Chitre Da˜ra (Chitre Ridge) photographed from Khamletar Puchare. Forest patch at center is Baysinda Temple Forest; Chitre Village lies on the knoll above, Baysinda Village below. Crest on upper right is Chitre Taam, peaks in the background are the Sankhuwa Sir.

Chapter One

Problem, Objectives, Scope and Setting

The Problem

The Eastern Himalaya Region is one of Earth's "biodiversity hotspots," an area where continued habitat destruction is likely to lead to a disproportionate loss of global biological diversity (Bibby et al. 1992a, Stattersfield et al. 1998, Myers et al. 2000). Much of the region's biological diversity resides in its mid-elevation broadleaved forests (Hunter and Yonzon 1993, Acharya et al. 2011, Renner and Rappole 2011), forests which are facing unprecedented degradation (FAO 2005). In the Indian states of West Bengal, Sikkim, and Arunachal Pradesh, as in southwestern China, extensive tracts of temperate broadleaved forest are being felled for timber in areas that forty years ago were among the most inaccessible places on Earth. The impacts of subsistence agropastoralism (integrated crop and livestock production) are even more pervasive than timber felling. As populations of subsistence agropastoralists expand, increasingly "marginal" lands - the last patches of primary temperate broadleaved forest - are put into cultivation (Inskipp and Baral 2010). Governments have been slow to curb the loss of forest cover and biodiversity (Government of Nepal 2002). Extraction of forest resource is fundamental to national economic development, as well as local subsistence livelihoods. Current levels of government technical knowhow, organization, and funds are inadequate to maintain biologically diverse ecosystems. Nonetheless, governments and conservation organizations alike are looking increasingly toward local knowledge and local communities to manage forest resources (Poffenberger and McGean 1996, Stevens 1997, Kothari et al. 1998, Government of Nepal 2002, Millennium Ecosystem Assessment 2005). The degree to which subsistence communities can or will adopt more ecologically-sound land use practices at the very time they are being "integrated into the growth and consumption mainstream" (Soulé 1995), remains an open question (Mehta and Kellert 1998, Heinen and Mehta 2000), particularly in remote areas, where the relative ease of access to forest resources discourages adoption of better management practices (Metz 1998).

Few places in the Himalaya are better suited than Nepal to study the interrelationships of subsistence forest use and biodiversity conservation in temperate broadleaved forest. Nepal's biological and cultural resources are comparatively well documented. Much of the recent research and exploration has been conducted with foreign collaborators, so data on Nepal's resources are more widely available in major scientific publications. The forest conservation situation in Nepal illustrates the challenges confronting sustainable use and biological conservation throughout the region.

After Nepal eased restrictions on Western visitors in the early 1950s, it became known as a "naturalist's dreamland" (Biswas 1960). Nepal's first national park was established in 1973, and by 1995 more than 14% of the country was placed under reserve status (Shakya 1995), a remarkable figure for one of the poorest countries in the world. But relatively little forested land has been preserved between 500 and 3500 m elevation, where the human population can exceed 200 persons/km^2. Twenty-seven percent of the country's mammal species and 35 percent of its bird species breed in this zone, including many of the most vulnerable species (Hunter and Yonzon 1993). Few large tracts of forest remain in this zone, and those that remain have been altered by centuries of subsistence use (Mahat et al. 1987b, Ives and Messerli 1989).

The people of mid-elevation Nepal face many hardships. Kathmandu-based rulers have neglected and exploited them for centuries (Regmi 1978), creating the circumstances that lead to a recent civil war (1996-2006) and the rise of socialism. Electrification, transportation systems, industry, and other hallmarks of development are only beginning to appear in many areas. Many villagers still depend on daily access to forest resources for subsistence. Faced with mounting population pressure and few alternatives, subsistence farmers expand cultivation onto steep slopes (Schroeder 1985, Ives and Messerli 1989). As a consequence, forest cover is diminished further, cropland productivity declines, landslides are more frequently, and many animal species must retreat to remnants of primary forest in the most rugged and isolated locations (Inskipp and Baral 2010).

It is unlikely that additional large tracts of land will be placed under nature reserve status in mid-elevation Nepal, given recent trends in rural development, resource conservation, and indigenous tenure rights. To do so would be an additional hardship for many people, and might displace indigenous people - potential allies in resource conservation - from their traditional homelands. The Nepalese government would also have difficulty effectively policing and managing additional nature reserves with its limited resources (Ives and Messerli 1989). It is more likely that some form of forest co-management (a.k.a. community-based management) will prevail in the region (Stevens 1997). Under forest co-management, local user groups retain substantial authority over the use and management of forest resources, while government provides technical and organizational expertise. Co-management relies on "indigenous wisdom gathered over generations of experience" (Poffenberger et al. 1996), although government retains ultimate control (Heinen and Mehta 2000).

In 1992 a large-scale co-management scheme was initiated in northeastern Nepal with the establishment of the Makalu-Barun Buffer Zone (MBBZ; Nepali et al. 1990, Shrestha et al. 1990b). Conceding to the ineffectiveness of prior efforts to develop and conserve the region's resources, and spurred by the potential social and environmental impacts of a proposed hydroelectric development, the Nepalese government and an international consortium of non-governmental organizations (NGOs) formulated a new development paradigm for the region. According to Nepali et al. (1990), local "human resources" would be "activated to manage the available resources in a sustainable manner ... to achieve economically and environmentally sustainable development while furthering the aims of ecological and cultural conservation." Administrators would "create an awareness of the relevant issues," and *the people themselves* would "achieve the desired objectives."

Forest co-management offers considerable promise for conserving the culture, lifestyle and autonomy of indigenous peoples (Stevens 1997). However, fundamental contradictions exist between indigenous forest management and biodiversity conservation (Heinen and Mehta 2000, Khadka and Schmidt-Vogt 2008, Shrestha et al. 2010). Indigenous practices are, above all, utilitarian. They primarily concern access to, and equitable allocation of, high-value resources (Gilmour 1990). They can greatly increase forest cover and resource output of degraded forests, to the benefit of local people and the general physical environment (Messerschmidt 1987, Poffenberger and McGean 1996) but, as currently implemented, they are inadequate for maintaining biological diversity and ecosystem functions (Shrestha et al 2010).

In Nepal, indigenous forest management systems rely largely on knowledge of the *social* resources and *social* conditions necessary to manage forest resources (Messerschmidt 1987), rather than *ecological* knowledge. In the absence of imposed biodiversity criteria, they enhance economically and culturally important species at the expense of species with negligible perceived value. It is incorrect to suggest, as many have (Shrestha et al. 2010), that forest co-management can conserve biodiversity, when the empirical knowledge of that biodiversity, and the biological processes that support it, are inadequate or lacking. Metz (1998) contends "numerous" social forestry programs currently underway are likely to simplify ecosystems to the point that any remnant patches of mature forests will be eliminated. Shrestha et al. (2010) report "serious negative impacts of current community forests management [in Nepal that] if not corrected, will pose a serious threat to biodiversity."

In order for forest co-management to succeed in the Himalaya, indigenous knowledge must be reconciled with knowledge from the natural sciences, then incorporated into scientifically-credible management guidelines that will be understood and embraced by local communities (Mehta and Kellert 1998, Heinen and Mehta 2000, Shrestha et al. 2010). Sundriyal and Sharma (1996) acknowledge there has been a "lack of use of scientific information in [forest] management programs all over the Himalaya ..." Scientific knowledge regarding the disturbance ecology of temperate Himalayan forests is particularly limited, and in urgent need of advancement. Despite a series of published appeals over the past 30 years (Thompson et al. 1986, Metz 1990, Shrestha et al. 2010), few robust scientific field studies have addressed the ecological linkages between human and non-human communities in the temperate Himalaya (e.g., Schmidt-Vogt 1990, Sundriyal and Sharma 1996, Metz 1998, Chettri et al. 2001, 2002). With this study, I endeavor to advance this body of knowledge.

Transliteration of Nepali Terms

The Nepali language includes aspirated consonants, dental and retroflex "d" and "t" sounds, nasalized "n" sounds, and low back and schwa "a" sounds. With Romanized spellings of Nepali words I indicate aspirated consonants with the addition of an "h," as in *dhami*. I indicate retroflex sounds with an uppercase letter, as in *goTh,* which is pronounced much like the English word "goat." I indicate nasalized "n" sounds with a tilde, as in *chau˜ri.* Finally, I indicate the low back "a" sound with an uppercase "A," which is pronounced as in the English word "car," and the schwa sound with a lowercase "a," as in the English word "ago." When I use foreign words, the first time I use them I indicate which language they are from with the following symbols: Nepali, N.; Sherpa, S.; and Tibetan, T. For place names and other proper nouns I do not indicate Nepali phonetics or language origins. For these words I use the most common Romanized transliteration in order to facilitate cross-referencing to maps or other literature.

Objectives and Scope

My overall goal is to model how subsistence use of Temperate Sikkim-East Nepal Forest changes indigenous plant and animal communities (Chapter 6). Constituent objectives include analyses of household collection and consumption of woody plants (Chapter 2), analysis of woody plant associations along a disturbance gradient (Chapter 3), analysis of habitat associations of selected bird and small mammal species (Chapter 4), and analysis of plant and animal communities across regressively-disturbed habitat zones surrounding a village (Chapter 5).

For most purposes, the *geographic scope* of this study is the middle elevations of the Temperate Sikkim-East Nepal Himalaya phytoclimatic region (TSENH, Troll 1967), which extends from eastern Nepal through Sikkim and northern West Bengal to Bhutan. This study pertains to the broadleaved zone of the TSENH, which ranges from ~2000-3000 m elevation (Fig. 1.1). Ecological communities and human cultures of this zone, although diverse, are relatively consistent. Hereafter, references to the TSENH will pertain only to the broadleaved zone.

Several logistical and design considerations dictated that I collect field data at a single site, Chitre Village, within the Arun watershed (see Physical Setting below for precise location). At the time of data collection (1993-1994), permits required for foreigners to conduct research almost anywhere in the Eastern Himalaya were difficult or impossible to acquire, particularly for a mostly autonomous graduate student. Data collection at additional sites would have entailed additional permits, multiple expeditions, and less time getting to understand the people and circumstances at each site (see Hoffpauir 1978 and Zurick 1989). To achieve my objectives, it was more important to collect data over time (e.g., resource consumption by seasons) than across space. In the Eastern Himalaya, residents of remote villages are unaccustomed to foreigners, and often fear that government functionaries will limit their access to forest resources. Collecting data on household resource use without first establishing a friendly rapport with the community would have invited biased information, ostracism, threats, or worse (*see* Metz 1989a).

I resided in Chitre for 18 months: Mar-Nov, 1993, Apr-Nov, 1994, and Jan, 1996. During the first seven months I employed a Nepalese facilitator/translator and a few field assistants from outside the village, but thereafter I relied entirely on Chitre residents, and conducted all work in the Nepali language (at the time, no Chitre resident spoke English).

The *biotic scope* of the study encompasses woody plants, small diurnal birds, and small non-volant mammals of the TSENH. For species that are at the periphery of their distribution at Chitre, my findings might differ somewhat from sites more central to the species' distribution. I do not investigate large raptorial birds or mid- and large-sized mammals because, with the exception of muntjac (*Muntiacus muntjak*), they are rare in the study area. Furthermore, because their home ranges cover large areas, encompassing multiple villages, they are best studied at larger geographic scales than I was logistically able to cover. The *cultural scope* of the study is primarily Sherpa culture, and to a lesser degree on Rai culture. Hereafter, for brevity, I will occasionally refer to Sherpa culture as *Bhotia* (N. Tibetan) culture, even though the term Bhotia is usually applied to Tibetan communities that immigrated to Nepal more recently than the Sherpas. Rai communities down slope from Chitre make seasonal use of the forest around Chitre for grazing, hunting, bamboo harvest, and occasional timber harvest. The principal forest use activities I investigate are fuelwood harvest, timber harvest, bamboo harvest, leaf litter collection, tree fodder lopping, and livestock grazing. I also investigate local valuation of woody plant species and local forest management systems. For the most part, I do not investigate cultural perceptions of the environment, or the role of human decision-making in molding the environment, topics which have underpinned much of the environmental research conducted in the Himalaya in recent decades (Ramble and Chapagain 1990, Gilmour and Fisher 1991, Diemberger 1992, Kothari et al. 1998, Guneratne 2010).

Human communities have unique relationships to the land surrounding them, relationships that reflect the community's history, ethnic composition, and trade relationships. My findings on cultural practices at Chitre will therefore have more limited geographic application than my findings on forest biota. Nonetheless, most small communities throughout the TSENH practice some form of agropastoralism (Metz 1989b), so findings on the ecological impact of subsistence agropastoralism are relevant, if not directly applicable, throughout the region. The form of agropastoralism practiced at Chitre - integrated maize (*Zea mays*), potato (*Solanum tuberosum*), and cattle-yak hybrid (N. *chau~ri*) production - is primarily practiced among Tibetan (N. *Bhotia*) cultural groups (see Cultural Setting below) that occupy a narrow altitudinal zone at the upper limit of cultivation in Eastern Nepal, West Bengal, and Sikkim. Agropastoral systems of other ethnic groups - primarily Rais and Limbus - are based on millet (*Elusine coracana*), rice (*Oryza sativa*), sheep (*Ovis* sp.), and goat (*Capra* sp.) production. Most ethnic communities in the Makalu Barun region practice some form of slash-and-burn agriculture (Sharma and Kharti-Chhetri 1995), but "forest interior" slash-and-burn (see below) is uncommon at Chitre. The greater scale and intensity of disturbance caused by "forest interior" slash-and-burn must be taken into account when extrapolating my findings to areas where it is practiced.

