Chapter 11
The Future of Mammals in Southeast Asia: Conservation Insights from the Fossil Record

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Abstract The Pleistocene zoogeographic history of Southeast Asian megafauna are examined in order to determine if any patterns of extinction vulnerability can be discerned, and if so determine which extant megafauna species may be in need of heightened conservation effort. Sites in Southeast Asia were examined for three time periods: Early, Middle and Late Pleistocene, and compared with modern distribution patterns. Taxa were divided into one of four conservation statuses: extinct, critically endangered, endangered and vulnerable. One pattern clearly observable for the species in the extinct and critically endangered categories was a widespread distribution throughout the Pleistocene, only to suffer extreme range reductions or extinctions between the Late Pleistocene and today. At least three species in the endangered category display similar distribution patterns: the giant panda (*Ailuropoda melanoleuca*), the tiger (*Panthera tigris*) and the Malayan tapir (*Tapirus indicus*). Although the panda, and to a more limited extent the tiger are well recognised as conservation priorities, this is less true for the tapir. If the zoogeographic patterns observed for extinct or critically endangered species are any guide, the outlook for the panda, tiger, and tapir, independent of stepped-up conservation efforts, are bleak.

Keywords Conservation • Giant panda • Malayan tapir • Paleo-distribution • Pleistocene • Tiger • Zoogeography

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11.1 Introduction

Southeast Asia is one of the richest regions on Earth in terms of its biodiversity. It is home to the highest proportion of country-endemic mammal species (Sodhi et al. 2010) as well as over half a billion people. Over the last 2 million years it has hosted a wide variety of large-bodied mammals, including rhinoceroses, giant tapirs, giant pangolins, and many elephants and elephant-like stegodons, only some of which are now extinct (Louys et al. 2007). However, the continued existence of many species in Southeast Asia is severely under threat from over-hunting, urbanisation and especially deforestation (Sodhi et al. 2004; Corlett 2007, 2010; Woodruff 2010). Currently Southeast Asia has the highest proportion of endangered species across all taxonomic groups except amphibians (Sodhi et al. 2010). Wildlife is being removed from hunting and the illegal pet trade at six times sustainable rates (Sodhi et al. 2004), such that the density of large mammals even in protected areas is much lower than expected (Steinmetz et al. 2006; Corlett 2007). It has been estimated that 24–63% of Southeast Asian endemic taxa are at risk of extinction due to deforestation alone (Sodhi and Brook 2006).

During the world's last great extinction event, the Late Quaternary megafauna extinctions, over 100 genera of large-bodied mammals became extinct (Barnosky 2008). Climate change and human over-hunting are the two primary factors often debated as producing these extinctions (Barnosky et al. 2004). Compared to other continents, the extinction event in Southeast Asia appears relatively minor, with only 28 genera of megafauna becoming extinct over the entire Pleistocene – equivalent to the extinctions experienced by North America in the late Quaternary alone. Although hominins have been in Southeast Asia since the Early Pleistocene (Louys and Turner 2012), there are no indications that they have adversely affected megafauna until the end of the Late Pleistocene (Louys et al. 2007; Louys 2008). Evidence from Borneo, where arguably the best zooarcheological record exists for the region, shows that only one species became extinct during the Late Pleistocene; all other extinctions occur well into the Holocene (Cranbrook 2010).

The extinction of most megafauna in Southeast Asia through the Pleistocene is likely to have been primarily driven by extreme changes in habitat, in turn driven by regional and global changes in sea-level, precipitation, hydrology and temperature (Louys 2008). Most paleoecological data suggest that during the Last Glacial Maximum (LGM), Southeast Asia was a complex mosaic of grasslands, open woodlands and closed forests (Bird et al. 2005). This came as a result of the exposure of the low-lying Sunda shelf as well as changes in the latitudinal extent of the Inter-Tropical Convergence Zone and the intensity of the Asian monsoon. Although the exposure of the Sunda shelf was greatest during the LGM, heterogeneous environments were also present in Southeast Asia throughout Pleistocene glacial periods, with conditions returning to more homogenous, forested habitats during interglacials (Louys and Meijaard 2010).

