998-2000. Forest Resources Development Section, Department of Forestry, Royal Government of Bhutan, Thimphu.

NRC (National Research Council). 1981. *Techniques for the study of primate population ecology.* National Academy Press, Washington D.C.

Oppenheimer, J.R., 1978. *Presbytis entellus*, The Hanuman Langur. In *Primate Conservation*, Rainier and Bourne eds. Academic Press.

Organization, Roles, Responsibilities, and Staffing Pattern of the Ministry of Agriculture. PPD, MOA. November 1999.

Orlando Patterson, 1999. The Western Chord: Trust and Democracy in the Culture of Freedom," Storrs Lecture Series, Yale Law School, New Haven, April 12, 1999.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press.

Peters, Edward. 1997. *Eurpoe and The Middle Ages*. 3rd Edition. Prentice Hall.

Prater, S.H., 1965. *The Book of Indian Animals*. Bombay Nat. Hist. Soc.

Putnam, R., 1993. *Making Democracy Work: Civic Traditions in Modern Italy* (New Jersey: Princeton University Press.

RGoB (Royal Government of Bhutan) 1996. Eight Five Year Development Plan, 1997- 2001. Thimphu.

RGOB (Royal Government of Bhutan), 1987. Landsat map of Bhutan. Thimphu.

RGOB (Royal Government of Bhutan), 1999. *Bhutan 2020: A Vision for Peace, Prosperity, and Happiness.* Planning Commission. Thimphu.

RGOB (Royal Government of Bhutan) 1999. Enhancing Good Governance: Promoting Efficiency, Transparency, and Accountability for Gross National Happiness. by Twenty five member task force instituted by the Council of Ministers of Bhutan. Thimphu.

Rousseau, Jean-Jacques. 1968. *The Social Contract*. London: Penguin.

Rinchen, D., and M. Maatta, 1993. Management plan for Wangdigang Forest Management Unit 1993-2002. Forest Resources Management Division, Department of Forestry, Royal Government of Bhutan.

Rose, Leo. 1977. The Politics of Bhutan. Cornell University Press.

Ross, John. 1990. The Origin of the Chinese People. Pelanduk Publications. Royal Botanic Garden, Edinburgh.

Scott, J., 1985. *Weapons of the Weak: Everyday forms of Peasant Resistance*. Yale University Press.

Scott, J., 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. Yale University Press.

Shapiro, Ian, 1996. *Democracy's Place* Ithaca, N. Y.: Cornell University Press.

Isaacman, Allen. 1996. *Cotton is the Mother of Poverty: Peasants, Work, and Rural Struggle in Colonial Mozambique, 1938 - 1961*. Heinemann, Portsmouth.

Siu, H., 1995. *Down to Earth : The Territorial Bond in South China*. Yale University Press.

Spillet, J. J., 1966. The Kaziranga Wildlife Sanctuary, Assam. *J. of Bombay Nat. Hist. Soc.* 63: 494-533.

Sristava, A., J. Biswas, J. Das, and P. Bujarbarua, 2001. Status and distribution of

Statistical Unit, PPD, MOA Development of a Reliable, Consistent, and Efficient RNR Data Management System in Bhutan. Statistical Unit, PPD, MOA. January, 2000. Thimphu.

Stedman-Edwards, P., 1998. *Root Causes of Biodiversity Loss: An Analytical Approach*. World Wide Fund for Nature, Washington D.C.

Stephen Holmes, 1999. "Political Theory and the End of Communism," Castle Lectures in Ethics, Politics, and Economics, Yale University (New Haven, February 1999).

Subba, P. B. 1989. The status and conservation of the Golden langurs in the Manas National Park. *Tigerpaper* October - December: 16 - 18.

Sugiyama, Y. 1964. Group composition, population density, and some sociological observations of Hanuman Langurs (*Presbytis entellus*). *Primates* 5 (3-4): 7-37.

Sugiyama, Y. and M. D. Parthasarathy. 1979. Population change of the Hanuman Langur (*Presbytis entellus*), 1961 - 1976, in Dharwar area, India. *J. of Bombay Nat. Hist. Soc.* 75 (3): 860-867.

Thompson, E.P. 1991. *Customs in Common*. The New Press, New York.

Ura, Karma. 1995. The Hero With a Thousand Eyes. White Lotus, Bangkok.

_________. 1994. Decentralisation and Development in Medeival and Modern Bhutan. In M. Hutt and M. Aris eds. Bhutan: Aspects of Culture and Development. Paul Strachan - Kiscadale Ltd.

van Driem, George. 1994. Language Policy in Bhutan. In M. Hutt and M. Aris eds. Bhutan: Aspects of Culture and Development. Paul Strachan - Kiscadale Ltd.

