CHAPTER 8: CONCLUSIONS AND IMPLICATIONS OF THE NEW MODEL

STOP!!!, you're wrecking the forest!!
TIGGER in the Many Adventures of
Winnie the Pooh

"The two boys faced eachother. There was the brilliant world of hunting, tactics, fierce exhilaration, skill; and there was the world of longing and baffled common sense."
Lord of the Flies, W. Golding

The remains of tropical rainforest after 20 years of logging and fire.

In this research I have managed to compile a large amount of information on mammalian evolution in Sundaland and the possible factors that may have influenced it. The information has been assimilated into a comprehensive model and tests of that model indicated that it is applicable to the evolution of at least some species groups. Clearly, it remains a hypothesis and much further testing and new data are needed to assess its value for future evolutionary research in the region. Still, I believe that the new model contains valuable information that will allow other researchers to interpret their results in an alternative way. The model may especially be useful for molecular and palaeobiological research, but it has also much to offer to two other fields: conservation and human evolution. These I want to discuss here in a bit more detail.

Conservation in Sundaland

Level lowland non-swampy evergreen dipterocarp rainforest in the Sundaic region is widely acknowledged to be among the richest, if not *the* richest, in terms of biodiversity, on the planet (Whitmore 1984; Collins et al. 1991; Mittermeier & Mittermeier 1998), but it appears to be seriously overlooked that it is such forest *in the extreme lowlands* (below 150–200 m)—not simply below 500 m or even 1,000 m—that is the richest and most species-rich, for birds, mammals, and many plants (BirdLife International 2001). These are exactly the areas that may well disappear from Java, Sumatra, and Borneo within the next 5 years (Jepson et al. 2001), and the disappearance of lowland habitat is considered by many, including myself, to be the main factor in the extinction of much of the region's biodiversity. But is this really the case? Many mammal species are not necessarily negatively affected by the effects of logging, at least not in the relatively short term that is by necessity the focus of such research. Also, my biogeographic and evolutionary model indicates that many species have in the past experienced significant range contractions, either by being isolated on small islands or in rainforest refugia. Many species have gone extinct because of this, but it appears that most species have survived, and one could argue that the decrease in available habitat clearly has an effect, but that species can recover after more habitat becomes available again (as presumably happened after glacially induced range contractions during the LGM).

Recently, I analysed the size change of remaining Orangutan habitat fragments in Borneo (Table 8.1) (Meijaard & Dennis 2003). This indicates that in Borneo's lowland forest there is now only 1 area left > 5,000 km^2, while the vast majority of contiguous forest areas is smaller than 1,000 km^2. Can we model the future faunistic composition of such forest fragments? In fact, we can by looking at the mammal species that occur on Sunda Shelf islands (after Meijaard 2003), as these provide an indication of the maximum number of species that can survive in a forest area of certain size.

	early 1990s	2002
number of areas > 5000km^2	11	1
number of areas between 5,000 and 1000km^2	26	20
number of areas between 1,000 and 100km^2	50	92

Table 8.1. Counts of size classes of contiguous Bornean Orangutan habitat areas; a comparison between the early 1990s and 2002.

Fig. 8.1 shows that the number of species drops off very quickly with decreasing area size. At $_{10}$log area = 5 (= 100,000 ha = 1,000 km^2), the number of species has already declined to ca. 22. Fig. 8.1 may give a slightly biased picture because all these islands were smaller during the Holocene high sea levels; the ratio of species per area unit may therefore be slightly higher, but overall the trend remains the same: In the long term, few species survive in small forest fragments. Normally Bornean rainforests contain far more species than that. For instance, the Maliau Basin in Sabah has 72 species; Gunung Palung National Park, West Kalimantan has 84 species (Blundell 1996); Danau Sentarum, West Kalimantan has at least 46 species (Jeanes & Meijaard 2000); and Emmons (2000) found 78 species in Poring, her study site in Sabah (all counts excluding bats). Considering the size of the remaining habitat fragments on Borneo, and their continuing decrease, it is therefore very likely that the mammalian faunas of these fragments will continue to decline. The first species to disappear will be the large mammals, such as orang-utans, leopards, tigers, elephants, rhinoceroses, and gibbons; of these only the tiger and leopard have been found on some of the largest islands, while *Hylobates klossi* is found on 4 of the Mentawai Islands with a size between 530 and 3,829 km^2.