As a result of the prevalence of more open habitats during the Pleistocene, many Southeast Asian megafauna were ecologically adapted to these types of environments (Louys 2008; Pushkina et al. 2010). Southeast Asian mammals show a significant shift in diet over the Pleistocene, from more C4-based diets during the Middle Pleistocene to more C3-based in modern individuals, suggesting that the loss of open habitats during interglacials drove open-adapted mammals into more forested landscapes (Pushkina et al. 2010). Those species unable to effectively migrate to more suitable habitats or adapt ecologically experienced range reduction and/or eventually became extinct (Tougard et al. 1996; Jablonski and Whitford 1999; Louys et al. 2007; Louys 2008; Woodruff and Turner 2009).

Of all the extinctions suffered by large-bodied mammals in Southeast Asia throughout the Quaternary, the majority were lost during the Early Pleistocene (Louys et al. 2007). Most of the extinctions recorded during this time were of Mio-Pliocene species that had been in decline through the Neogene. A drop-off in extinction intensity is observable over the Middle Pleistocene, although the number of extinctions suffered during this time is still significant (Louys et al. 2007). Finally the Late Pleistocene saw the smallest extinction signature of the Pleistocene. In fact, Southeast Asia experienced very few generic-level extinctions during this period, and of these only four represent global extinctions: the giant tapir (*Megatapirus*), two proboscideans (*Stegodon* and *Palaeoloxodon*) and the giant hyena (*Pachycrocuta*), with at least three of these probably surviving into the Holocene. However, an examination of only global extinctions of megafauna in this region is misleading, and range reductions need to be examined to fully appreciate the extent of losses (Louys et al. 2007; Corlett 2010).

This chapter will examine the Pleistocene distribution of those Southeast Asian taxa that became extinct, as well as those currently considered critically endangered, to determine whether any major zoogeographic patterns through time are discernable. Philosophically, this chapter follows similar studies conducted by Jablonski and Whitford (1999) and Tougard et al. (1996), who studied the paleo-distribution of select Southeast Asian species through the Pleistocene. This study differs in that I examine paleo-distributions of extinct or critically endangered megafauna species in order to determine if deep time patterns indicative of extinction threat exist. I then extend the study to endangered and vulnerable species to see if such patterns are repeated in these groups, and hence if any endangered and vulnerable species should be prioritised in conservation efforts.

11.2 Methods

I used published species lists from select Southeast Asian sites spanning the Early to Late Pleistocene (Table 11.1). These sites are not suggested as being exhaustive of the paleo-distribution of species in Southeast Asia; however they are indicative of the ranges that were occupied by the species under consideration. Several sites were

Table 11.1 The sites from which species in Figs. 11.1–11.4 were drawn, listed in alphabetical order. Sites where only *Pongo* sp. were found are indicated by * next to the site names

Early pleistocene	Middle pleistocene	Late pleistocene
Djetis, Java	Ban Fa Suai, Vietnam	Duoi U'Oi, Vietnam
Gongwangling, China	Chenjiawo, China	Hang Hum, Vietnam
Irrawady beds, Myanmar	Daxin, China*	Jiande, China
Jianshi, China	Guanyindon, China	Keo Leng, Vietnam
Liucheng, China*	Hexian, China	Lang Trang, Vietnam
Mohui, China	Hoshantung, China	Lida Ajer, Sumatra
Trinil, Java	Hsingan, China	Liujang, China
Yuanmou, China	Kao Pah Nam*	Ma U'Oi, Vietnam
	Kedung Brubus, Java	Maba, China
	Koloshan, China	Niah, Borneo
	Mogok, Myanmar	Pubu, China
	Phnom Lang, Cambodia	Punung, Java
	Tam Hang, Laos	Sibrambang, Sumatra
	Tambun, Malaysia	Tongzi, China
	Tangshan, China	
	Tham Hai, Vietnam	
	Tham Khuyen, Vietnam	
	Tham Om, Vietnam	
	Tham Phra Khai Phet, Thailand	
	Thum Wiman Nakin, Thailand	
	Wuming, China	
	Wuyun, China	
	Xuetangliangzi, China	
	Yenangyuang, China	