Wangchuk, S., 1998. Local Perceptions and Indigenous Institutions as Forms of Social Performance for Sustainable Forest Management in Bhutan. ETH, Zurich.

Wangchuk, T., 2001. Changes in the Land Use System in Bhutan: Ecology, History, Culture, and Power, *Journal of Bhutan Studies* 2:1 (Autumn 2001), pp. 48–75.

Wells, M., 1997. Indonesia Integrated Conservation and Development Projects Review Draft document, World Bank.

Wells, Michael. 1997. Review of ICDPs in Indonesia. Unpublished draft, World Bank.

Wilson, E.O. 1995. Forward in Land Mosaics: The Ecology of Landscapes and Regions by Richard Forman. Cambridge University Press.

Wolfheim, J. H. (ed) 1983. *Presbytis geei* Golden langur pp 601 - 604 in *Primates of the World: Distribution, Abundance, and Conservation*. Seattle: Univ. of

Washington Press.

World Bank, 2000. Strategy Note on Bank Involvement in Bhutan Forestry Sector, South Asia Rural, Washington DC.

World Bank Report, 1996. *Bhutan Country Economic Memorandum* 1996. Report no. 16113-BHU Washington.DC.

World Bank, 1998. Integrated Conservation and Development Projects Review, Draft Document, Washington DC.

World Wildlife Fund-US, 1998. Review of Integrated Conservation and Development Projects in the Asia-pacific Region, WWF-US Washington D.C.

Worster, Donald. 1992. Transformations of the Earth: Toward an Agroecological Perspective in History. J. of American History, Vol 76 (4): 1087-1106.

Appendix 8: Questionnaire on Land Management

Village Location:______________________Date:________________
Number of Households:_________________Population:___________
Name or pseudonym of respondent:____________________________
Enumerator:______________________

1. How many people in household:

2. How many livestock:

3. Where do they graze, how many months in each:
   Private tsamdo: ____ Community:______Public:__________

4. How did you acquire private / group tsamdo?

5. Where do you collect firewood from:

6. Where do you get house building / renovation timber from:

7. Do you have any problems getting firewood and timber permits, if so what are some of the problems:

8. Have you always followed the same procedures in getting timber? Did you always need a permit to collect wood:

9. Draw a resource use map of the village showing respondent's wood collection areas, skoshing (leaf litter collection areas), livestock grazing areas,

tseri (shifting cultivation areas), agricultural fields, and boundaries of village forest. Enumerator to assist. Use reverse side of page.

10. Could you describe how forests in your village were managed prior to the formation of the Forest Department? Did you need to get permission from anywhere for collecting timber and firewood? If not how were such resources allocated in your village?

11. Would you prefer reverting to the traditional system of management of village forests whereby permits from the Forest Department were not needed? Why or why not?

12. Do you think that the traditional system of forest management would work well in your village? Do you for see any problems? What might be some of the issues?

13. Can you compare the traditional system with the present system of permits and tree marking by the Forest Department?

14. How would you manage your village forest? Would a *chathrim* (rules and regulations) be needed to manage your village forest should they revert back to the village? What might you include in the rules? Who would be responsible for enforcing the rules? What role do you see for the Forest Department under this system?

15. Do you think forest management by villagers would work elsewhere too, especially in villages near urban areas? Why or why not?

16. Does the golden langur cause any problems for you? Do they raid your fields?

17. Do you have any beliefs / stories about the golden langurs?

18. Can you describe how you traveled across the Mandge and Chamkhar rivers in the past? Were there permanent bridges or did you use rok (cane rope). When and where were the new bridges built?

Literature Cited

Agrawal, A., 1998. *Community in Conservation: Beyond Enchantment and Disenchantment.* Conservation and Development Forum Discussion Paper, Gainesville, Florida.

Allchin, Raymond. 1982. The Rise of Civilization in India and Pakistan. Cambridge University Press, Cambridge.

Aris, Michael. 1979. Bhutan: The Early History of a Himalayan Kingdom. Aris & Phillips Ltd., Warminister.

__________. 1980. Notes on the History of the Mon-yul Corridor in M. Aris Ed. Tibetan Studies in Honour of Hugh Richardson. Aris and Phillips Ltd.

__________. 1987. Views of Medieval Bhutan: The Diary and Drawings of Samuel Davis, 1783. Serindia Publications.

__________. 1992. Lamas, Princes, and Brigands: Joseph Rock's Photographs of the Tibetan Borderlands of China. China House Gallery, New York.