Conceptual, Theoretical and Methodological Approach

In the mid-1980s, Michael Thompson and colleagues (Thompson and Warburton 1985, Thompson et al. 1986) advanced the need for better integrated research and management of Himalayan forests. They observed that development planners and ecologists often viewed their work as completely separate enterprises. For rural development in the Himalaya to be sustainable, they argued, it must be bedded in nature: "... the simple fact is that biological processes and resources are often fundamentally linked to the lives of those Himalayan villagers who are most in need of assistance. In consequence, some of the best (indeed quite possibly, the only) openings for village level rural development, and for the design of effective conservation strategies, hinge directly on understanding and exploiting this connection."

I employ theories and methods from several disciplines. My approach for studying human culture is based in ecological anthropology, the study of human population dynamics, social organization, and culture in relation to the environments in which people live (Rappaport 1971, Orlove 1980). My use of household monitoring, key-informant interviews, and participant observation are all based on standard methods of ecological anthropology (Pelto and Pelto 1978). My approach to studying vegetation is based on the traditions of vegetation ecology (Barbour et al. 1987), disturbance succession (Pickett and White 1985), and ecological gradient analysis (Whittaker 1967). My approach to studying animal ecology is rooted in the traditions of wildlife management (Leopold 1933) and wildlife ecology (Flowerdew 1976, Stoddart 1979, Perrins and Birkhead 1983, Bookhout 1994), with particular emphasis on wildlife-habitat relationships (Morrison et al. 1992, Block and Brennan 1993, Anderson and Gutzwilller 1994), forest fragmentation, and edge effects (Harris 1984, Harris 1988, Yahner and Scott 1988, Faaborg et al. 1995). Geography, the most integrative of the natural sciences (Schaefer 1953), provided a framework for integrating all these theories and methods.

There are two disciplinary traditions in human ecology, the physical and the cultural, and they have never been entirely compatible (Brookfield 1973, Chorley 1973, Bennett 1976, Vayda and Rappaport 1976). The physical approach is more materialist, the cultural approach more cognitive. Geographers, with their roots in spatial science, have traditionally emphasized environmental variables, natural and cultural landscapes, and "man's record upon the landscape" (Sauer 1956). Anthropologists, who have traditionally considered human culture superorganic, emphasize cultural and social phenomena (Grossman 1977). In the Himalaya, where anthropologists have led the design and implementation of resource management and rural development, the anthropological approach prevails (see Guneratne 2010). Both approaches are needed to create truly sustainable resource management and biodiversity conservation programs. The theories and methods of the physical tradition are especially needed when gathering initial empirical knowledge, and the cultural tradition is especially needed when determining how best to implement conservation in the local cultural context.

Physical Setting

The rugged Himalayan terrain is the product of millions of years of geological activity (Jhingran 1981). Prior to the Permian Period, 280 million years ago, Peninsular India was joined with Africa, Australia, South America and Antarctica in a single southern continent, Gondwanaland. During the late Mesozoic era the Indian tectonic plate broke away from Gondwanaland, drifted north, and 40-50 million years ago collided with the Eurasian plate (Molnar 1986). The Indian plate was subducted by the Eurasian plate, and the Himalaya began to rise from what was formerly the Tethys Sea.

The south face of the Himalaya is particularly steep in the eastern region. The ~8,800 m altitudinal incline from the Gangetic plain to the crest of Mount Everest spans a horizontal distance of only ~150 km. The Arun Valley, just 10 km east of the Chitre Study area and flanked by Mount Everest (8848 m) on the west and Mount Kanchenjunga (8586 m) on the east, is considered one of the deepest canyons on Earth (Cronin 1979). Such relief has a strong influence on continental- and local-scale climates. Dominant continental-scale climatic phenomena include influxes of cold-dry air from the Tibetan Plateau in winter, warm-moist air from the Bay of Bengal in summer, and the ebb and flow of continental air masses through deeply incised canyons such as the Arun (~10 km east of the Chitre study area). Walter and Lieth (1960) place the Eastern Himalaya at the center of a zone of "tropical summer-rain mountains" extending from Mussoorie in northwestern India to Bhutan and southeastern Bangladesh. The highest annual rainfall known on Earth occurs in this zone: 11.86 m at Mawsynram, India (NGS 1997). In summer, moisture-laden monsoonal air sweeps across the Himalayan Ranges from east to west, depositing extraordinary amounts of precipitation at mid-elevations of the Eastern Himalaya (>4000 mm/yr; Banerjee 1952, Shrestha 1989).

Local topography also has profound effects on climate (Schweinfurth 1956, Troll 1967, Stainton 1972, Mani 1981). During the summer monsoon, moist air is forced up south-facing slopes by high pressure systems originating over the Bay of Bengal. When this air reaches cooler heights, clouds form, moisture condenses, and precipitation begins to fall. In large river valleys like the Arun, a zone of dense mountain mist and high precipitation occurs between ~1800 and 3000 m elevation throughout the monsoon season. North-facing slopes receive less precipitation from moist rising air but, because they do not receive direct sunlight, they remain cool and moist throughout the year. Within gullies and small drainages, microclimates are further influenced by the daily katabatic movement of cool air.

There are few long-term meteorological records for the temperate Eastern Himalaya. Published meteorological data are readily available for Chaurikharka (2700 m, Solukhumbu District, Nepal, Dhar and Narayanan 1965), Jiri (1895 m, Solukhumbu District, Nepal, Kraus 1966), Num (1497 m, Sankhuwasabha District, Nepal, Shrestha 1989), Taplejung (1768 m, Taplejung District, Nepal, Dobremez 1972), and Darjeeling (2140 m, West Bengal, India, Hatakeyama *in* Kanai 1966, Yoda 1967, Mani 1981). Taken together, these data provide a general impression of the annual climatic pattern of the region's temperate zone.

The Himalayan climate is commonly divided into four seasons (Mani 1981): winter (~December-February), spring/pre-monsoon (~March-May), summer/monsoon (~June-October), and autumn/post-monsoon (~October-November). The annual climatic pattern of Darjeeling (2140 m) is characteristic of the TSENH. Temperatures are moderate and stable during the summer monsoon period, with a mean daily maximum around 20° C and a daily minimum of 10 to 15 ° C. Daily temperatures begin to decline in October, and continue to drop until a low is reached in January. Mani (1981) reports a record low temperature for Darjeeling of -5° C. Temperatures begin to climb again in February, and by the end of May approach the summer monsoon average.

Relatively little precipitation falls in the TSENH between November and the end of February. At Darjeeling, precipitation is at its lowest in December, when average daily precipitation drops to ~5 mm. Precipitation begins to rise markedly in late March or April. The first rains of the summer monsoon are heavy in the Eastern Himalaya (Shrestha 1989), and arrive in spates (Dobremez 1972, Joshi 1982, Brower 1991, Stevens 1993). Their dramatic onset results from the periodic passage of low-pressure systems, in conjunction with local orographic influences (Mani 1981). Precipitation rates climb until a peak is reached sometime between late

June and early August. Peak monthly precipitation averages 400-600 mm, but can exceed 1000 mm at some locations. By September, precipitation rates begin dropping rapidly. Typically, 90-95% of annual rainfall occurs during the 6-month period between May and October, and total annual precipitation averages between 2000 and 3000 mm. Annual totals as high as 6,300 mm have been reported, however. The slopes of large Eastern Himalayan valleys receive particularly high precipitation as a result of pronounced "valley-side hangwinds," which deposit moisture as they rise up the sides of a valley and cool (Schweinfurth 1956). Schmidt-Vogt (1990) provides a colorful narrative of characteristic daily weather patterns similar to those at Chitre.

Most soils in temperate Eastern Nepal originate from either gneissic or granitic parent materials (Shrestha 1989). Lower horizons are poorly differentiated and upper horizons are brown, moderately acidic, and often loamy. The humic horizon, where well developed, is often dark brown (Papadakis 1969, Byers 1987).

Chitre study area

Chitre Village (Fig. 1.2) is a nuclear village of 10 households clustered around a small Buddhist temple, Phinchho Norling *Gomba* (S. Buddhist temple), located in Bala-Sisuwa Village Development Committee, Sankhuwasabha District, northeastern Nepal (27°29'50"N, 87°02'55"E, 2350 m). It is the most remote settlement on an "obscure and difficult route" (Anderson 1989) connecting Khandbari, the regional center of government, to alpine regions of Makalu Barun and Mount Everest (Sagarmatha) National Parks by way of Khemba-la Pass. My first expedition to Chitre in January 1993, required seven days' travel by foot from the nearest road (at Hile).

Chitre lies on the upper south-facing slope of a ridge, known as Chitre *Da~ra* (N. ridge), which separates the Sisuwa and Sankhuwa Rivers. The two rivers converge just below Chitre, from where they drain into the nearby Arun River. The conical peak of Chitre *Da~ra* is known as

Chitre Taam (2885 m), which rises ~530 m above Chitre Village (Fig. 1.3). Northwest of Chitre Taam, the ridge constricts along a narrow saddle known as Chakedho, turns northward, widens again, and ultimately ascends to Chamlang Peak (7129 m).

Chitre Village is located within Makalu Barun Buffer Zone (MBBZ), just beyond the southwestern boundary of Makalu Barun National Park (MBNP). Together, MBNP and MBBZ encompass several western drainages of the Arun River and cover an area of 2330 km^2. MBNP abuts Sagarmatha (Mt Everest) National Park to the west and Qomolangma Nature Preserve (Tibet, China) to the north. Famous peaks within MBNP include Mt Makalu (8463 m), the fifth highest peak in the world, Mt Chamlang (7319 m), Mt Baruntse (7129 m) and Mera Peak (6654 m).

There are no meteorological records for the Chitre area, so I recorded daily precipitation and minimum and maximum temperatures during the periods I resided there (Appendix 1.1). Chitre's climate is similar to that of Darjeeling (Fig. 1.4), ~135 km to the southeast. During the summer monsoon (June-October), the mean daily maximum temperature was ~21° C (SD = 1.6° C), and the mean daily minimum was ~13.5° C (SD = 1.0° C). Precipitation peaked during the month of August, with a daily average of 31 mm and a monthly total of 944 mm. Limited winter data suggest mean daily minimum temperature drops to near 0° C in January. According to local informants, the forest floor just upslope from Chitre is covered with as much as 1 m of snow for several weeks in January and February, but the amount of snowfall varies considerably from year to year. In 1994, the total annual precipitation at Chitre exceeded 3500 mm, slightly less than the 3759 mm total reported for Num 10 km to the east (Shrestha 1989). Most other meteorological stations in temperate Eastern Nepal report annual precipitation more in the range of 2000 to 2500 mm.

Soils at Chitre are gneissic in origin. Upper soil horizons are somewhat reddish, with texture ranging from loamy to clay.

Biotic Setting

As the Himalayan ranges arose from the Tethys Sea they became colonized by plant and animal taxa from adjoining western Eurasia, Central Asia, East Asia, and Indomalaya (Kanai 1966, Stainton 1972, Grierson and Long 1983, Fleming 1971, Martens and Eck 1995). The modern TSENH biota is most closely affiliated with temperate East Asia, and to a lesser degree with tropical Indomalaya (Ali 1949, Kanai 1966). The temperate broadleaved zone also has Indomalayan and Central Asian elements (Shakya 1983).

The Eastern Himalaya is one of the most species-rich regions on Earth (WWF and IUCN 1995, Olson and Dinerstein 1998, Stattersfield et al. 1998, Myers et al. 2000, Wikramanayake et al. 2001, WWF and ICIMD 2001, WWF 2005), yet the region's biota remains one of the least well known (WWF and ICIMD 2001, WWF 2005). Large areas remain poorly surveyed (WWF 2005), and new taxa are being discovered at a rate of ~35/yr (WWF2009). The status of 38% of Nepal's mammal species cannot be determined satisfactorily due to lack of knowledge (Jnawali et al. 2011).

In Nepal alone, just 141000 km^2 in area, there are an estimated 5856 species of flowering plants, 208 mammal species, and 755 breeding bird species (Inskipp 1989, Government of Nepal 2002, Jnawali et al. 2011). By comparison, California, which is three times the size of Nepal and also known for its natural diversity, has 3% fewer flowering plant species, 11% fewer mammal species, and ~46% fewer breeding bird species (Zeiner et al. 1990, Hickman 1993, Small 1994).

The region's biotic richness is increasingly threatened, primarily by loss and degradation of habitat by humans and by illegal hunting (Inskipp 1989, Government of Nepal 2002, WWF 2005, Jnawali et al. 2011). According to recent assessments, the proportion of East Himalayan forest cover classified as dense (>40%) will decrease to ~37.5% by 2100 (Pandit et al. 2007), and the loss of primary forest cover in Nepal (of all types) has accelerated to 70 km^2/yr (FAO 2005). In Nepal, 55 (26%) of its mammal species and ~49 (8%) of its breeding bird species are critically endangered, endangered, or vulnerable (Inskipp et al. 2011, Jnawali et al. 2011). In the country's temperate broadleaved forests alone, where ~191 bird species and ~75 mammal species breed, 40 bird species (~20%) are at risk (Inskipp 1989), and 15 mammal species (~20%) are critically endangered, endangered, or vulnerable (Jnawali et al. 2011).