very close geographically and for the sake of clarity were grouped together when shown on the maps (Figs. 11.1–11.4). The grouped sites are Pubu, Wuyun and Mohui; Keo Leng, Tham Khuyen and Tham Hai; Lang Trang, Ma U'Oi and Duoi U'Oi; Thum Wiman Nakin and Thum Phra Khai Phet; Lider Ajer and Sibrambang; and Trinil and Djetis. Species lists were compiled from Antoine (2012), Bacon et al. (2011), Han and Xu (1985), Louys et al. (2007, 2009), Louys and Meijaard (2010), Meijaard (2004), Norton et al. (2010), Piper et al. (2007), Rink et al. (2008) and Wang et al. (2007).

Southeast Asia is herein defined as the area west of Wallace's line, including both Sundaic (Borneo, Java, Sumatra, Malaysia and Thailand south of the Isthmus of Kra) and Indochinese (Thailand north of the Isthmus of Kra, Cambodia, Laos, Vietnam, Burma and southern China) biogeographical subregions. The northern extent of the Indochinese subregion fluctuated throughout the Pleistocene (Louys et al. 2009; Norton et al. 2010), but is herein roughly delineated by the Qinling Mountains and the Yangtze River. The most northern site included in this analysis is that of Gongwangling, Lantian, an Early Pleistocene site situated on the northern slopes of the Qinling Mountains.

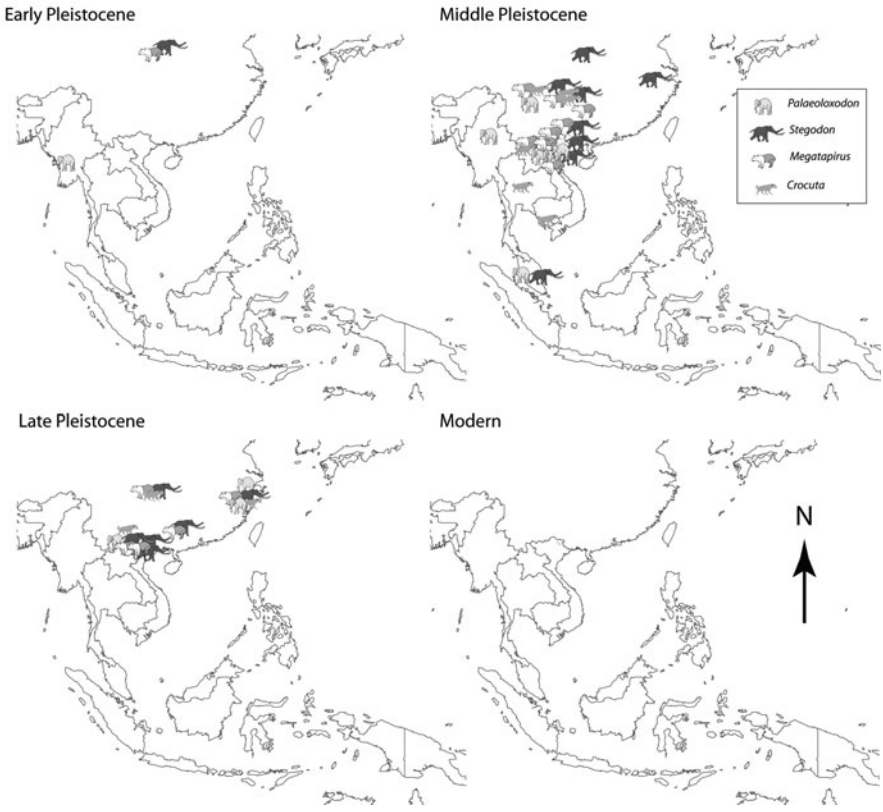

Fig. 11.1 Paleo-distribution of globally or regionally extinct species in the Early, Middle and Late Pleistocene of Southeast Asia