__________. 1994. The Raven Crown: The Origins of Buddhist Monarchy in Bhutan. Serindia Publications, London.

Avise, J., 2000. *Phylogeography: The History and Formation of Species*. Harvard Univ. Press, Cambridge.

Avise, J., and R. Ball., 1990. Principles of genealogical concordance in species concepts and biological taxonomy. *Oxford Survey Evol. Biol.* 7:45-67

Aziz, Barbara. 1978. Tibetan Frontier Families: Reflection of Three Generations from D'ing-ri. Carolina Academic Press.

Baker, L., T. Nadler, and T. Geissmann, T. 2000. *Viet Nam: Primate Field Guide*. Fauna & Flora International, Indochina Programme, Hanoi. 8 pp. (English and Vietnamese text).

Barry, J., E. Lindsay and L. Jacobs, 1982. A biostratigraphic zonation of the Middle and Upper Siwaliks of the Potwar Plateau of Northern Pakistan. *Palaeogeography, Palaeoclimatology, Palaeoecology* 37 (1): 95-130.

Baum, D., and K. Shaw., 1995. Genealogical perspectives on the species problem. In P.C. Hoch and A.G. Stephenson, eds., *Experimental and Molecular* Approaches to Plant Biosystematics. Missouri Botanical Garden.

Baviskar, A. 1997. *In the belly of the River: Tribal Conflicts over Development in the Narmada Valley*. Oxford India Paperbacks, Delhi.

Bhargava, O., 1997. *The Bhutan Himalaya : A Geological Account.* Geological Survey of India. New Delhi.

Bishop, N. 1979. Himalayan langurs: temperate colobines. *J. of Human Evolution*. 8: 251-281

Bloch, Marc. 1961. *Feudal Society*. University of Chicago Press.

Blunier, T., J. Chappellaz, J. Schwander, A. Dällenbach, B. Stauffer, T. Stocker, D. Raynaud, J. Jouzel, H. Clausen, C. Hammer and S. Johnsen, 1998: Asynchrony of Antarctic and Greenland climate change during the last glacial period. *Nature* 394: 739-743.

Brandon-Jones, D., 1996. The Asian Colobinae (Mammalia: Cercopithecidae) as indicators of Quaternary climatic change. *Biological Journal of the Linnean Society* 59:327-350.

Brandon-Jones D; A. Eudey, T. Geissman, C. Groves, D. Melnick, J. Morales, M. Shekelle, C-B. Stewart, 2004. Asian primate classification. *Int. J. Primatology* 25(1): 97-164.

Brown, W., M. George, and A. C. Wilson. 1979. Rapid evolution of animal mitochondrial DNA. *Proc. Natl. Acad. Sci.* USA 76:1967–1971.

Burch, William, G.E. Machlis, J.E. Force,1997. The Human Ecosystem Part I: The Human Ecosystem as an organizing Concept in Ecosystem management. *Society and Natural Resources*, 10:347-376.

Burch, William. 1997. Daydreams and Nightmares: A Sociological Essay on the American Environment. Social Ecology Press, Wisconsin.

Bush, G.L. 1969. Sympatric host race formation and speciation in frugivorous flies of the genus *Rhagoletis* (Diptera: Tephritidae). *Evolution* 23:237-251.

Butlin, R. 1989. Reinforcement of premating isolation. p. 158–179 in D. Otte and J. Endler, eds. *Speciation and its consequences*. Sinauer Associates, Inc., Sunderland, MA.

Cann, R., M. Stoneking, M., and A. Wilson, 1987. Mitochondrial DNA and human evolution. *Nature* 325: 31-36.

Carrasco, Pedro. 1959. *Land and Polity in Tibet*. University of Washington Press.

Center for Bhutan Studies *"25 Years a King: His Majesty King Jigme Singay Wangchuck 1974 -1999"* (Thimphu: Center for Bhutan Studies, 1999), pp. 8.

Chhoki, Sonam. 1994. Religion in Bhutan I: The Sacred and The Obscene. In M. Hutt and M. Aris eds. *Bhutan: Aspects of Culture and Development*. Paul Strachan - Kiscadale Ltd.

Clifford, James. 1997. *Routes: Travel and Translation in the Late Twentieth Century*. Harvard University Press.

Corbet, G., and J. Hill, 1992. *The mammals of the Indomalayan region: a systematic review.* Oxford University Press, Oxford

Cracraft, J., 1983. Species concepts and speciation analysis. *Current Ornithology* 1: 159-87.