Much of the existing knowledge of the Himalayan biota dates to the late 1800s, when the British Government in India dispatched plant collectors to search for species with potential commercial value (Desmond 1992). The preeminent Himalayan botanist was Joseph Dalton Hooker, who described hundreds of new plant species (Hooker 1849, 1854, 1906). Hooker and his contemporaries Griffith (1847), Gamble (1875) and Ward (*in* Schweinfurth and Schweinfurth-Marby 1975) also provided the first descriptions of forest structure and composition. The preeminent Himalayan zoologist was Brian Houghton Hodgson, who was British Resident in Nepal through the early 1800s. Hodgson published descriptions of 120 bird species and 40 mammal species from the region (Inskipp and Inskipp 1985). In the late 1800s, the first comprehensive volumes on animals of the Indian subcontinent were compiled by British medical officers (Jerdon 1862-64, 1867, Blanford 1888-91). Scully (1879) recorded >300 bird species around Kathmandu Valley. In the early 1900s, naturalists associated with early expeditions to Mount Everest collected animal specimens from the north slope of Mount Everest (Thomas and Hinton 1922, Kinnear and Wollaston 1922, Hingston 1928), Stevens (1923-25) studied the avifauna of Sikkim, Fry (1925) collected mammals from west-central Nepal, and Cowan (1929) and Champion (1936) devised the first classification schemes for Himalayan forests.

The easing of travel restrictions to Nepal in the 1950s spurred many natural history expeditions to eastern Nepal. A series of botanical expeditions resulted in many floras for Eastern Nepal, including works by Banerji (1958, 1965), Hara (1966), Hara et al. (1982), and Polunin and Stainton (1984). Other botanical expeditions emphasized phytogeography, including works by Schweinfurth (1957), Banerji (1963), Kanai (1966), Hara (1966), Troll (1967), Yoda (1967), Dobremez (1972, 1976), Stainton (1972), Kanai et al. (1975), Shakya (1975), Ohsawa (1983), Ohsawa et al. (1986), and Shrestha et al. (1990a). Ornithological collections were made in and around the Kathmandu Valley by Smythes (1948, 1950), Ripley (1950), Biswas (1961-68), and Proud (1949, 1952, 1955, 1958, 1961). Ripley (1952) undertook a zoological expedition to the Arun Valley, Biswas reported zoological results of an expedition to Mount Everest (Biswas and Khajuria 1957, Biswas 1974), and Leviton et al. (1956) reported zoological results of an expedition to Mount Makalu. German scientists conducted a broad array of natural history studies in the Mount Everest Region (Diesselhorst 1968, Gruber 1969, Weigel 1969). In the early 1970s, Abe (1971) studied small mammals in central Nepal, and Cronin and McNeely (Cronin 1979) led a wildlife survey to the upper Arun Valley (of which most scientific findings were not published, but see Mitchell 1977 for mammals and ectoparasites collected). In the late 1970s, Robert Fleming Sr. and Jr. published the first Nepalese bird guide (Fleming et al. 1976), based on >200 expeditions (Fleming 1971), and Mitchell (1977) completed the first comprehensive study of Nepalese mammals. In the 1980s, Carol and Tim Inskipp compiled decades of observations by professional naturalists and bird watchers for comprehensive works on the distribution and status of Nepalese birds (Inskipp and Inskipp 1985, 1991; Inskipp 1989). Martens and Eck (1995) published a scholarly volume on the taxonomy, ecology and vocalizations of Himalayan birds, based on seven expeditions throughout Nepal. The most recent ornithological studies have emphasized regional-scale biodiversity gradients (Acharya et al. 2011, Price et al. 2011, Renner and Rappole 2011, Ghosh-Harihar and Price 2014). Field studies that have contributed most substantively to ecological knowledge of the Makalu Barun National Park and Buffer Zone are Hara (1966), Cronin (1979, Mitchell 1977), Shrestha et al. (1990a), Shakya (TMI 1995), Carpenter and Zomer (1996), Zomer et al. (2001), and Carpenter (2005).

Few prior studies have investigated stand-scale ecological disturbance in temperate Himalayan forests. In the western Himalaya (Uttarkhand), Singh et al. (1985) assessed the impact of lopping and grazing on forest structure and composition. In central Nepal, Metz (1997, 1998) investigated the influence of lopping, livestock browsing, and proximity to village on forest composition and regeneration, and Khatry Chhetri (1997) developed an "anthropoic disturbance index" based on five measures of cutting and lopping intensity. In eastern Nepal, Ohsawa et al. (1975), Ohsawa (1983), and Carpenter and Zomer (1996) described the ecological traits of early-successional plant species where anthropogenic and natural disturbances had taken place. In Sikkim, Sundriyal and Sharma (1996) and Chettri et al. (2002) studied the influence of lopping, fuelwood harvest, and timber harvest on forest structure, composition, regeneration, and productivity. Most recently, Chettri et al. (2001, 2005) compared the structure of tree and bird communities in closed-canopy stands to those in stands thinned by fuelwood harvest, lopping, and livestock grazing.

Broadleaved forests throughout the TSENH have been degraded by decades or centuries of human occupation, subsistence agriculture, and livestock grazing (Hoffpauir 1978, Poffenberger 1980, Sundriyal and Sharma 1996, Metz 1998, WWF 2005). Human population densities in the Sankhuwasabha District of Nepal can exceed 760 persons/km^2 of arable land in some locations (Bajracharya 1983). Throughout northeastern Nepal, the area under cultivation has expanded to its upper climatic limit, ~2000 m elevation (Yoda 1967, Stainton 1972, Shakya 1975, Dobremez 1976, Kleinert 1983, Shrestha 1989). Remaining stands of primary temperate broadleaved forest in the TSENH are fragmented and isolated (Yoda 1967, Shakya 1975, Carpenter and Zomer 1996). One such remnant lies on the outskirts of Chitre Village.

Chitre study area

MBNP&BZ is inhabited by at least 3128 species of flowering plants, 88 species of mammals, 421 species of birds (440 according to Jackson et al. 1990), and 59 species of reptiles and amphibians (Shakya 1995). Six bioclimatic zones are recognized within MBNP&BZ: tropical (400-1000 m; *Shorea*/*Albizia* forest), subtropical (1000-2000 m; *Castanopsis*/*Schima* forest), temperate (2000-3000 m; *Quercus*/*Rhododendron*/*Acer* forest), subalpine (3000-4000 m; *Abies*/*Betula*/*Rhododendron* forest), alpine (4000-5000 m; *Juniperus*/*Rhododendron* scrub) and nival (> 5000 m) (Shrestha 1989).

Common woody plant taxa of temperate broadleaved forest include Aceraceae (*Acer*), Caprifoliaceae (*Viburnum*), Ericaceae (*Rhododendron*, *Lyonia*), Fagaceae (*Quercus*, *Castanopsis*), Lauracea (*Lindera*, *Litsea*, *Persea*), Magnoliaceae (*Magnolia, Michelia*), Moraceae (*Ficus*), Rutaceae (*Tetradium*), and Theaceae (*Eurya, Symplocos*). Dominance and co-occurrence of canopy tree species vary widely (Champion and Seth 1968, Kawakita 1956, Stainton 1972, Dobremez 1976, Carpenter and Zomer 1996). Chitre Village lies just below the transition from warm temperate broadleaf forest, dominated by oaks, chestnuts, and laurels (*Quercus*, *Castanopsis*, *Lindera*, *Litsea*, *Persea*), and cool temperate forest, where maple, birch, and conifers (*Acer*, *Betula*, *Abies*) become important canopy components (Shrestha 1989).

Jackson et al. (1990) report 190 bird species observed in temperate broadleaved forests of the MBNP&BZ's. According to Inskipp et al. (2011), 3 of these are globally near-threatened (satyr tragopan *Tragopan satyra*, yellow-rumped honeyguide *Indicator xanthonotus*, rufous-throated wren babbler *Spelaeornis caudatus*, Fig. 1.5), 1 is globally vulnerable (wood snipe *Gallinago nemoricola*), 2 are critically endangered in Nepal (coral-billed scimitar babbler *Pomatorhinus ferruginosus*, spotted wren babbler *Spelaeornis formosus*), 3 are endangered in Nepal (rufous-throated wren babbler, broad-billed warbler *Tickellia hodgsoni*, Gould's shortwing *Brachypteryx stellata*), and 16 are vulnerable in Nepal (satyr tragopan, wood snipe, barred cuckoo dove *Macropygia unchall*, brown wood owl *Strix leptogrammica*, yellow-rumped honeyguide, slender-billed scimitar babbler *Xiphirhynchus superciliaris*, golden babbler *Stachyris chrysaea*, great parrotbill *Conostoma oemodium*, fulvous parrotbill *Paradoxornis fulvifrons*, grey-sided laughingthrush *Garrulax caerulatus*, blue-winged laughingthrush *Garrulax squamatus*, black-headed shrike babbler *Pteruthius rufiventer*, rusty-fronted barwing *Actinodura egertoni*, white-gorgeted flycatcher *Ficedula monileger*, dark-sided thrush *Zoothera marginata*, golden-naped finch *Pyrrhoplectes epauletta*). Two additional threatened bird species have been documented in MBNP&BZ's temperate broadleaved forest since Jackson et al.'s list, long-billed wren-babbler (*Rimator malacoptilus*, critically endangered in Nepal) and purple cochoa (*Cochoa purpurea*, endangered in Nepal) (Inskipp et al. 2011).

Occurrence and habitat associations of mammals in MBNP&BZ are less well known than for birds (e.g., so little information exists on 48% of Nepal's bats, shrews, and rodents that their conservation status cannot be assessed, Jnawali et al. 2011). Based on information provided by Jackson et al. (1990) and Jnawali et al. (2011), a minimum of 50 species of non-volant mammals occur in temperate broadleaved forests of MBNP&BZ, of which five are endangered in Nepal (clouded leopard *Neofelis nebulosa*, dhole *Cuon alpinus*, Asiatic black bear *Selenarctos* *thibetanus*, Himalayan water shrew *Chimarrogale himalayica*, red panda *Ailurus fulgens*), three are vulnerable in Nepal (barking deer *Muntiacus muntjak*, common leopard *Panthera pardus*, leopard cat *Felis bengalensis*), and three are near-threatened in Nepal (Eurasian otter *Lutra lutra*, goral *Nemorhaedus goral*, large Indian civet *Viverra zibetha*) (Jnawali et al. 2011).

The forest at Chitre Village is one of the largest remnants of primary temperate broadleaved forest in the MBBZ. Its plant and animal life had not been investigated prior to this study, even though Shakya (1995) considered it to be one of the least biologically explored areas in the entire Makalu Barun region. Lists of the woody plant, bird, and mammal species I recorded near Chitre are provided in Appendixes 1.2, 1.3, and 1.4, respectively. Table 1.1 is a list of species at Chitre that are of conservation concern.

Cultural Setting

Human cultures of the Eastern Himalaya are unusually diverse: Hindus, Animists, Buddhists, Muslims, rice farmers, sheep or yak (*Bos grunniens*) agropastoralists, slash-and-burn farmers, and hunter-gatherers (Bista 1996, Fürer-Haimendorf 1962, Rhoades and Thompson 1975). I limit this overview to the two cultures found in the Chitre study area, the Solukhumbu Sherpas and Kulunge Rai, and base it on ethnographic works by Chemjong (1966), Fürer-Haimendorf (1964, 1975, 1979, 1984), Ortner (1978, 1989), McDougal (1979), Kunwar (1989), Bishop (1989), Stevens (1989, 1993), Ramble and Chapagain (1990), Fisher (1990), Brower (1991, 1996), Gaenszle (1991), and Diemberger (1992).

"Sherpa people" originate from several ethnic lineages (Fürer-Haimendorf 1964, 1979, 1984, Ortner 1978, 1989, Clarke 1980, Parker 1989). The historic origins of most can be traced to Tibet, and most share the Tibetan cultural heritage, which includes Tibetan (Vajrayana) Buddhism, characteristic social and agropastoral systems, and distinctive architecture and clothing. The Sherpas of mountaineering renown - known for their dedication, endurance, courage, good spirit, and devotion to Tibetan Buddhism - trace their roots to the Solukhumbu (Mt Everest) region. According to oral tradition and limited empirical evidence (Fürer-Haimendorf 1964, Oppitz 1968, 1974), Solukhumbu Sherpas immigrated to Nepal in the mid-1500s from the Kham region of eastern Tibet. They first settled in the subalpine valleys of Khumbu, near Mt Everest, then spread south to temperate elevations of Solu. Four major out-migrations occurred from Solu (Ortner 1989): west to Deorali Bhandar Valley in 1725-1750, east to the Arun Valley in ~1825 (Fürer-Haimendorf 1975), northwest to Rolwaling Valley in 1860 (Sacherer 1981), and east to Gunsa and Darjeeling in the 1860s.