Taxonomy of many Pleistocene Southeast Asian faunas is in need of revision (Bacon et al. 2011). Here, I used the taxonomy of Louys et al. (2007), which largely follows that of Nowak (1999), with revisions to Rhinocerotidae following Antoine (2012). *Pongo pygmaeus* is considered as one species here, as it is not readily distinguished as two separate species in the fossil record. In three sites, *Pongo* was only identified to genus level, however these occurrences were also plotted (these sites are indicated in Table 11.1). Modern species distributions were obtained from Antoine (2012), Lekagul and McNeely (1988) and the IUCN Red List (IUCN 2011). Threatened species from SE Asia were obtained from the IUCN Red List (IUCN 2011), with the addition of *Stegodon orientalis, Palaeoloxodon namadicus, Megatapirus augustus* and *Crocuta crocuta*, Pleistocene Asian species which are either extirpated from the region (in the case of *C. crocuta*) or became extinct sometime in the Holocene (in the case of the other three species). I examined only large-bodied species that had at least three fossil occurrences in at least one time period.

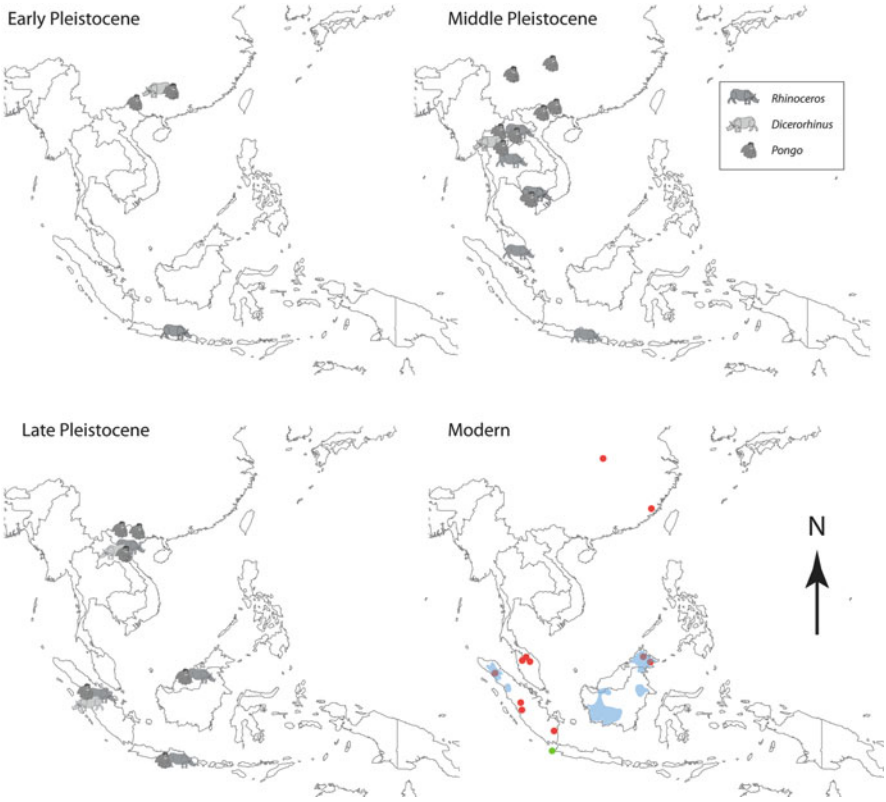

Fig. 11.2 Paleo-distribution of critically endangered species in the Early, Middle and Late Pleistocene of SE Asia; and current distributions: *Rhinoceros sondaicus* green; *Dicerorhinus sumatraensis* red; *Pongo pygmaeus* blue

11.3 Results

11.3.1 Extinct Species

The following extinct species are considered (Fig. 11.1): archaic elephant (*Palaeoloxodon namadicus*), stegodon (*Stegodon orientalis*), giant tapir (*Megatapirus augustus*) and the spotted hyena (*Crocuta crocuta*). Both elephants see an expansion from Indochina (Early Pleistocene) to maximum distribution in both Indochina and Sundaland (Middle Pleistocene), back to an Indochinese distribution in the Late Pleistocene. Both probably survived into the Holocene (Tong and Liu 2004; Li et al. 2011). The hyena makes its first appearance in the Middle Pleistocene where it is found throughout Indochina, but appears restricted to southern China by the Late Pleistocene. Currently, it is restricted to Africa, although it persisted in China until the Holocene (Tong and Liu 2004). The giant tapir shares a similar distribution history,