Crandall, K., O. Bininda-Emonds, G. Mace and R. Wayne, 2000. Considering evolutionary processes in conservation biology *Trends Ecol. Evol.* 15 (7): 290-295.

Cronon, William. 1992. A Place for Stories: Nature, History, and Narrative. *J. of American History*, Vol 78 (4): 1347-1376.

Delson, E, 1994. Evolutionary history of the colobine monkeys in paleoenvironmental perspective, p. 11-44 in *Colobine Monekys: Their Ecology, Behaviour and Evolution*, A. Davies and J. Oates, eds. Cambridge Univ. Press, Cambridge:

de Queiroz, K. 1998. The general lineage concept of species, species criteria, and the process of speciation: A conceptual unification and terminological recommendations. p. 57-75 in *Endless Forms: Species and Speciation*, D. Howard and S. Berlocher eds. Oxford University Press, Oxford.

Dahl, R., 1956. *A Preface to Democratic Theory*. Chicago: University of Chicago Press.

Dahl, R., 1989. *Democracy and Its Critics* New Haven: Yale University Press.

Dahl, R., 1990. *After the Revolution? Authority in a Good Society* New Haven: Yale University Press.

Dalai Lama, “Buddhism, Asian Values, and Democracy,” *Journal of Democracy* 10:1 (1999), pp. 3–7.

Dobzhansky, T. 1970. *Genetics of the evolutionary process*. Columbia Univ. Press.

de Queiroz, K., and M. Donoghue. 1988. Phylogenetic systematics and the species problem. *Cladistics* 4:317-338.

Donoghue, M. J. 1985. A critique of the biological species concept and recommendations for a phylogenetic alternative. *Bryologist* 88:172-181.

Dorji, J., 1993a. Estimation of grazing animal feed requirement in Bhutan. Background paper for Bhutan’s National Environmental Strategy. National Environment Commission, Thimphu, Bhutan.

Dorji, J., 1993b. Livestock development and pasture development. Background paper for Bhutan’s National Environmental Strategy. National Environment Commission, Thimphu, Bhutan.

Duby, Georges. 1980. The Three Orders: Feudal Society Imagined. University of Chicago Press.

Ellerman, J., and T. Morrison-Scott, 1966. *Checklist of Palaearctic and Indian Mammals 1758 to 1946.* 810 pp. British Museum (Natural History). London.

Fagan, Brian. 1990. *The Journey From Eden: The Peopling of Our World*. Thames and Hudson Ltd.

Feder, J., 1998. The apple maggot fly, *Rhagoletis pomonella*: flies in the face of conventional wisdom about speciation? p. 130-144 in *Endless Forms: Species and Speciation,* D. Howard, S. Berlocher, eds. Oxford University Press, Oxford.

Ferguson, J., 1994. *The Antipolitics Machine: Development, Depoliticization, and Bureaucratic Power in Lesotho*. Minneapolis: University of Minneapolis Press.

Finn, F., 2002. *Sterndale's Mammalia of India*. Cosmo, New Delhi 347p.

Fischer, H., M. Wahlen, J. Smith, D. Mastroiani and B. Deck, 1999. Ice core records of atmospheric CO_2 around the last three glacial terminations. *Science*, 283: 1712-1714

Forest Resources Development Division 1999. Forest Resources Management Program. FRDD, Thimphu.

Forman, Richard. 1995. *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge University Press.

Foucault, M. 1980. *Power/Knowledge: Selected interviews and other writings, 1972-1977*. Edited by Colin Gordon. Pantheon Press.

French, Rebecca. 1990. The Golden Yoke: A Legal Ethnography of Tibet Pre-1959. Ph.D. Dissertation. Yale University.

Gee, E.P. 1956. A new species of langur in Assam. J. Bombay Nat. Hist. Soc. 53: 252- 254.

________1961. The distribution and feeding habits of the golden langur, *Presbytis* *geei* Gee (Khajuria, 1956). J. Bombay Nat. Hist. Soc., 58: 1-12.

Geertz, Clifford. 1988. *Works and Lives: The Anthropologist as Author*. Stanford Univ. Press.

Geissmann, T., C. Groves, C. Roos, 2004. The Tenasserim Lutung, *Trachypithecus barbei* (Blyth, 1847) (Primates: Cercopithecidae): Description of a live specimen, and a reassessment of phylogenetic affinities, taxonomic history, and distribution. *Contributions to Zoology*, in press.

Ghosh, A. K., and Biswas, S. 1975. A note on ecology of the golden langur (*Presbytis geei* Khajuria). J. Bombay Nat. Hist. Soc., 72: 524-528.