Homesteading and emigration are Sherpa strategies for eluding adverse socio-political circumstances (Ortner 1989). The original Sherpa immigrants to Nepal are thought to have left Tibet at a time of Mogul incursions (Oppitz 1974), and mid-nineteenth century out-migrations from Solu coincided with a period of heavy taxation by Nepal's Rana Regime (Regmi 1978). Sherpa inheritance customs encourage emigration and homesteading. Family properties are divided among sons each generation. After a few generations, family landholdings become so small that descendants must pursue additional economic endeavors, bring new lands into cultivation, or homestead elsewhere.

Today, settlements of Solukhumbu Sherpas are found from the Sun Kosi River of Central Nepal to Darjeeling in northeastern India (Fürer-Haimendorf 1964). According to oral tradition, Solukhumbu Sherpas immigrated to the Arun Valley as early as the mid-sixteenth century (Oppitz 1968). Most Solukhumbu Sherpas living in the Nepalese portion of the Arun Valley appear to have immigrated there in the mid-1800s (Fürer-Haimendorf 1964, Stevens 1993). Additional Bhotia settlements in the Arun Valley consist of people who immigrated directly from Tibet and share only rudimentary cultural and linguistic ties with Solukhumbu Sherpas (Fürer-Haimendorf 1975). In a few Arun Valley Bhotia settlements, Solukhumbu immigrants have intermarried with Bhotia of more direct Tibetan origin, as in the Nawa and Khumbo communities of Tashigaun (Diemberger 1992).

The prehistoric settlement of northeastern Nepal is uncertain, preserved primarily in oral tradition, and steeped in mythology (Regmi 1960, Chemjong 1966, Ortner 1989, Gaenszle 1991). The first people to settle the Solukhumbu-Arun region were apparently the Kirati (or Kiranti), who arrived as early as the sixteenth century. According to Kulunge Rai oral tradition, three brothers led their followers from eastern lowlands, possibly Assam, to the confluence of the Sun Kosi, Arun and Tamur Rivers. Each brother led his followers up a different canyon. Those who proceeded up the Dudh Kosi became Khambuhang Rai (including Kulungi Rai), those who proceeded up the Arun became Mewahang Rai, and those that proceeded up the Tamur became the Limbu.

Chitre study area

Chitre Village is relatively recent, settled by two families of Solukhumbu Sherpas in the early 20th century. The village appears to be indicated on Fürer-Haimendorf's 1964 distribution map of Nepalese Sherpa and Bhotia settlements, but is not identified by name (Fürer-Haimendorf 1964). The following account of Chitre's settlement history is based primarily on interviews with village elders and regional ethnographic studies by Fürer-Haimendorf (1964), McDougal (1979), Stevens (1993), Ramble and Chapagain (1990), and Gaenszle (1991).

Lands near the confluence of the Sisuwa and Sankhuwa Rivers were settled by successive waves of people. Legends and village genealogies indicate the lower reaches of the Sankhuwa Valley were first settled by Sangpange Rais. About 300 years ago, the Sangpange Rais were supplanted by Mewahang Rais (Gaenszle 1991). These early communities occupied more level ground above Sisuwatar, a fluvial plain at the confluence of the Sisuwa and Sankhuwa Rivers, within the subtropical *Schima-Castanopsis* forest zone. The temperate forests and subalpine meadows above Sisuwatar were used for hunting and seasonal grazing - essential elements of Rai subsistence.

The Kulunge Rai arrived from the west ~170 years ago, and settled the relatively steep slopes above the Mewahang communities, still within subtropical *Schima-Castanopsis* forest. According to oral tradition, the Kulunge Rai came from Hongu Valley in the Dudh Kosi watershed, ~25 km west of Chitre (McDougal 1979). McDougal (1979) characterized the immigration to western drainages of the Arun Valley as "a draining off ... of excess population, in terms of available resources."

According to oral tradition, the site now known as Chitre was first farmed by itinerant Sherpas who did not establish a year-round presence. Sherpa et al. (1990) describe a present-day equivalent at Dragnag, in nearby Inkhu Valley, where itinerant herders from Chaurikharka sow potatoes in summer. Oral tradition and the village genealogical record indicate Chitre was initially settled by two Sherpa families, each with a few children, in about 1915. Both families were from Chathuk, near Kharikhola Village, Solu. It is unclear why the families left Kharikhola. They were probably familiar with the Chitre area because it was located along a trade route connecting Solu Sherpa communities, by way of Khemba-la Pass, with recent Sherpa settlements in the Apsuwa and Isuwa Valleys (15-30 km northeast of Chitre). The climate at Chitre was milder than at Solu, so greater crop yields and crop diversity would have been possible.

A local Rai *jimmAwAl* (N. tax collector) might have enticed Sherpas to settle Chitre as *dhAkre* (N.), tenants on lands belonging to a local Rai clan under the *kipat* land tenure system

(Regmi 1976, McDougal 1979). Under the kipat system, a *jimmAwAl* could charge immigrants a fee, called *chArdAm*, for the right to use kipat land, so long as other members of the clan agreed. As non-Rais, Sherpas were obliged to pay an annual *beThi Thiki* tribute of food and alcohol to the *jimmAwAl* to maintain their use rights, but could not gain title to the land. The Sherpas of Chitre remained *dhAkre* tenants until ~1940, when the *kipat* system was ostensibly abolished (McDougal 1979, Nepali et al. 1990). Upon completion of the 1993 cadastral survey each Chitre household began paying an annual tax directly to the Land Revenue Office at Sisuwatar, based on the amount of cultivable land deeded to each household and payable in cash only.

Chitre's two pioneering families were joined approximately 20 years later (~1935) by two additional Sherpa families. One family came from Makhuwa Village on the south rim of the Sisuwa Valley, where they had lived for a single generation. Previous generations had resided near Salleri Village, central Solu. The other family came from Kiraunle Village, eastern Solu. According to this family's living descendants, Chitre offered better lands and tenure relations than were available at Kiraunle. All ten of Chitre's present-day households trace their patrilineal origins to one of the village's four founding families (according to Sherpa exogamic marriage customs, wives generally originate from other villages, Ortner 1989).

Just prior to settlement, Chitre was probably marked by a *khArka* (N. ~pasture), surrounded by oak-laurel forest (see Chapter 6). Large tree stumps remain from this forest at the periphery of Chitre's present-day cultivated fields (see Chapter 3). Rai slash-and-burn swiddens might have extended up from Baysinda Village to the vicinity of the *khArka*. The *khArka* might have been used much as present-day Hile *khArka,* 10 minutes' walk from Chitre. There was probably a *goTh* (N. itinerant herder's hut) near the center of the pasture, which during the off-season could have been little more than a naked frame of sticks. There might also have been a crude fence to exclude livestock from an untended crop of tubers or grains. A few hundred meters up slope, at the source of Kali Khola stream, there was an earthy Rai temple, comprised of a small rock-walled terrace at the base of a massive *halAwde* tree (N. *Ilex sikkimensis*) and adorned with copper bells and wrought-iron tridents.

Today, Chitre's Sherpas are the principal day-to-day users of the Chitre study area, although Rais from villages down slope (Pelungma, Dharagaon, Baysinda, Kantila, Sherba-la) use the area seasonally for grazing and hunting, and to harvest minor (alternative) forest resources or pole timber (infrequently). Subsistence at Chitre is highly dependent on resources from nearby forest, as is true of subsistence agropastoral systems throughout the world (Rhoades and Thompson 1975, Guillet 1983, Pandey and Singh 1984, Orlove and Guillet 1985, Marten and Saltman 1986). The principal forest resources harvested at Chitre are fuelwood, timber, pollarded stems, tree-leaf fodder, bamboo, leaf litter, plant fibers (e.g., paper plant *Daphne blolua*), medicinal herbs (e.g., chirata *Swertia chirayita*), and supplemental foods (e.g., mushrooms). The Sherpas of Chitre generally do not hunt or otherwise kill wild animals, except when crops or livestock are threatened, but some Bhotia communities elsewhere in the Makalu-Barun Region do hunt animals (Ramble and Chapagain 1990).

Sherpa land use practices have been studied in considerable detail, beginning with the pioneering work of Fürer-Haimendorf (1964) and culminating most recently with Stevens' (1993) account. However, Sherpa land use practices in temperate environments, such as the Solu and Makalu regions, differ considerably from those in subalpine environments like the Khumbu region, where a majority of Sherpa studies have been conducted. Schmidt-Vogt (1990) describes the land use practices of a Sherpa community occupying "evergreen upper montane forest" on Chyochyo Danda in central Nepal (~2100-2400 m), where neighboring ethnic groups include Tamangs and

Gurungs. The primary works on Rai land use are by McDougal (1979) and Gaenszle (1991).

Sherpa subsistence strategies typically combine fixed-field agriculture, itinerant herding, and trade (Fürer-Haimendorf 1964, 1975, Schmidt-Vogt 1990, Stevens 1993). In recent decades, out-of-village wage labor in the trekking industry has also become an important component (Fisher 1990). Many, but not all, Sherpa communities of the Makalu Barun region also practice some form of swidden agriculture (Sharma and Kharti-Chhetri 1995). Swiddens on the outskirts of Chitre Village are primarily the work of Rai sharecroppers. Sherpas tend to be agricultural specialists, and agricultural expansion is often constrained by lack of broad agronomic knowledge, lack of acquired tastes for additional crops, improbability of irrigation, and difficulty of access to markets.

The principal summer crops at Chitre are potato and maize, which are intercropped on unirrigated terraced fields (N. *bAri*). Both crops were introduced to temperate regions of Nepal as recently as the mid-1800s (Suto and Yoshida 1956, Fürer-Haimendorf 1964:9, Kunwar 1989). Potatoes are the staple diet of most Sherpas, with a family of four consuming as much as 2 metric tons/yr (Stevens 1993). Some Chitre households grow winter crops of wheat and barley (*Hordeum vulgare*), which are sown after maize and potato crops are harvested. Other minor crops at Chitre include mustard (*Brassica juncea*), taro (*Colocasia esculenta*), green bean (*Phaseolus vulgaris*), soybean (*Glycine max*), coyote squash (*Sechium edule*), and radish (*Raphanus sativus*), which are grown in small kitchen gardens near residences. A single household recently attempted cultivating apples (*Malus sylvestris*). Chitre Sherpas do not cultivate plants specifically for livestock fodder, with the exception of a few fig trees (*Ficus auriculata, F. neriifolia*). Chirata cultivation has increased dramatically over the past two decades, and is now the most important cash crop.

Most households own a village-based livestock herd, and a few own an itinerant *chau˜ri* herd. A household's choice of which type of bovine stock to own depends on its financial resources, labor resources (family size and commitment to education), access to pasturage and crop residue, and entrepreneurial inclination. *Chau˜ri* are the most lucrative, but are also the most expensive, and require some family members to reside at remote *khArka*s most of the year. Village-based herds are comprised primarily of cattle (*Bos taurus*) and water buffalo (*Bubalo bubalis)*, which provide milk, dung and other products, and sometimes serve as draft stock. Village-based herds graze within ~1 km of the village, and are often herded by 10-15 year old children (Fig. 1.6). Sherpas have gradually expanded the variety of livestock they keep, adopting species and husbandry techniques from other nearby cultural groups (Fürer-Haimendorf 1975). At Chitre, water buffalo first arrived in ~1970 and the first pig arrived in the late 1990s.

Itinerant herds follow an annual circuit from high elevation pastures (S. *yersa*, N. *KhArha*) in summer to temperate-elevation agricultural fields in winter. They are usually managed by some combination of men, women, and children. Three types of itinerant herds graze the forest around Chitre Village seasonally: 1) small, mixed, herds of cattle, water buffalo and goats belonging to Rais of nearby villages, 2) large herds of sheep and goats belonging to Rais of nearby villages, and 3) Chitre's own *chau˜ri* herds (which include a few cattle). Chitre's *chau˜ri* herds arrive at the village in November, having spent most of the summer at a *yersa* at Bhakam kharka (~3300 m). They remain at Chitre for ~1 month, before continuing down slope to subtropical fields on the banks of the Sisuwa river (~1700 m), where they spend the winter. While at Chitre, *Chau˜ri* herds graze much like village-based livestock, foraging in nearby forests during the day and returning to fallow village croplands each evening.

Livestock dung is essential for maintaining crop productively where subsistence agropastoralism is practiced (Rhoades and Thompson 1975). Consequently, Sherpa households keep as many livestock as they can provide fodder for, and pay (or barter with) itinerant herders to temporarily corral livestock on their fallow croplands. The oldest form of crop fertilization in the region is the *goTh* system. Livestock are kept at a series of remote herders' camps (N. *goTh*) while crops are sown at villages. After crops are harvested, the animals are tethered on agricultural fields to fertilize the soil with raw manure (Metz 1989a). The *mal* (N.) system of crop fertilization was adopted more recently (the early or mid 19th century at Chitre). With the *mal* system, leaf litter is collected from a nearby forest, mixed with the fresh dung of village-based livestock, aged, and then tilled into the soil prior to sowing. Similar mulching systems are found throughout the world where subsistence agropastoralism is practiced (Guillet 1983, Pandey and Singh 1984).

Agricultural trade is also an important element of Sherpa subsistence. Because Sherpa agricultural products are unique to high-elevations - yak butter, yak cheese, *chau~ri* calves, barley, wheat, potatoes (either mature tubers or young "seed" potatoes used for planting) - Sherpas have willing trade partners at lower-elevations. Most households at Chitre meet their annual needs for rice and millet - which cannot be cultivated at Chitre - by trading for potatoes with lower-elevation Rais, who arrive by foot from as far away Chandanpur (~25 km).