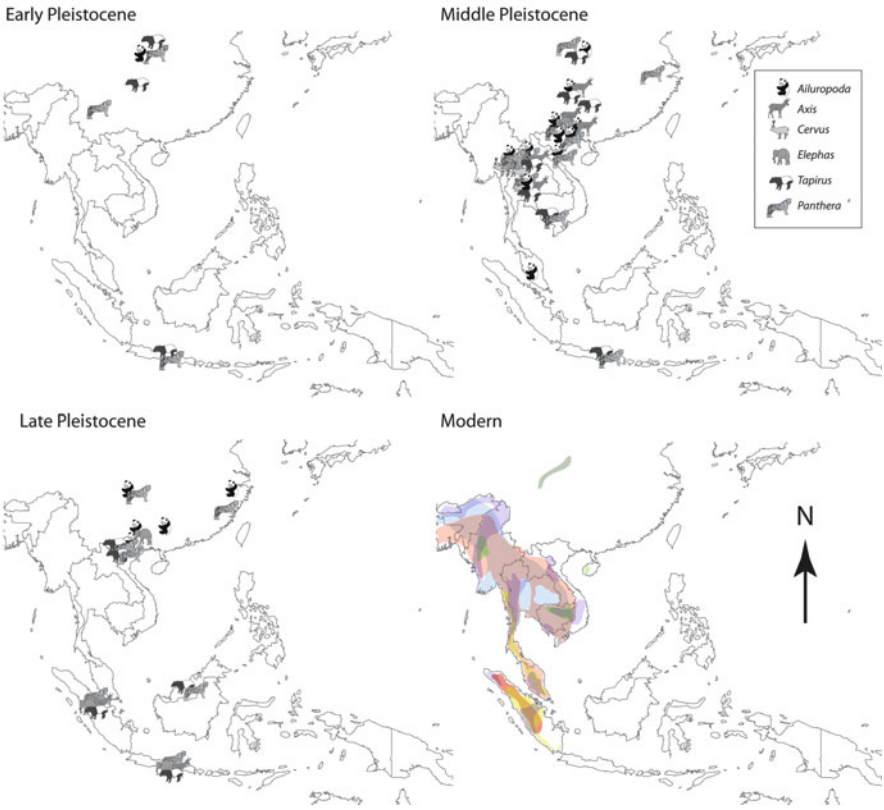

Fig. 11.3 Paleo-distribution of endangered species in the Early, Middle and Late Pleistocene of SE Asia; and current distributions: *Ailuropoda melanoleuca* dark green; *Axis porcinus* blue; *Cervus eldii* green; *Elephas maximus* red; *Tapirus indicus* yellow; *Panthera tigris* purple

with a widespread presence in Indochina by the Middle Pleistocene, and apparent restriction to southern China in the Late Pleistocene. It also persisted in China until the Holocene (Tong and Liu 2004).

11.3.2 Critically Endangered Species

Three critically endangered species are considered (Fig. 11.2): the Javan rhino (*Rhinoceros sondaicus*), the Sumatran rhino (*Dicerorhinus sumatraensis*) and the orangutan (*Pongo pygmaeus*). The Javan rhino is well represented in Java in the Early Pleistocene, and from that point on is found throughout both Sundaland and Indochina well into the Late Pleistocene. It continues to be found throughout Southeast Asia well into historical times (Antoine 2012). Since then, its