Gillooly J., A. Allen, G. West, J. Brown, 2005. The rate of DNA evolution: effects of body size and temperature on the molecular clock. *Proc. Natl. Acad. Sci.* USA. 4, 102(1):140-5.

Gluckman, Max. 1965. The ideas in Barotse Jurisprudence. Yale University Press.

Goodman, M., C. Porter, J. Czelusniak, S. Page, H. Schneider, J. Shoshani, G. Gunnell, and C. Groves, 1998. Toward a phylogenetic classification of primates based on DNA evidence complemented by fossil evidence. *Mol. Phylogenet. Evol*. 9:585–598.

Goody, Jack. 1971. Feudalism in Africa? In George Dalton Ed. Economic Development and Social Change: The Modernization of Village Communities. The Natural History Press, New York.

Grewal, Dalvinder. 1997. Tribes of Arunachal Pradesh: Identity, Culture, and Languages. South Asia Publications, Delhi.

Grierson AJC, Long DG (1984). *Flora of Bhutan. Volume 1: Part 1*. Royal Botanic Garden, Edinburgh,

Groves, C. 2001. *Primate taxonomy*. Smithsonian Series in Comparative Evolutionary Biology.: Smithsonian Institution Press. Washington and London.

Gupta, K.K., 1974. Fauna of Orang Wildlife Reserve. *Rhino*. 2: 2 *J. of Kaziranga Wildlife Soc.* 0-30.

Hardin, Garret. 1968. The Tragedy of the Commons. *Science*. 162:1243-8.

Harry, M., 1997. The Karen People of Burma. White Lotus Press, Bangkok.

Hayasaka, K., T. Ishida, and S. Horai. 1991. Heteroplasmy and polymorphism in the major noncoding region of mitochondrial DNA in Japanese monkeys: Association with Tandemly Repeated Sequences. *Mol. Biol. Evol.* 8(4):399-415.

Hennig W., *Phylogenetic Systematics* (English trans); U. Ill. Press, Urbana.

Hrdy, S., 1977. *The Langurs of Abu: Female and Male Strategies of Reproduction*. Cambridge: Harvard Univ. Press.

Ingman, M., H. Kaessmann, S. Paabo and U. Gyllensten, 2000. Mitochondrial genome variation and the origin of modern humans. *Nature* 408:708-712.

Irwin D. M, T.D. Kocher, A.C. Wilson. 1991. Evolution of cytochrome *b* gene in mammals. *J. Mol. Evol.* 32(2):128-144.

Johns, G., and J. Avise. 1998. A domparative summary of genetic distances in the vertebrates from the mitochondrial cytochrome *b* gene. *Molecular Biology and Evolution*, 15(11): 1481-1490.

Kahn, J.R., 1995. The Economic Approach to Environmental and Natural Resources. Harcourt Brace & Company, Orlando.

Karan, P. P. 1963. The Himalayan Kingdoms: Bhutan, Sikkim, and Nepal. Van Norstrand Company.

Karanth, P., 2000. Molecular Systematics and Phylogeography of the Langurs of Asia. Ph.D. dissertation, University at Albany, State Univ. of New York.

Karma Ura, 1994. "Development and Decentralization in Medieval and Modern Bhutan," in *Bhutan: Aspects of Culture and Development*, eds. Michael Aris and Michael Hutt Gartmore**,** Scotland: Strachan-Kiscadale.

Khajuria, H. 1956. A new langur (Primates: Colobidae) from Goalpara district, Assam. *Ann. Mag. Nat. Hist*., 12 (9): 86-88.

Khajuria, H. 1978. The golden langur, *Presbytis geei* Khajuria: Its discovery, authorship, taxonomic status, and bibliography. Primates, 19: 237-240.

Khajuria, H. 1977. Ecological Observations on the Golden langur (*Presbytis geei* Khajuria) with remarks on its conservation. In *Use of Non-human primates in biomedical research*. M.R. Prasad and T.C. Kumar, eds. Indian National Science Academy, New Delhi.

Kocher, T. D., W. K. Thomas, A. Meyer, S. V. Edwards, S. Pääbo, F. X. Villablanca, and A. C. Wilson. 1989. Dynamics of mitochondrial DNA evolution in animals: amplification and sequencing with conserved primers. *Proc. Natl. Acad. Sci*. USA. 86:6196–6200

Kosambi, D.D. 1965. *Ancient India*. Pantheon Books.

Lansing, Stephen. 1991. *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*. Princeton University Press.