Current Rai subsistence strategies combine fixed-field agriculture, swidden agriculture, herding (primarily goats and sheep), hunting, and agricultural labor. Traditionally, Rais practice shifting "forest interior" swidden, or slash-and-burn, agriculture (Fig. 1.7). Farmers clear and burn a patch of forest, sowing it annually with unirrigated crops until the soil became infertile, and then clear another patch of forest somewhere else. In the MBBZ, swiddens are usually burned in early spring and planted with maize, barley, or tubers such as potato or taro (*Colocasia* *esculenta*). Depleted plots are left fallow for ~10 years (N. *khoriya*), until secondary forest has become established. Rais probably adopted fixed-field agriculture from lowland Hindu farmers centuries ago (Schroeder 1985). After adopting fixed-field agriculture, they also started practicing short-rotation "shrubland fallows" swidden agriculture (Schroeder 1985). Shrubland fallows (N. *lose*, Fig. 1.8) are established on marginal lands at the outskirts of permanent settlements (Shrestha et al. 1990b, Shakya 1995). After cultivated plots become infertile, they are left fallow for 3-7 years, until they are dominated by shrubs, then they are burned and planted. Plots in more remote areas are sometimes rotated less frequently, allowing secondary forest to develop.

Itinerant Rai livestock are herded according to the *goTh* grazing system, in which herds and herders reside temporarily at a series of *khArka* as they progress through the area (Metz 1989a). Rai *goThAla* (N. *goTh* dwellers) and their herds arrive at Chitre in mid-April, on their way to high-elevation pastures (Fig. 1.9). They remain at each *khArka* for a few days or weeks, until much of the herbaceous biomass within 2 m of the ground is consumed (Figs. 1.10-1.11). *GoThAla* also lop tree fodder from trees near the *goTh*, and collect fuelwood, edible and medicinal plants, plant fibers, and wild game (Metz 1994). By the end of June (mid-monsoon), most itinerant herds have left the Chitre area. They return in October, on their way back to their home villages at lower elevations.

In modern times, local Rai communities, particularly the Kulunge Rai, have become densely populated and deficient in natural resources (McDougal 1979). As a result, they have expanded onto increasingly marginal (steep) lands, and become increasingly dependent on *goTh*-based livestock production, "wild" supplemental foods (Daniggelis 1997), and out-of-village wage labor, including agricultural labor at Chitre and service in foreign police and military forces

(Nepali et al. 1990). Over the past ~15 years, however, cardamom (*Amomum subulatum*, N. *alainchi*) production has flourished in the area, bringing unprecedented wealth to Rai communities (Chitre is too cool for cardamom production).

Since about 1995, permits must be purchased from a Local Community Forest User Group Committee to graze livestock or harvest economically valuable resources from the "community forest" surrounding Chitre Village. The revenues generated are used to fund local development projects, thereby increasing local support for forest conservation (Metha and Kellert 1998).

TABLE 1.1. Species of special concern that are confirmed or suspected in the vicinity of Chitre Village (2200 - 2600 m). Species in bold were investigated intensively.

	Common name	Scientific name	Confirmed	Conservation status
Mammals	Bear, Himalayan black	*Selenarctos thibetanus*	yes	endangered in Nepal[B]
	Cat, leopard	*Felis bengalensis*	no	vulnerable in Nepal[B]
	Civet, large Indian	*Viverra zibetha*	no	near-threatened in Nepal[B]
	Deer, barking	*Muntiacus muntjak*	yes	vulnerable in Nepal[B]
	Goral	*Nemorhaedus goral*	no	near-threatened in Nepal[B]
	Leopard, clouded	*Neofelis nebulosa*	no	endangered in Nepal[B]
	Leopard, common	*Panthera pardus*	yes	vulnerable in Nepal[B]
	Shrew, Himalayan water	*Chimarrogale himalayica*	no	endangered in Nepal[B]
Birds	**Babbler, black-headed shrike**	*Pteruthius rufiventer*	yes	vulnerable in Nepal[C]
	Babbler, coral-billed scimitar	*Pomatorhinus ferruginosus*	no	critically endangered in Nepal[C]
	Babbler, golden	*Stachyris chrysaea*	no	vulnerable in Nepal[C]
	Babbler, rufous-throated wren	*Spelaeornis caudatus*	yes	globally near-threatened[C] endangered in Nepal[C]
	Babbler, slender-billed scimitar	*Xiphirhynchus superciliaris*	yes	vulnerable in Nepal[C]
	Babbler, spotted wren	*Spelaeornis formosus*	no	critically endangered in Nepal[C]
	Barwing, rusty-fronted	*Actinodura egertoni*	no	vulnerable in Nepal[C]
	Cochoa, purple	*Cochoa purpurea*	yes	endangered in Nepal[C]

TABLE 1.1. Continued.

	Common name	Scientific name	Confirmed	Conservation status
Birds (cont.)	Cuckoo dove, barred	*Macropygia unchall*	no	vulnerable in Nepal[C]
	Flycatcher, white-gorgeted	*Ficedula monileger*	no	vulnerable in Nepal[C]
	Finch, golden-naped	*Pyrrhoplectes epauletta*	yes[D]	vulnerable in Nepal[C]
	Honeyguide, yellow-rumped	*Indicator xanthonotus*	no	globally near-threatened[C] vulnerable in Nepal[C]
	Laughingthrush, blue-winged	*Garrulax squamatus*	no	vulnerable in Nepal[C]
	Laughingthrush, grey-sided	*Garrulax caerulatus*	yes	vulnerable in Nepal[C]
	Parrotbill, fulvous	*Paradoxornis fulvifrons*	no	vulnerable in Nepal[C]
	Parrotbill, great	*Conostoma oemodium*	no	vulnerable in Nepal[C]
	Shortwing, Gould's	*Brachypteryx stellata*	yes[D]	endangered in Nepal[C]
	Thrush, dark-sided	*Zoothera marginata*	no	vulnerable in Nepal[C]
	Tragopan, satyr	*Tragopan satyra*	yes	globally near-threatened[C] vulnerable in Nepal[C]
	Warbler, broad-billed	*Tickellia hodgsoni*	no	endangered in Nepal[C]
	Wood owl, brown	*Strix leptogrammica*	no	vulnerable in Nepal[C]

[A] Shakya 1995, [B] Jnawali et al. 2011, [C] Inskipp et al. 2010, [D] passage migrant

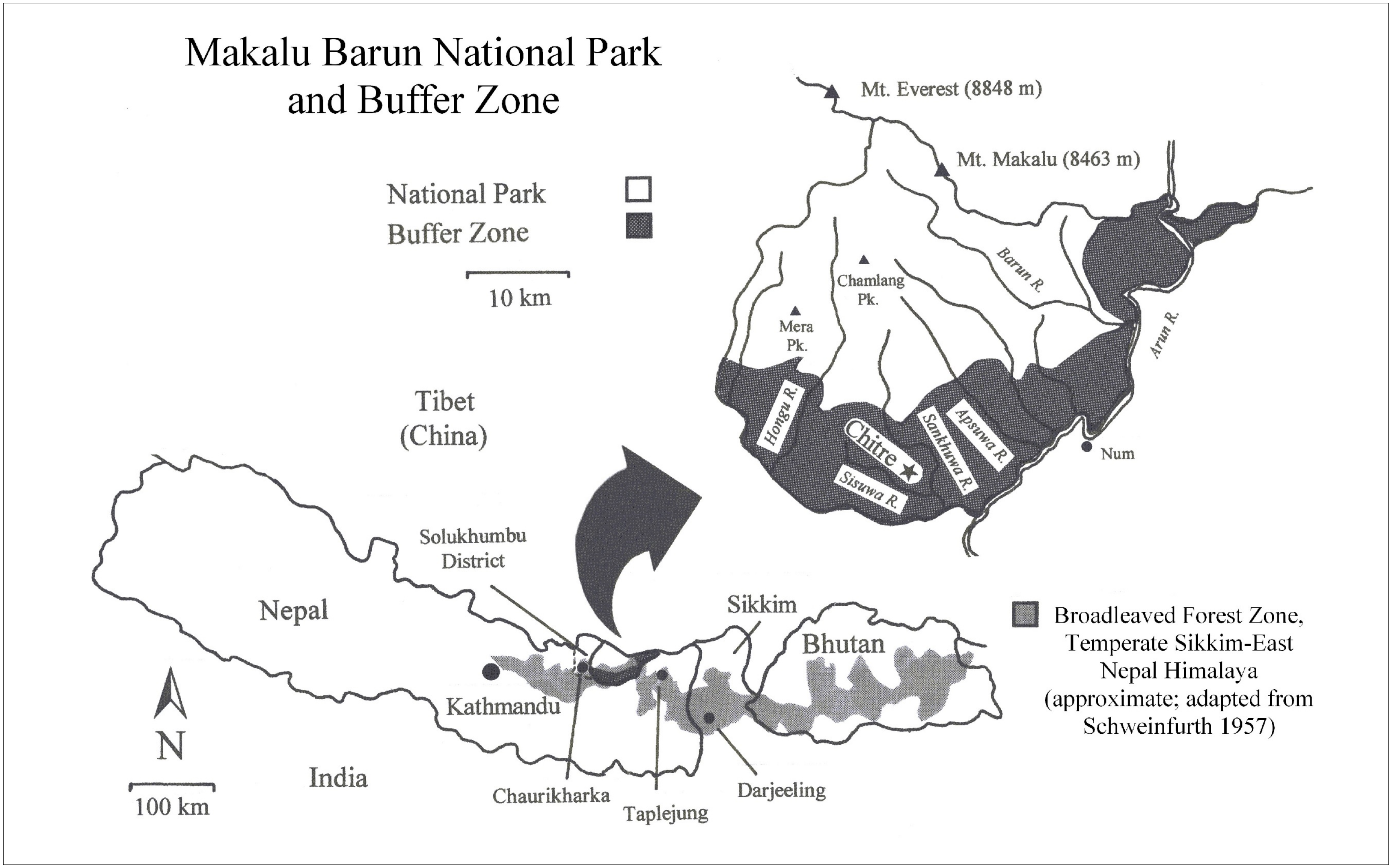

FIGURE 1.1. Location of Chitre Village and Makalu Barun National Park and Buffer Zone within the Broadleaved Forest Zone of the Temperate Sikkim-East Nepal Himalaya.

FIGURE 1.2. Satellite image of Chitre Village and surroundings. Forested knoll at upper right is Chitre Taam, and snow-capped peaks in the background are the Sankhuwa Sir.

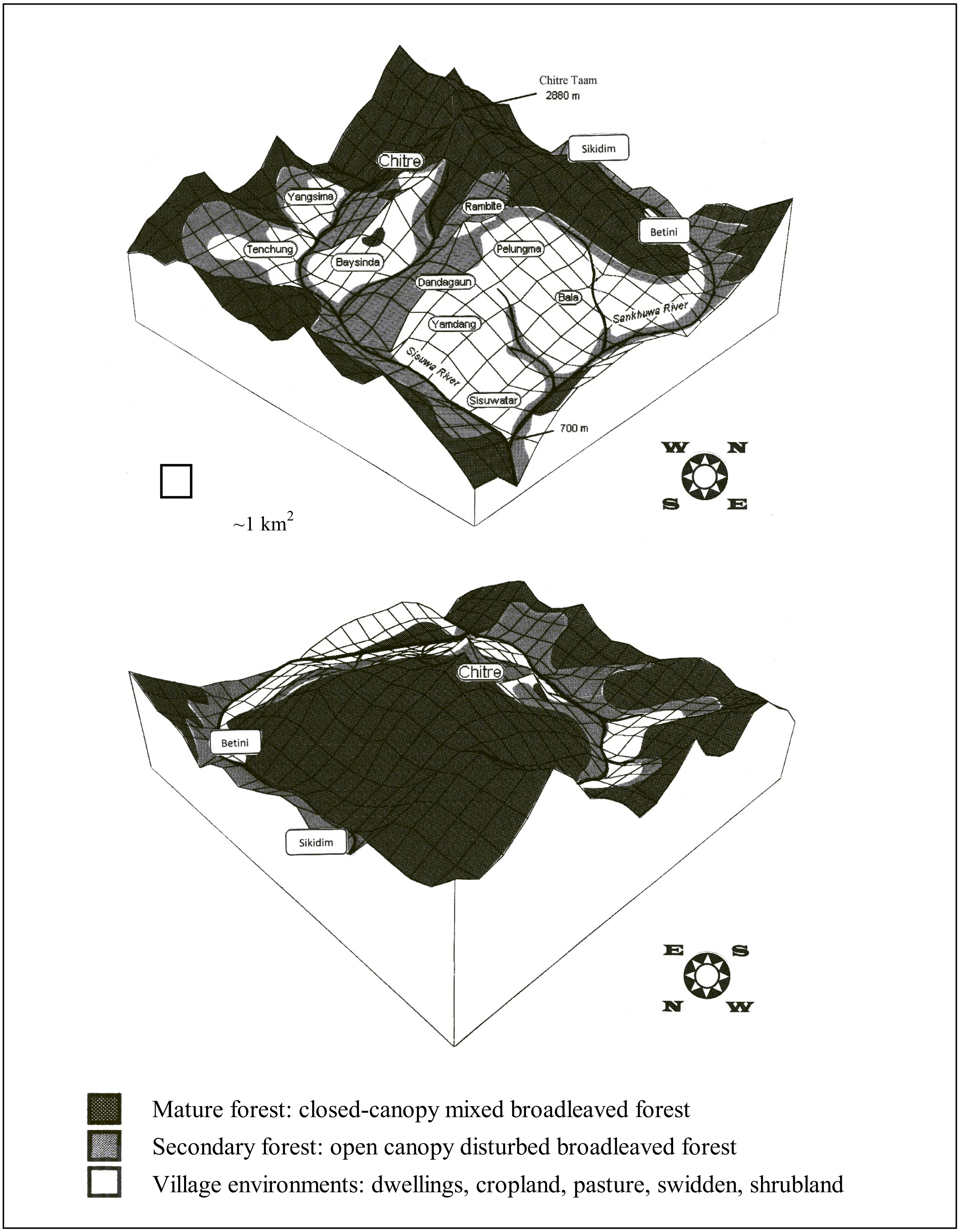

FIGURE 1.3. Villages and landscape features of the Sisuwa and lower Sankhuwa watersheds (Data sources: Government of Nepal 1984, 1996).