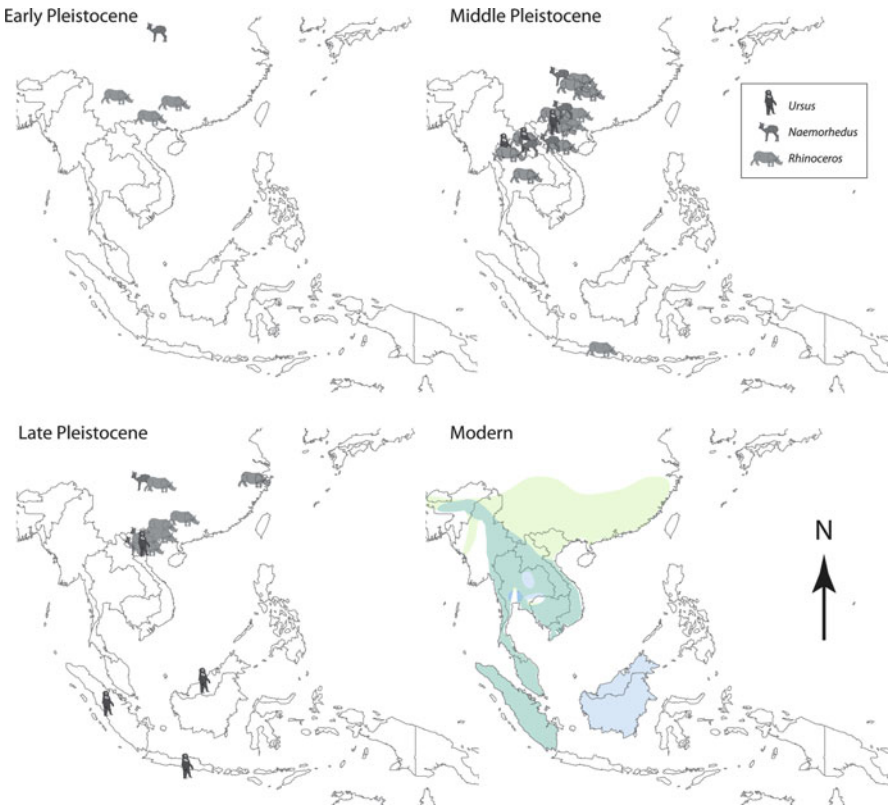

Fig. 11.4 Paleo-distribution of endangered species in the Early, Middle and Late Pleistocene of SE Asia; and current distributions: *Ursus malayanus* blue; *Naemorhedus sumatraensis* green

geographical and population decline has been the result of loss of habitat, as well as massive poaching and over-killing, a practice that sadly continues today (Milliken et al. 2009; Antoine 2012). Since its extinction in Vietnam (Kinver 2011), it is now restricted to a tiny (~40 individuals) population in west Java, and is perhaps the most endangered large-bodied species in the world. The Sumatran rhino shares a similar fate. It is recorded from southern China in the Early Pleistocene, Vietnam in the Middle Pleistocene, with a pan-Southeast Asian distribution by the Late Pleistocene, which extended well into historical times (Antoine 2012). Like the Javan rhino, it has suffered heavily from loss of habitat, poaching and hunting over the last 200 years. The orangutan is found in the Early Pleistocene of southern China, with a widespread Indochinese distribution by the Middle Pleistocene, extending well into the Late Pleistocene and perhaps even the Holocene (Kahlke 1972). It is currently found in isolated populations restricted to Borneo and Sumatra, and is critically threatened due to loss of habitat to palm oil plantations (IUCN 2011).

11.3.3 Endangered Species

The following endangered species are examined (Fig. 11.3): the giant panda (*Ailuropoda melanoleuca*), the hog deer (*Axis porcinus*), Eld's deer (*Cervus eldii*), the Asian elephant (*Elephas maximus*), the Malayan tapir (*Tapirus indicus*) and the tiger (*Panthera tigris*). The giant panda had a much greater distribution throughout the Pleistocene compared to today, where it is restricted to several protected areas in China. The hog deer makes its first appearance in the Middle Pleistocene, where it is found throughout northern Indochina. By the Late Pleistocene it is restricted to Sundaland, however is currently only found in Indochina. This is probably a collection/identification issue, as fossil cervid taxonomy is notoriously poor for Southeast Asia (Bacon et al. 2011). If real, this palaeo-distribution pattern is unique for Southeast Asian mammals. The Eld's deer's fossil record is poor – it is found in northern Indochina in the Middle Pleistocene, is absent from Late Pleistocene and is currently found in parts of Indochina. Regardless of its paleo-distribution, however, its range has alarmingly decreased since historical times (Lekagul and McNeely 1988). The Asian elephant is found in Indochina in the Middle Pleistocene; by the Late Pleistocene it is found through most of Southeast Asia, mirroring its current distribution. The Malayan tapir is found throughout Southeast Asia from the Early to the Late Pleistocene. However in recent times it has undergone a significant range reduction and is restricted to the western portions of Sundaland. Likewise, the tiger, which shares a near pan-Southeast Asian distribution throughout its Pleistocene history experienced significant range reductions in Southeast Asia during historic times.