Leo E. Rose, 1977. *The Politics of Bhutan* Ithaca, N. Y.: Cornell University Press.

Lowi, T., 1969. *The End of Liberalism: The Second Republic of the United States*. New York: W.W. Norton.

Machlis, G.E., J.E. Force, and W.R. Burch, Jr. 1997. The Human Ecosystem Part I: The Human Ecosystem as an organizing Concept in Ecosystem management. *Society and Natural Resources*, 10:347-376.

Mackinnon, J. 1991. *National Conservation Plan: Bhutan*. Unpublished report for the Department of Forestry, Thimphu.

Mayr, E., 1963. *Animal species and evolution*. Harvard Univ. Press. Cambridge.

Melnick, D., and G. Hoelzer, 1993. What is mtDNA good for in the study of primate evolution? *Evolutionary Anthropology*. 2:191-199.

MoA (Ministry of Agriculture), 2002. Renewable Natural Resources Statistics 2000. Ministry of Agriculture, Royal Government of Bhutan, Thimphu, Bhutan.

Moritz, C., 1994. Defining 'evolutionary significant units' for conservation. *Trends Ecol. Evol.* 9 (10) 373–375

Mukherjee, R. P. and S.S. Saha, 1974. The Golden langurs of Assam. *Primates* 15(4): 327-340

Mukherjee, R. P. 1978. Further observations on the golden langur (*Presbytis geei* Khajuria, 1956), with a note to capped langur (*Presbytis pileatus* Blyth, 1843) of Assam. Primates, 19: 737-747.

Mukherjee, R. P. 1981. Distribution and present status of the golden langur, *Presbytis geei* Khajuria, in some forests of Assam, India. Proc. Wild Life Workshop, 129-131.

Napier, P., 1985. Catalogue of primates in the British Museum (Natural History). Part III. British Museum of Nat. Hist., London.

NCS (Nature Conservation Section), 1996. Jigme Dorji National Park Conservation Management Plan. NCS, Thimphu.

Norbu, P., 1998. Working scheme for Chapley Khola Forest Management Unit 1998-2000. Forest Resources Development Section, Department of Forestry, Royal Government of Bhutan, Thimphu.

NRC (National Research Council). 1981. *Techniques for the study of primate population ecology*. National Academy Press, Washington D.C.

Oboussier, H., and von Maydell, G. A. 1959. *Zur Kenntnis des indischen Goldlangurs: Ergebnisse der Deutschen Indien-Expetition 1955-1957 Leitung G. A. Frhr. V. Maydell*. Z. Morph. Ökol. Tiere, 48: 102-114.

Oppenheimer, J.R., 1978. *Presbytis entellus*, The Hanuman Langur. In *Primate Conservation*, Rainier and Bourne eds. Academic Press.

Orlando Patterson, 1999. The Western Chord: Trust and Democracy in the Culture of Freedom," Storrs Lecture Series, Yale Law School, New Haven, April 12, 1999.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

Paetkau, D., 1999. Using genetics to identify intraspecific conservation units: a critique of current methods. *Conserv. Biol.*13, 1507–1509.

Peters, Edward. 1997. *Eurpoe and The Middle Ages*. 3rd Edition. Prentice Hall.

Pocock, R., 1928. The langurs, or leaf monkeys, of British India. J. Bombay Nat. Hist. Soc. 32: 472 – 677.

__________, 1934. The monkeys of the genera Pithecus (or Presbytis) and Pygathrix found to the east of the Bay of Bengal. *Proc. Zool. Soc. London*. 895 - 961.

Posada D and Crandall KA 1998. Modeltest: testing the model of DNA substitution. *Bioinformatics* 14 (9): 817-818.

Pray, L. 2003 Mechanisms of Speciation. *The Scientist*. 17(21) 14-18.

Prater, S.H., 1965. *The Book of Indian Animals*. Bombay Nat. Hist. Soc.

Purvis, A. 1995. A composite estimate of primate phylogeny. *Phil. Trans. R. Soc. London* 348: 405-421

Putnam, R., 1993. *Making Democracy Work: Civic Traditions in Modern Italy* (New Jersey: Princeton University Press.

RGoB (Royal Government of Bhutan) 1996. Eight Five Year Development Plan, 1997- 2001. Thimphu.

RGOB (Royal Government of Bhutan), 1987. Landsat map of Bhutan. Thimphu.

RGOB (Royal Government of Bhutan), 1999. *Bhutan 2020: A Vision for Peace, Prosperity, and Happiness.* Planning Commission. Thimphu.