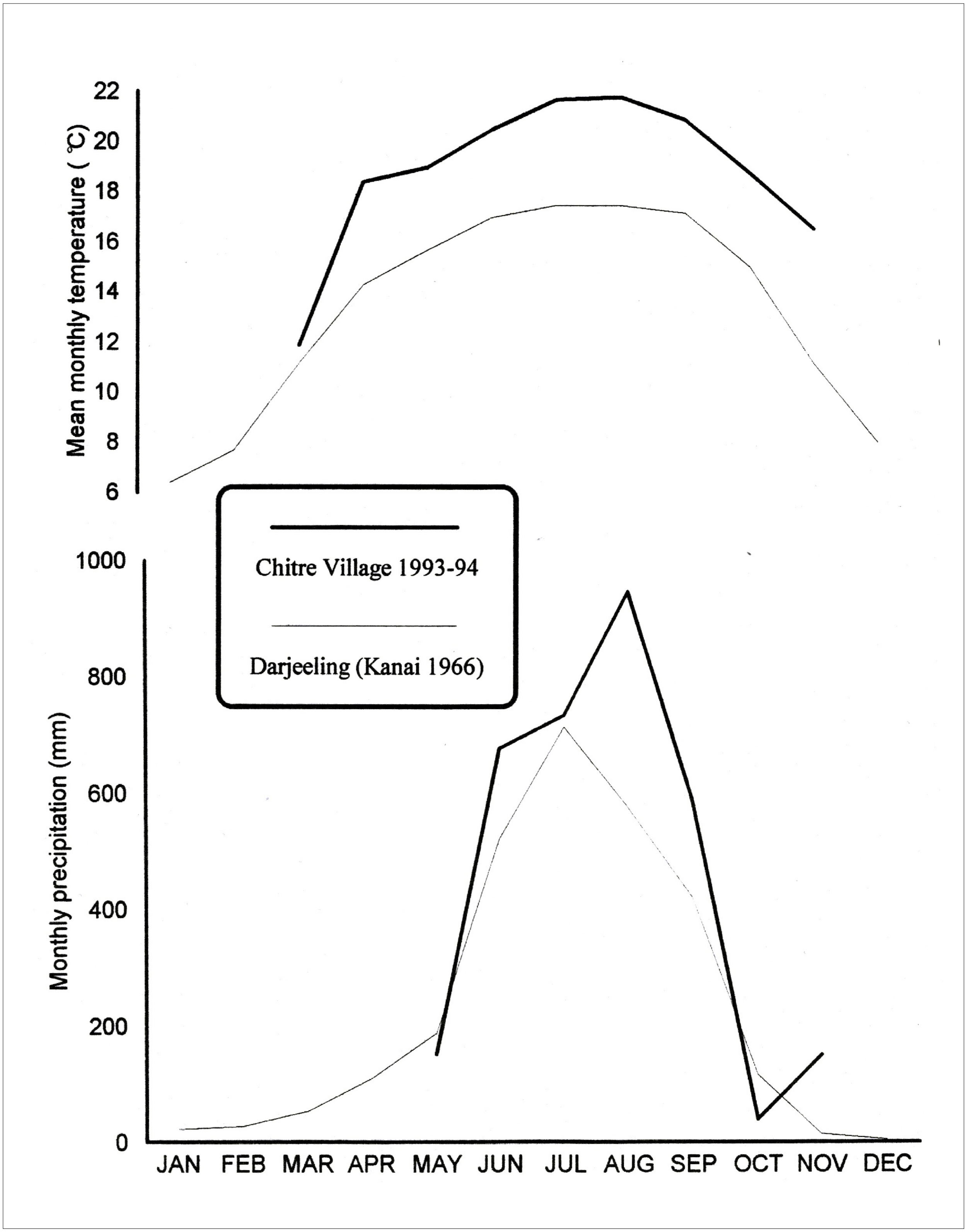

FIGURE 1.4. Weather patterns at Chitre Village (2350 m) and Darjeeling, India (2045 m, ~135 km southeast of Chitre).

FIGURE 1.5. Rufous-throated wren babbler (*Spelaeornis caudatus*), which is near-threatened globally and endangered in Nepal, breeds near Chitre Village.

FIGURE 1.6. Girl herding village-based cattle in shrubby pastures near Chitre Village.

FIGURE 1.7. Rai long-rotation swidden, or *khoriya,* in the lower Sisuwa watershed.

FIGURE 1.8. Short-rotation swiddens, or *lose*, at the perimeter of Chitre Village croplands.

FIGURE 1.9. Rai *goThala* with mixed herd of goats and sheep at Bagalekhop, a forest-interior *khArka* ~800 m from Chitre Village.

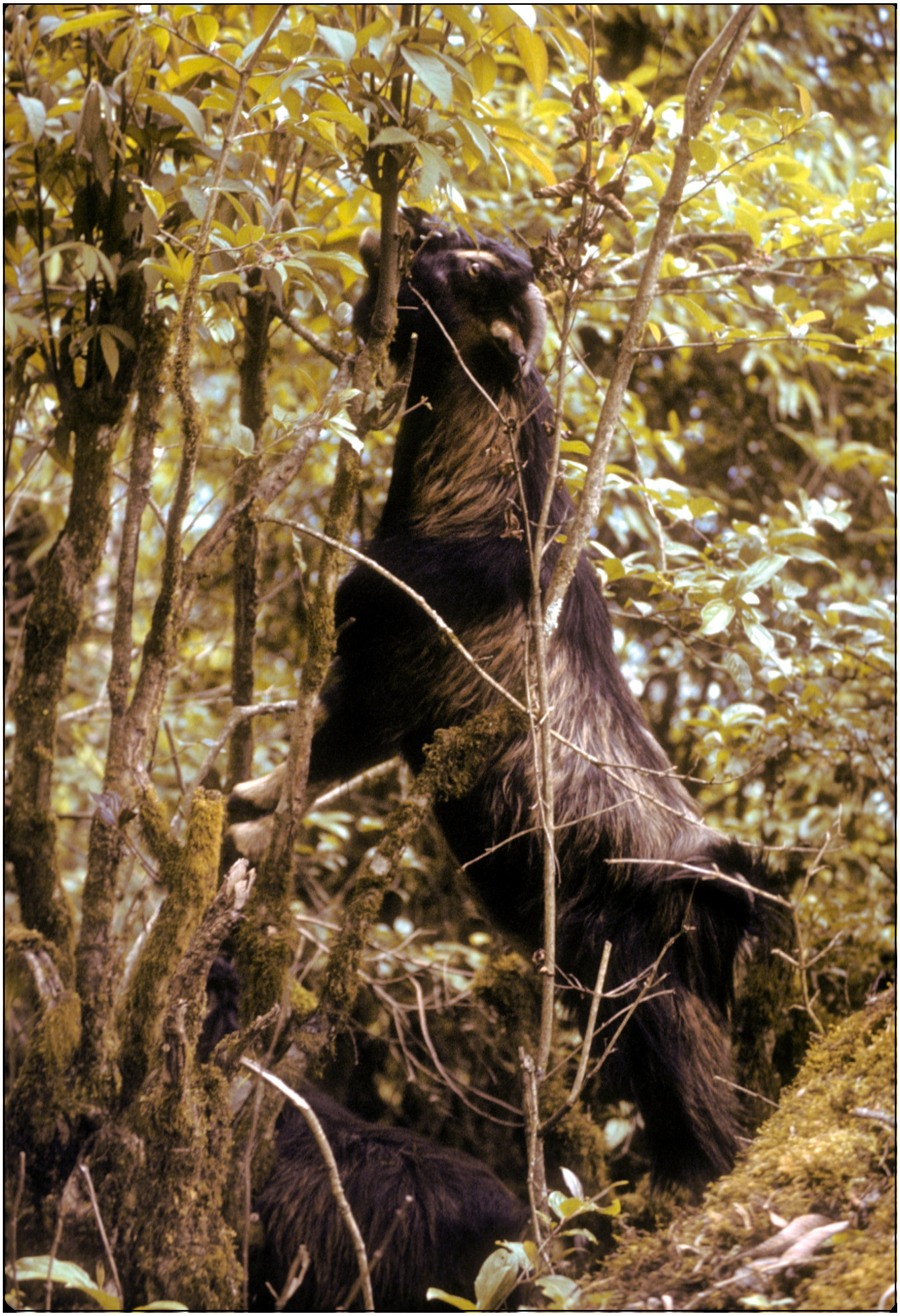

FIGURE 1.10. Goat browsing understory vegetation at a forest-interior *khArka*.

FIGURE 1.11. Condition of a forest-interior *khArka* after short-term use by an itinerant herd of goats and sheep.

APPENDIX 1.1. Climatological data from Chitre Village, 1993-1994.

	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1993									
Avg. daily min. °C	6.3[a]	7.7	11.0	13.8	14.7	14.8	13.6	10.9	7.0[b]
Avg. daily max. °C	11.9[a]	18.1	18.4	20.1	21.0	20.9	20.8	18.7	17.6[b]
1994									
Avg. daily min. °C	--	9.0[c]	11.5	14.4	14.5	14.8	13.8	9.3	6.1[d]
Avg. daily max. °C	--	18.7[c]	19.6	20.9	22.3	22.7	20.9	18.9	15.6[d]
Rainfall/mo (mm)	--	--	151	675	732	944	587	39	111[d]

[a] Calculated from the last 12 days of the month, [b] Calculated from the first 26 days of the month, [c] Calculated from the last 6 days of the month, [d] Calculated from the first 21 days of the month.

APPENDIX 1.2. Woody plant species recorded near Chitre Village, 2200-2600 m. (Taxonomic sources: Hara et al.1982, Grierson and Long 1983, Howland and Howland 1984).

Family	Scientific name (synonyms - not exhaustive)	Nepali name (not exhaustive)	Local name[A]	Code
Aceraceae	*Acer campbellii*	*kapasi*	*chArikutti*	ACECAM
Alangiaceae	*Alangium chinensis* (*Marlea begoniifolia*)	*okane*	*sAnopAte GolpAte*	ALACHI
Anacardiaceae	*Rhus chinensis* (*Rhus javanica*, *Rhus semi-alata*)	*bhakimlo*	*sAnopAte bhokimla*	RHUCHI
	Rhus succedanea (*Rhus acuminata*)	*rani bhalayo*	*bhalAyo*	RHUSUC
Aquifoliaceae	*Ilex exelsa*	*puwanle*	*puwa˜le*	ILEEXE
	Ilex fragilis		*bhAle arupAte*	PRUVEN[B]
	Ilex sikkimensis		*halawde*	ILESIK
Araliaceae	*Schefflera impressa* (*Heptapleurum impressum*)	*bhalu chinde, bhalu phutta*	*phutta*	SCHIMP
Berberidaceae	*Berberis aristida* (*Berberis sikkimensis*, *Berberis ceratophylla*)	*chutro*	*chutra kha˜da*	BERARI
	Berberis insignis (*Berberis incrassata*)	*chutro*	*chutra kha˜da*	BERARI[B]
Betulaceae	*Alnus nepalensis*	*utis*	*utis*	ALNNEP
	Betula alnoides	*sauer*	*sauer*	BETALN
Buxaceae	*Sarcococca wallichii* (*Sarcococca pruniformis*)			SARWAL
Caprifoliaceae	*Viburnum erubescens*	*ganaune, sano lodo*	*asAre*	VIBERU
	Viburnum coriaceum	*ghargure, bakal pate*	*gAraguri*	VIBCOR
Cupressaceae	*Juniperus recurva*	*dhupi*	*dhupi*	JUNREC
Ericaceae	*Rhododendron arboreum*	*laliguras*	*lAligura˜s*	RHOARB
	Lyonia ovalifolia (*Andromeda elliptica*, *Pieris ovalifolia*)	*angeri*	*angeri*	LYOOVA
	Gaultheria fragrantissima	*dhasingre*	*angeri*	GALFRA

APPENDIX 1.2. Continued.