11.3.4 Vulnerable Species

Three vulnerable species are examined (Fig. 11.4): the Indian rhino (*Rhinoceros unicornis*), the sun bear (*Ursus malayanus*) and the serow (*Naemorhedus sumatraensis*). The Indian rhino shows a strong presence throughout Pleistocene assemblages in Indonchina, and also makes a presence in Java in the Early and Middle Pleistocene (Antoine 2012). Currently it is restricted to South Asia (namely India, Nepal and Bhutan). The sun bear is found throughout Indochina in the Middle Pleistocene, and spreads through to Sundaland by the Late Pleistocene. This is similar to its current range, except for its extinction from Java. The serow is restricted to southern China and the northern parts of Vietnam and Laos for most of the Pleistocene. It currently has a broad Southeast Asian distribution.

11.4 Discussion

The analysis above highlights that the species that underwent considerable range reductions from Pleistocene to current distributions are some of those under the most critical threat of extinction, or are those that have already become extinct. Of particular note in the extinct category are two species of proboscidean (the archaic elephant and stegodon), the giant tapir, and the Indian rhino – currently found only in South Asia, but which previously had a wide Southeast Asian distribution. Of the critically endangered SE Asian megafauna, both species of rhino (Javan and Sumatran) as well as the orangutan suffered considerable range reductions; for the rhinos at least this occurred during historic times. As argued elsewhere (Sodhi et al. 2004; Corlett 2007; Louys 2008), this Holocene-recent extinction signature is largely a result of massive habitat loss, but also over-hunting, either for subsistence but increasingly for the traditional medicines market (Corlett 2007).

While the Indian rhino shows complete extirpation from Southeast Asia between the Late Pleistocene and current distributions, no other vulnerable species examined shows the same level of range reduction. However, three species in the endangered category clearly do. These are the giant panda (*Ailuropoda melanoleuca*), the tiger (*Panthera tigris*) and the tapir (*Tapirus indicus*). Although Eld's deer (*Cervus eldii*) has a spotty fossil record, its alarming range decline in historical times indicates that this species may also have a zoogeographic pattern similar to those of the tapir, tiger and panda. These latter species share the extreme range reductions between the Late Pleistocene and today that many extinct or critically endangered large-bodied species experienced. While the plight of the panda and tiger are well known internationally, that is less true of the tapir and Eld's deer. The paleontological record suggests that if conservation efforts towards the tiger, in particular the four Southeast Asian subspecies, the Malayan tapir and Eld's deer are not stepped up, then they will likely suffer the same fate as the stegodon, the giant tapir and the archaic elephant.

11.5 Final Comments

Environmental changes in Southeast Asia over the Pleistocene primarily affected more open-adapted species, and many surviving megafauna are likely to be those best adapted for forested conditions, such that even reduced rates of deforestation in the region will likely have devastating effects on many species' survival. However, surviving megafauna may well be those that show some level of ecological flexibility. An understanding of the ecology and biology of the past factors that detrimentally influenced the survival of mammals in the region is paramount in any attempt to prevent further extinctions. In particular, it is important to understand the ecology of fossil Southeast Asian mammals, and the factors that have previously contributed to their extinction. If just those megafauna species

experiencing any range reduction during the Late Pleistocene become extinct, a very likely possibility given current trends, then this would bring the intensity of extinction commensurate with that of other continents during the Late Quaternary. This projection is in line with estimates based on the species-area relationship, which predicts that up to 85% of mammals in the region could be extinct by the end of the century (Sodhi et al. 2010). Southeast Asia is a region of critical importance to matters of biological conservation and to human long-term sustainability during an era of global climate change. There is an urgent need to intensify local and international conservation efforts and to address both biological and socio-economic issues if we are to avoid a megafauna extinction event within our lifetime.

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