RGOB (Royal Government of Bhutan) 1999. Enhancing Good Governance: Promoting Efficiency, Transparency, and Accountability for Gross National

Happiness. by Twenty five member task force instituted by the Council of Ministers of Bhutan. Thimphu.

RGOB (Royal Government of Bhutan) 1999. Organization, Roles, Responsibilities, and Staffing Pattern of the Ministry of Agriculture. PPD, MOA, Thimphu.

Rinchen, D., and M. Maatta, 1993. Management plan for Wangdigang Forest Management Unit 1993-2002. Forest Resources Management Division, Department of Forestry, Royal Government of Bhutan.

Roberts, T., 1997. *Mammals of Pakistan*. Oxford University Press, Oxford.

Roos C., 2004. Molecular Evolution and Systematics of Vietnamese Primates. p 23-28 in *Conservation of Primates in Vietnam* T. Nadler, U. Streicher, and Ha Thang Long eds., 23-28. Publisher? City?

Roos, C., T. Geissmann, C. Groves, 2004. Molecular phylogeny of leaf monkeys. Unpublished direct sequence submission to GenBank. (http://www.ncbi.nlm.nih.gov/entrez/viewer.fcgi?db=nucleotide&val=46410423)

Rose, Leo. 1977. The Politics of Bhutan. Cornell University Press.

Ross, John. 1990. The Origin of the Chinese People. Pelanduk Publications. Royal Botanic Garden, Edinburgh.

Rousseau, Jean-Jacques. 1968. *The Social Contract*. London: Penguin.

Ryder, O., 1986. Species conservation and systematics: the dilemma of subspecies. *Trends Ecol. Evol.*1, 9–10.

Schluter, D. 1998. Ecological causes of speciation. p. 114-129 in *Endless Forms: Species and Speciation,* D. Howard, S. Berlocher, eds. Oxford University Press, Oxford.

Schluter, D. and L. M. Nagel. 1995. Parallel speciation by natural selection. *American Naturalist*. 146:292-301

Scott, J., 1985. *Weapons of the Weak: Everyday forms of Peasant Resistance*. Yale University Press.

Scott, J., 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. Yale University Press.

Shapiro, Ian, 1996. *Democracy's Place* Ithaca, N. Y.: Cornell University Press.

Isaacman, Allen. 1996. *Cotton is the Mother of Poverty: Peasants, Work, and Rural Struggle in Colonial Mozambique, 1938 - 1961*. Heinemann, Portsmouth.

Sinha, A., Datta, A., Madhusudan, M.D., and Mishra, C. The Arunachal macaque *Macaca munzala*: a new species from western Arunachal Pradesh, northeastern India. *Intl. Journal of Primatology* (in press).

Siu, H., 1995. *Down to Earth : The Territorial Bond in South China*. Yale University Press.

Spillet, J. J., 1966. The Kaziranga Wildlife Sanctuary, Assam. *J. of Bombay Nat. Hist. Soc.* 63: 494-533.

Sristava, A., J. Biswas, J. Das, and P. Bujarbarua, 2001. Status and distribution of golden langurs (*Trachypithecus geei*) in Assam, India. *Am. J. of Primatology* 55:15–23

Statistical Unit, PPD, MOA Development of a Reliable, Consistent, and Efficient RNR Data Management System in Bhutan. Statistical Unit, PPD, MOA. January, 2000. Thimphu.

Stedman-Edwards, P., 1998. *Root Causes of Biodiversity Loss: An Analytical Approach*. World Wide Fund for Nature, Washington D.C.

Stephen Holmes, 1999. "Political Theory and the End of Communism," Castle Lectures in Ethics, Politics, and Economics, Yale University (New Haven, February 1999).

Stewart C-B, and T. Disotell, 1998. Primate evolution: In and out of Africa. *Current Biology* 8:R582-R587.

Strasser, E and E. Delson, 1987. Cladistic analysis of cercopithecid relationships. *J. Human Evol.*, 16(1):81-99.

Subba, P. B. 1989. The status and conservation of the Golden langurs in the Manas National Park. *Tigerpaper* October - December: 16 - 18.

Sugiyama, Y. 1964. Group composition, population density, and some sociological observations of Hanuman Langurs (*Presbytis entellus*). *Primates* 5 (3-4): 7-37.

Sugiyama, Y. and M. D. Parthasarathy. 1979. Population change of the Hanuman Langur (*Presbytis entellus*), 1961 - 1976, in Dharwar area, India. *J. of Bombay Nat. Hist. Soc.* 75 (3): 860-867.