Family	Scientific name (synonyms - not exhaustive)	Nepali name (not exhaustive)	Local name[A]	Code
Fagaceae	*Castanopsis hystrix*	*katus*	*katus*	CASHYS
	Lithocarpus elegans (*Quercus spicata*, *Lithocarpus grandifolius*)	*arkaula*	*argaula*	LITELE
	Quercus lamellosa	*bajrant*	*thulo pAte phalAnt*	QUELAM
	Quercus oxyodon (*Quercus lineata*)	*sano phalant*	*sano pAte phalAnt*	QUEOXY
	Quercus semecarpifolia	*kharsu*	*kharsu*	QUESEM
Guttiferae	*Hypericum hookerianum*	*mehandiphul*	*bhAkrega˜s*	SPIBEL[B]
Labiatae	*Leucosceptrum canum*	*bhusure*	*gurpis*	LEUCAN
Lauraceae	*Lindera assamica*	*sanu Pahenle*	*lampAte*	LINASS
	Lindera pulcherrima	*sissi*	*shingkawli*	LINPUL
	Litsea cubeba (*Litsea citrata*)	*siltimur*	*siltimur*	LITCUB
	Litsea elongata	*phusre*, *thulo pahenle*	*pahenle*	LITELO
	Neolitsea foliosa	*sisi phul*	*shingkawli*	LINPUL[B]
	Persea clarkeana (*Persea gammieana*, *Machilus clarkeana*, *Machilus gammieana*)	*chipli kawla*, *seto kawla*	*sAno pAte kawlo*	PERCLA
	Persea duthiei (*Machilus duthiei*)	*kawla*	*thulo pAte kawlo*	PERDUT
Magnoliaceae	*Magnolia campbellii*	*lalchamp*,	*goge cha˜p*	MAGCAM
	Michelia kisopa	*ban champ*, *seto champ*	*rani cha˜p*	MICKIS
Moraceae	*Ficus auriculata* (*Ficus roxburghii*)	*nebharo*	*nibhara*	FICAUR
	Ficus neriifolia (*Ficus nemoralis*)	*dudila*	*dudhila*	FICNER
	Ficus sarmentosa (*Ficus foveolata*)	*ban timila*	*dudhila*	FICSAR

APPENDIX 1.2. Continued.

Family	Scientific name (synonyms - not exhaustive)	Nepali name (not exhaustive)	Local name[A]	Code
Myrsinaceae	*Maesa chesia*	*bilaune*	*bilaune*	MAECHE
	Myrsine semiserrata	*kali kath*	*phalame*	MYRSEM
Rosaceae	*Prunus cerasoides* (*Prunus puddum*)	*paiyun, paiyu*	*poinya*	PRUCER
	Prunus napaulensis	*arupate*	*pothe arupAte*	PRUNAP
	Prunus venosa (*Prunus undulata*)		*bhAle arupAte*	PRUVEN
	Photinia integrifolia	*gaj phul*		PHOINT
	Spiria bella	*lahare phul*	*bhAkrega˜s*	SPIBEL
Rutaceae	*Skimmia arborescens*			SKIARB
	Tetradium fraxinifolium		*thulo pAte bhokimla*	TETFRA
	Zanthoxylum oxyphyllum	*bhainsi timur*	*timur*	ZANOXY
Sabiaceae	*Meliosma pinnata* (*Meliosma wallichii*)	*lekh dabdabe*	*sAno pAte bhokimla*	MELPIN
Salicaceae	*Salix* sp.	*bains*	*dhup*	SAL-SP
Saxifragaceae	*Hydrangea heteromalla*	*phusre kath*	*thulo pAte golpAte*	HYDHET
Smilaxaceae	*Smilax rigida*		*kha˜da*	SMIRIG
Taxaceae	*Taxus baccata* (*Taxus wallichiana*)	*burma sala*	*sala*	TAXBAC
Tetracentraceae	*Tetracentron sinense*			TETSIN
Theaceae	*Eurya acuminata*	*jhingane, tingar*	*jhinguni*	EURACU
	Symplocos ramosissima	*dabdabe, kharane*	*bAle khArane*	SYMRAM
	Symplocos sumuntia (*Symplocos racemosa* *Symplocos floribunda* *Symplocos caudata*)	*haku lal*	*bAle khArane*	SYMRAM[B]
	Symplocos theifolia (*Symplocos phyllocalyx*, *Symplocos lucida*)	*ghole*	*pothe khArane*	SYMTHE

APPENDIX 1.2. Continued.

Family	Scientific name (synonyms - not exhaustive)	Nepali name (not exhaustive)	Local name[A]	Code
Thymelaeaceae	*Daphne blolua*	*layokta, kagati pate*	*dangma lokta*	DAPBHO
	Edgeworthia gardnerii	*aryili*	*argeli lokta*	EDGGAR

[A] Local versions of Nepali names provided by local informants and might not conform to general usage. [B] Specimens of these species were assigned the code of a similar, more abundant, species in the field because local informants did not differentiate between the two species.

APPENDIX 1.3. Bird species recorded near Chitre Village, 2200-2600 m. Scientific and vernacular names are from Grimmett et al. 1998, with additional information from Ali and Ripley 1987 and Inskipp and Inskipp 1991. Habitats where detected (including incidental detections): cropland, shrubland, pasture, DF(disturbed forest), CF (closed-canopy forest).

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Accentor, maroon-backed	*Prunella immaculata*	I	2	I/N		✔	✔		
Babbler, black-eared shrike (chestnut-throated shrike babbler)	*Pteruthius m. melanotis*	O-N	<10	G/HD			✔	✔	✔
Babbler, black-headed shrike (rufous-bellied shrike babbler)	*Pteruthius rufiventer*	I-N	<10	G/HD		✔	✔	✔	✔
Babbler, green shrike	*Pteruthius x. xanthochloris*	I-N	<10	G/HD		✔	✔	✔	
Babbler, pygmy wren (lesser scaly-breasted wren babbler, brown wren babbler)	*Pnoepyga p. pusilla* (*P. pusilla pygmaea*)	C-N	20-50	GS/HD			✔	✔	✔
Babbler, rufous-capped (red-headed babbler)	*Stachyris r. ruficeps*	O-N	<10	G/HD	✔	✔	✔	✔	✔
Babbler, rufous-throated wren (tailed wren babbler)	*Spelaeornis caudatus*	I-N	<10	G/HD		✔	✔	✔	✔
Babbler, scaly-breasted wren (greater scaly- breasted wren babbler, eastern scaly-breasted wren babbler)	*Pnoepyga a. albiventer*	C-N	20-50	GS/HD			✔	✔	✔
Babbler, slender-billed scimitar	*Xiphirhynchus s. superciliaris*	I-IR	1	I/N				✔	
Babbler, streak-breasted scimitar (rufous-necked)	*Pomatorhinus ruficollis*	O-N	<10	G/HD		✔	✔	✔	✔
Babbler, white-browed shrike (red-winged shrike babbler)	*Pteruthius flaviscapis validirostris*	I	5	I/N					✔

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Barbet, golden-throated	*Megalaima f. franklinii*	I	2	I/N				✔	✔
Barbet, great	*Megalaima virens*	O-N	10-20	G/HD		✔	✔	✔	✔
Barwing, hoary-throated (hoary barwing)	*Actinodura nipalensis vinctura*	O-N	10-20	G/D				✔	✔
Blackbird, grey-winged	*Turdus boulboul*	I-N	<10	G/HD			✔	✔	
Blackbird, white-collared	*Turdus albocinctus*	I-W	10-20	I/N			✔	✔	
Bulbul, black (grey bulbul)	*Hypsipetes leucocephalus*	O	10-20	I/N				✔	✔
Bulbul, red-vented	*Pycnonotus cafer*	I-PBV	10-20	I/N	✔	✔	✔		
Bulbul, striated (striated green bulbul)	*Pycnonotus s. striatus*	O	10-20	G/HD			✔	✔	✔
Bullfinch, red-headed	*Pyrrhula erythrocephala*	I-W	5	I/N			✔	✔	
Bunting, little	*Emberiza pusilla*	I-W	<10	I/N			✔		
Bushchat, grey (dark-grey bushchat)	*Saxicola f. ferrea* (*Oreicola ferrea haringtoni*)	O-N	10-20	GS/HD	✔	✔	✔		
Cochoa, purple	*Cochoa purpurea*	I-N-IR	1	I/N				✔	
Crow, large-billed (jungle crow)	*Corvus macrorynchos*	O	4	I/N	✔		✔	✔	✔
Cuckoo, Eurasian (common cuckoo)	*Cuculus canorus*	C	<10	G/HD			✔	✔	✔
Cuckoo, large hawk	*Hieroccoccyx s. sparverioides* (*Cuculus sparverioides*)	C	10-20	G/HD			✔	✔	✔

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Cuckoo, lesser (little cuckoo, small cuckoo)	*Cuculus poliocephalus*	I	<10	I/N				✔	✔
Cuckoo, oriental (Himalayan cuckoo)	*Cuculus s. saturatus*	O	10-20	I/N				✔	✔
Dove, oriental turtle (Rufous turtle dove)	*Streptopelia orientalis agricola*	I-IR	1	I/N		✔			
Drongo, ashy (grey drongo)	*Dicrurus leucophaeus longicaudatus*	O	<10	G/HD	✔	✔			✔
Eagle (golden?)	*Aquila* sp.	I	<10	I/N			high overhead		
Eagle, black	*Ictinaetus malayensis*	O	10-20	I/N		✔	✔	✔	✔
Eagle, mountain hawk (Hodgson's hawk eagle)	*Spizaetus nipalensis*	O	10-20	I/N			✔	✔	✔
Falcon, unknown	*Falco* sp.	I-PM	3	I/N			high overhead		
Fantail, yellow-bellied	*Rhipidura hypoxantha*	O	20-50	G/HD			✔	✔	✔
Finch, crimson-browed (juniper finch)	*Propyrrhula subhimachala*	I-W	5	I/N			✔	✔	
Finch, gold-naped (gold-crowned black)	*Pyrrhoplectes epauletta*	I-PM	1	I/N				✔	
Finch, plain mountain (Hodgson's mountain finch)	*Leucosticte n. nemoricola*	I-PM	8	I/N		✔		✔	
Finch, scarlet	*Haematospiza sipahi*	I	1	I/N			high overhead		
Flowerpecker, fire-breasted (buff-bellied flowerpecker)	*Dicaeum i. ignipectus*	O	<10	G/HD		✔	✔	✔	

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Flowerpecker, yellow-bellied	*Dicaeum melanoxanthum*	I	2	I/N				✔	
Flycatcher, ferruginous	*Muscicapa ferruginea* (*M. rufilata*)	I-IR	3	I/N			✔	✔	✔
Flycatcher, pygmy blue	*Muscicapella h. hodgsoni*	I-N	10-20	G/HD		✔		✔	✔
Flycatcher, grey-headed	*Culicicapa ceylonensis pallidior*	O-N	<10	G/HD			✔	✔	✔
Flycatcher, rufous-gorgetted (orange-gorgetted flycatcher)	*Ficedula strophiata* (*Muscicapa strophiata*)	O-N	20-50	G/HD			✔	✔	✔
Flycatcher, slaty-backed (rusty-breasted flycatcher)	*Ficedula hodgsonii* (*Muscicapa hodgsoni*)	I	<10	G/HD			✔	✔	✔
Flycatcher, snowy-browed (rufous-breasted blue flycatcher)	*Ficedula h. hyperythra* (*Muscicapa hyperythra*)	C-N	<10	G/HD			✔	✔	✔
Flycatcher, verditer	*Muscicapa t. thalassina*	I-N	10-20	G/HD	✔	✔	✔		✔
Forktail, black-backed	*Enicurus immaculatus*	I-PBV	3	I/N				✔	
Forktail, little	*Enicurus s. scouleri*	I-IR	1	I/N				✔	
Fulvetta, rufous-winged (chestnut-headed tit-babbler)	*Alcippe c. castaneceps*	C-N	>50	G/HD		✔	✔	✔	✔
Fulvetta, white-browed (white-browed tit-babbler)	*Alcippe vinipectus*	O-N	10-20	G/HD			✔	✔	✔
Greenfinch, yellow-breasted (Himalayan goldfinch)	*Carduelis s. spinoides*	I-N	10-20	I/N		✔	✔	✔	
Griffon, Himalayan	*Gyps himalayensis*	I-PM	>50	I/N			high overhead		
Harrier, hen	*Circus cyaneus*	I-IR	1	I/N	✔				