Swofford, D., 2002. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4. Sinauer Associates, Sunderland, Massachusetts.

Tamura, K. and M. Nei, 1993. Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. *Mol. Biol. Evol.* 10:512-526.

Taylor E., J. McPhail, D. Schluter, 1997. History of ecological selection in sticklebacks: uniting experimental and phylogenetic approaches, p. 511-534 in *Molecular Evolution and Adaptive Radiation* T. Givnish, K. Sytsma, eds. Cambridge Univ. Press, Cambridge.

Templeton, A., 1989. The meaning of species and speciation: a genetic perspective. in D. Otte and J. Endler, eds. *Speciation and its consequences*. Sinauer Associates, Inc., Sunderland, MA.

Thompson, E. P., 1991. *Customs in Common*. New York: New Press.

Thompson, J., T. Gibson, F. Plewniak, F. Jeanmougin, and D. Higgins, 1997. The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic Acids Research*, 25:4876-4882.

Tocqueville, A., 1969. *Democracy in America*. New York: Doubleday.

Ura, Karma. 1995. The Hero With a Thousand Eyes. White Lotus, Bangkok.

_________. 1994. Decentralisation and Development in Medeival and Modern Bhutan. In M. Hutt and M. Aris eds. Bhutan: Aspects of Culture and Development. Paul Strachan - Kiscadale Ltd.

van Driem, George. 1994. Language Policy in Bhutan. In M. Hutt and M. Aris eds. Bhutan: Aspects of Culture and Development. Paul Strachan - Kiscadale Ltd.

Valdiya, K., 1988. *Dynamic Himalaya*. Jawaharlal Nehru Centre for Advanced Scientific Research. Hyderabad, India, Universities Press.

Vigilant, L., M. Stoneking, H. Harpending, K. Hawkes, and A. C. Wilson. 1991. African populations and the evolution of human mitochondrial DNA. *Science* 253: 1503- 1507.

Weber, M., 1947. *Max Weber: Essay in Sociology*, ed. by H. H. Gerth and C. Wright Mills Oxford: Oxford University Press.

Wangchuk, T., 1995. A census and biogeography of golden langurs (*Presbytis geei*) in Bhutan. *TigerPaper FAO, UN Bulletin on Wildlife and National Parks Management* 22 (3): 1-6.

Wangchuk, T., Y.Kawamto, M.Aimi, 2001. Discovery of a contact zone between golden langurs (*Trachypithecus geei*) and capped langurs (*Trachypithecus pileatus)* in Bhutan. *Am. J. of Primatology* 54 (Supplement 1): 40.

Wangchuk T., D. Inouye, M. Hare**,** 2003**.** A new subspecies of golden langur (*Trachypithecus geei*) from Bhutan. *Folia Primatologica*. 74(2):104-108

Wangchuk, T., P. Thinley, K. Tshering, C. Tshering, and D. Yonten, 2004. *A Field Guide to the Mammals of Bhutan.* Royal Government of Bhutan, Thimphu.

Wangchuk, S., 1998. Local Perceptions and Indigenous Institutions as Forms of Social Performance for Sustainable Forest Management in Bhutan. ETH, Zurich.

Wangchuk, T., 2001. Changes in the Land Use System in Bhutan: Ecology, History, Culture, and Power, *Journal of Bhutan Studies* 2:1 (Autumn 2001), pp. 48–75.

Wells, M., 1997. Indonesia Integrated Conservation and Development Projects Review Draft document, World Bank.

Wells, Michael. 1997. Review of ICDPs in Indonesia. Unpublished draft, World Bank.

Wilson, E.O. 1995. Forward in Land Mosaics: The Ecology of Landscapes and Regions by Richard Forman. Cambridge University Press.

Wolfheim, J. H. (ed) 1983. *Presbytis geei* Golden langur pp 601 - 604 in *Primates of the World: Distribution, Abundance, and Conservation*. Seattle: Univ. of Washington Press.

World Bank, 2000. Strategy Note on Bank Involvement in Bhutan Forestry Sector, South Asia Rural, Washington DC.

World Bank Report, 1996. *Bhutan Country Economic Memorandum* 1996. Report no. 16113-BHU Washington.DC.

World Bank, 1998. Integrated Conservation and Development Projects Review, Draft Document, Washington DC.

World Wildlife Fund-US, 1998. Review of Integrated Conservation and Development Projects in the Asia-pacific Region, WWF-US Washington D.C.

Worster, Donald. 1992. Transformations of the Earth: Toward an Agroecological Perspective in History. J. of American History, Vol 76 (4): 1087-1106.