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Hoopoe, common	*Upupa epops saturata*	I-PM	5	I/N			✔		
Kestrel, common	*Falco tinnunculus*	I	2	I/N	✔	✔			
Laughingthrush, black-faced	*Garrulax affinis*	I-PM	<10	I/N			✔	✔	✔
Laughingthrush, chestnut-crowned (red-headed laughingthrush)	*Garrulax erythrocephalus*	C-N	20-50	G/HD	✔	✔	✔	✔	✔
Laughingthrush, grey-sided	*Garrulax c. caerulatus*	I-N-IR	5	I/N				✔	
Laughingthrush, streaked	*Garrulax lineatus setafer*	I-N	10-20	G/HD	✔	✔			
Laughingthrush, striated	*Garrulax striatus*	O	10-20	G/HD			✔	✔	✔
Leiothrix, red-billed	*Leiothrix lutea calipyga*	I	2	I/N	✔	✔	✔		
Magpie, yellow-billed blue	*Urocissa flavirostris* (*Cissa flavirostris*)	I	10-20	I/N	✔		✔		
Martin, house	*Delichon* sp.	I	10-20	I/N	✔	✔	✔	✔	
Minivet, long-tailed	*Pericrocotus ethologus*	O	10-20	I/N	✔	✔	✔		✔
Minla, blue-winged	*Minla c. cyanouroptera*	I	<10	G/HD				✔	✔
Minla, chestnut-tailed (bar-throated minla)	*Minla s. strigula*	O-N	10-20	G/HD			✔	✔	✔
Minla, red-tailed	*Minla i. ignotincta*	I	<10	G/D				✔	✔
Nightjar, grey (Jungle nightjar)	*Caprimulgus indicus hazarae*	I	4	I/N			✔		
Niltava, rufous-bellied (beautiful niltava)	*Niltava s. sundara* (*Muscicapa sundara*)	C-N	>50	G/HD		✔	✔	✔	✔

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Nutcracker, spotted (Eurasian nutcracker)	*Nucifraga caryocatactes hemispila*	I	2	I/N					✔
Nuthatch, white-tailed	*Sitta h. himalayensis*	O	<10	G/HD				✔	✔
Oriole, maroon	*Oriolus t. trallii*	I	1	I/N					✔
Owl, tawny (Tawny wood owl)	*Strix aluco nivicola*	O	10-20	I/N				✔	✔
Owlet, Asian barred	*Glaucidium cuculoides*	I	2	I/N				✔	
Parrotbill, black-throated (Nepal parrotbill)	*Paradoxornis nipalensis*	I-IR	5	I/N		✔	✔	✔	
Partridge, common hill	*Arborophila t. torqueola*	C-R-N	<10	G/HD			✔	✔	✔
Pheasant, Nepal kalij	*Lophura l. leucomelanos*	O-R-N	10-20	G/HD			✔	✔	
Pigeon, ashy wood	*Columba pulchricollis*	O	<10	I/D					✔
Pigeon, wedge-tailed green	*Treron s. sphenura*	O-N	10-20	I/D			✔	✔	✔
Pipit, olive-backed (Hodgson's, olive tree)	*Anthus hodgsoni*	O-N	10-20	G/HD	✔	✔	✔	✔	✔
Prinia, striated (brown hill prinia)	*Prinia c. criniger*	I	4	G/D		✔	✔		
Redstart, blue-fronted	*Phoenicurus frontalis*	O-W	10-20	I/N	✔		✔		
Redstart, white-capped water (White-capped river chat)	*Chaimarrornis leucocephalus*	I-PBV-IR	2	I/N				✔	
Robin, Indian blue (Blue chat)	*Luscinia b. brunnea* (*Erithacus brunneus*)	C-N	20-50	GS/HD	✔	✔	✔	✔	✔

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Robin, orange-flanked bush (Red-flanked bluetail)	*Tarsinger cyanurus rufilatus* (*Erithacus cyanurus*)	I-PM	2	I/N				✔	
Robin, white-browed bush	*Tarsinger indicus indicus*	I-PM	<10	I/N					✔
Robin, white-tailed (white-tailed blue robin)	*Myliomela leucura* *(Cinclidium l. leucurum)*	O	<10	G/HD			✔	✔	✔
Rosefinch, common (scarlet rosefinch)	*Carpodacus erythrinus*	I-PM	6	I/N			✔	✔	
Rosefinch, dark-breasted (Nepal rosefinch)	*Carpodacus n. nipalensis*	I-W	10-20	I/N			✔	✔	
Rubythroat, white-tailed (Himalayan rubythroat)	*Luscinia pectoralis*	I-PM	2	I/N			✔		
Shortwing, Gould's	*Brachypteryx s. stellata*	I-PM	1	I/N					✔
Shortwing, white-browed	*Brachypteryx montana cruralis*	C-N	10-20	GS/HD			✔	✔	✔
Shrike, long-tailed (black-headed shrike)	*Lanius schach tricolor*	I	1	I/N	✔				
Sibia, rufous (black-capped sibia)	*Heterophasis capistrata bayleyi*	C	>50	G/HD		✔	✔	✔	✔
Siskin, Tibetan (Tibetan serin)	*Carduelis thibetana* *(Serinus thibetanus)*	I-W	4	I/N			✔	✔	✔
Sunbird, fire-tailed	*Aethopyga i. ignicauda*	I-PM	10-20	I/N		✔	✔	✔	
Sunbird, green-tailed (Nepal sunbird)	*Aethopyga nipalensis*	C-N	>50	G/HD		✔	✔	✔	✔

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Swallow, barn (common swallow)	*Hirundo rustica*	I	10-20	I/N	✔	✔	✔		
Swallow, red-rumped (striated swallow)	*Hirundu duarica*	I	<10	I/N	✔	✔	✔	✔	
Swift	*Apus* sp.	O	20-50	I/N			high overhead		
Tesia, chestnut-headed (chestnut-headed ground warbler)	*Tesia c. castaneocoronata* (*Tesia c. regia*, *Sylvia castaneo-coronata*)	C-N	10-20	GS/HD			✔	✔	✔
Tesia, grey-bellied (slaty-bellied ground warbler, yellow-browed ground warbler)	*Tesia cyaniventer*	O-N	10-20	GS/HD		✔		✔	✔
Thrush, blue whistling (Whistling thrush)	*Myophonus caeruleus timminckii*	I-PBV-IR	2	I/N				✔	
Thrush, dark-throated (black-throated thrush)	*Turdus ruficollis*	I-PM	<10	I/N			✔	✔	
Thrush, plain-backed	*Zoothera m. mollissima*	I-W	2	I/N					✔
Thrush, scaly (speckled mountain thrush)	*Zoothera d. dauma*	I-PM	<10	I/N			✔	✔	✔
Tit, black-lored (yellow-cheeked tit)	*Parus x. xanthogenys*	I	5	I/N				✔	
Tit, black-throated (red-headed tit)	*Aegithalos concinnus*	I	20-50	G/HD		✔	✔	✔	✔
Tit, green-backed	*Parus monticolus*	O	<10	G/HD	✔	✔			

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Tit, rufous-vented black (Sikkim black tit)	*Parus rubidiventris*	I	1	I/N				✔	
Tragopan, satyr (Crimson horned pheasant)	*Tragopan satyra*	I-R	4	I/N				✔	✔
Treepie, grey (Himalayan treepie)	*Dendrocitta formosae himlayensis*	O-PBV	10-20	I/N	✔	✔	✔	✔	✔
Wagtail, grey	*Motacilla c. cinerea* (*M. caspica*)	I-N	<10	G/D	✔	✔			
Wagtail, white (pied wagtail)	*Motacilla alba*	I-PM	<10	I/N	✔		✔		
Warbler, ashy-throated (grey-faced leaf warbler)	*Phylloscopus m. maculipennis*	O	10-20	G/HD		✔	✔	✔	✔
Warbler, Blyth's leaf (crowned leaf warbler)	*Phylloscopus reguloides*	O	10-20	I/N			✔	✔	✔
Warbler, brownish-flanked bush (strong-footed bush warbler)	*Cettia fortipes* (*Cettia montana*)	I-IR	<10	G/HD		✔			
Warbler, buff-barred (orange-barred leaf warbler)	*Phylloscopus pulcher*	O	10-20	G/D			✔	✔	
Warbler, chestnut-crowned	*Seicercus c. castaniceps*	O	20-50	G/D			✔	✔	✔
Warbler, golden-spectacled (yellow-eyed warbler)	*Seicercus b. burkii*	C-N	20-50	G/HD		✔	✔	✔	✔
Warbler, grey-hooded (grey-headed warbler)	*Seicercus xanthoschistos*	O-N	20-50	G/HD	✔	✔	✔	✔	✔

APPENDIX 1.3. Continued.

Vernacular name (synonyms - not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Warbler, grey-sided bush (rufous-capped bush warbler)	*Cettia brunnifrons*	I	3	I/N			✔	✔	
Warbler, large-billed leaf	*Phylloscopus magnirostris*	I	1	I/N				✔	
Woodcock, Eurasian	*Scolopax rusticola*	I-IR	1	I/N			high overhead		
Woodpecker, bay (red-eared rufous woodpecker)	*Blythipicus p. pyrrhotis*	I	<10	I/N				✔	✔
Woodpecker, Darjeeling (Darjeeling pied woodpecker)	*Dendrocopos darjellensis* (*Picoides darjellensis*)	I	<10	I/N				✔	✔
Wren, winter (northern wren)	*Troglodytes troglodytes nipalensis*	I-IR	1	I/N	✔				
Yuhina, rufous-vented	*Yuhina o. occipitalis*	I-IR	1	I/N				✔	
Yuhina, stripe-throated	*Yuhina gularis*	C	<10	G/HD				✔	✔
Yuhina, whiskered (yellow-naped yuhina)	*Yuhina f. flavicollis*	C-N	>50	G/HD	✔		✔	✔	✔

[a] I, infrequent; IR, irregular; N, Nesting; O, occasional; PBV, postbreeding visitor; PM, passage migrant; R, resident; WV, winter vagrant. [b] Values $\geq$10 are rough estimates of unique detections of individuals or flocks (likely re-counts resulting from systematic faunal surveys are omitted). [C] Census methods: I, incidental; G, general faunal surveys; S, territorial spot mapping. Analyses performed: N, none; H, habitat associations; D, species diversity.

APPENDIX 1.4. Mammal species recorded near Chitre Village, 2200-2600 m. Taxonomic sources: Mitchell 1977, Corbet and Hill 1992. Habitats where detected (including incidental detections): cropland, shrubland, pasture, DF(disturbed forest), CF (closed-canopy forest).

Vernacular name (synonyms-not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Bear, Asiatic black (Himalayan black bear)	*Selenarctos thibetanus* (*Ursus thibetanus, Euarctos thibetanus*)	D, F, N	<10	I/N	✔		✔	✔	✔
Cat, jungle	*Felis chaus* (*Felis affinis, Chaus libycus*)	F, D	10-20	I/N		✔	✔	✔	✔
Jackal, Asiatic	*Canis aureus indicus* (*Canis indicus*)	V, F	10-20	I/N		✔	✔	✔	✔
Leopard, common (panther)	*Panthera pardus* (*Felis fuscus, Felis pardus*)	F	2	I/N			✔	✔	
Marten, yellow-throated	*Martes flavigula* (*Mustela flavigula, Charronia flavigula*)	O, F, D, V	10-20	I/N			✔	✔	✔
Mouse, Himalayan house	*Mus musculus homourus* (*M. darjeelingensis, M. nipalensis*)	T	<10	G/HD	✔		✔	✔	✔
Muntjac, Indian (barking deer)	*Muntiacus muntjak* (*M. vaginalis, Cervulus muntjak*)	O, F, D, V	>50	I/N				✔	✔
Porcupine, crestless Himalayan	*Hystrix hodgsoni* (*Hystrix. bangalensis, Hystrix alophus*)	F	5	I/N	✔	✔	✔	✔	
Rat, chestnut	*Niviventer f. fulvescens* (*Mus fulvescens, Rattus fulvescens*)	T [C]	54	G/HD	✔		✔	✔	✔
Rat, lesser Nepalese brown	*Rattus rattus brunneusculus* (*Mus brunneusculus, R. r. sikkimensis*)	T	18	G/HD	✔		✔	✔	✔
Rat, smoke-bellied (spectacled rat)	*Niviventer eha eha* (*Epimys eha, Rattus eha*)	T [C]	42	G/HD			✔	✔	✔

APPENDIX 1.4. Continued.

Vernacular name (synonyms-not exhaustive)	Scientific name (synonyms - not exhaustive)	Status at Chitre[a]	Detections 1993-95[b]	Census / analyses[c]	Crop	Shrub	Pasture	DF	CF
Serow, mainland	*Capricornis sumatraensis* (*Nemorhaedus bubalinus*)	F, D	3	I/N					✔
Shrew, brown-toothed	*Soriculus caudatus* (*Sorex caudatus, Soriculus caudatus*)	T	62	G/HD			✔	✔	✔
Shrew, Himalayan pygmy	*Suncus etruscus pygmaeoides* (*Suncus pygmaeus*, *Sorex micronyx*) (*Crocidura hodgsoni*)	T [C]	30	G/HD	✔		✔	✔	✔
Shrew, India long-tailed	*Soriculus leucops* (*Sorex leucops, Soriculus macrurus*)	T	6	G/HD				✔	✔
Shrew, large-clawed (Himalayan shrew)	*Soriculus nigrescens* (*Sorex holosericeus*)	T	41	G/HD	✔	✔	✔	✔	✔
Squirrel, orange-bellied Himalayan	*Dremomys lokriah* (*Sciurus locria, S. subflaviventris*)	O, V	>50	I/N		✔	✔	✔	✔
Vole, Sikkim	*Pitymys sikimensis* (*Microtis sikimensis, Arvicola thricolis*)	T	2						✔

[a] D, dung; F, footprints; N, tree nest; O, observed; T, trapped; V, vocalizations. [b] Includes unique captures, footprints, incidental sightings, and vocalizations. [c] Not previously recorded in the Arun River watershed (Jnawali et al. 2011), but presumed present (Corbet and Hill 1992).