Considering that the protected areas in the lowlands of Kalimantan and Sumatra have a maximum size of ca 350,000 ha ($_{10}$log 350,000 = 5.5) this does not bode well for large mammal conservation on these islands. Admittedly, larger protected areas exist, but these mountainous reserves do not incorporate much lowland forest and are of relatively little value to many lowland species. It is therefore clear that a laissez-faire attitude in protected areas will lead to the extinction of most mammal species, even if the forest is well protected. Species will need to be managed actively in terms of genetic composition, disease control, food provision at times of low resource availability, and a very serious control of hunting impact. If this is not incorporated into conservation management, and protected forest and other remaining forest fragments are increasingly isolated from neighbouring forests, then the future of large mammals even in the biggest protected areas looks grim; Bangka Island, which is similar in size to the Kayan-Mentarang National Park, the largest protected area in Kalimantan, only has 38 mammal species (excluding bats).

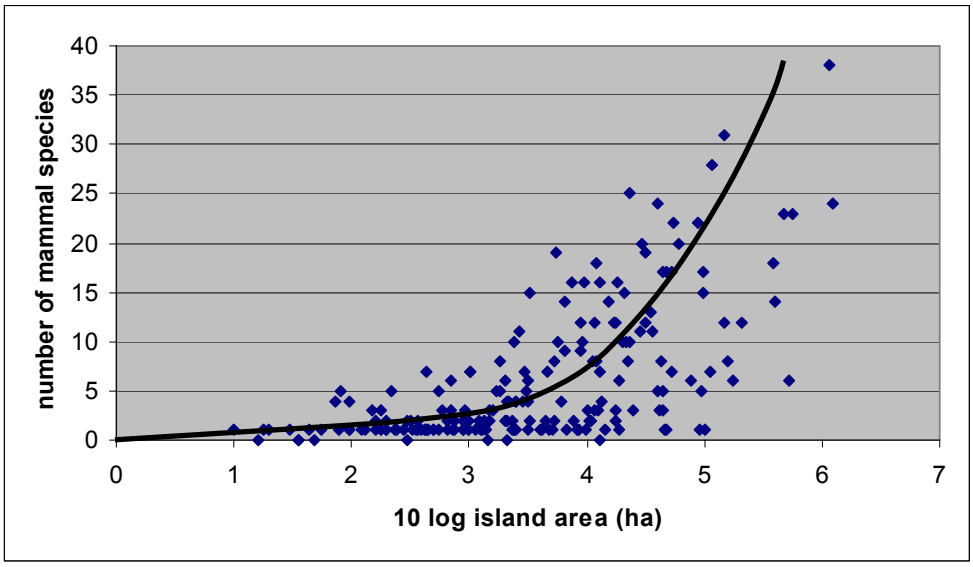

Figure 8.1. The number of mammal species (excluding bats) on small islands in SE Asia (after Meijaard 2003).

If we add to the effects of decreased habitat availability, the combined outcome of human greed, poverty, and climate change models that predict a 5°C temperature increase over the next century, one can only be more pessimistic about the future of Sundaic mammals. It is most likely that in less than 100 years there will be no more wild living large mammals in Sundaland, apart from those few selected populations

and species that are very actively managed. One could argue that in terms of evolution, which is immoral and unconcerned with ethical and esthetical concepts, the extinction of these species is irrelevant. As a member of a human species, however, that is apparently guided by the principles of 'good' and 'evil', or so they say, I think that respect for our environment and fellow beings should be an utmost priority.

I therefore suggest the necessity for very focused management in conservation work. It requires the complete protection of a selected few conservation areas with the sole purpose of maintaining high levels of biodiversity. Contrary to the present-day conservation paradigms of sustainable development and participatory management, this requires the complete exclusion of human activities that potentially harm species [hunting and fishing, introduction of live stock, logging (unless proven to benefit certain species)]. Such management will be unpopular and expensive, but it is the only way to keep alive the large number of Sundaic mammal species for the long-term future. If such management is unfeasible in Sundaland, the establishment of breeding, wild or semi-wild living populations of Sundaic species outside the region should be considered.

Human dispersal and evolution in Sundaland

During my research I have been asked a few times if I can make a link between human evolution and my palaeoenvironmental model. For several reasons I have paid little attention to this. Firstly, human evolution is a highly contentious field with several camps supporting different models. I felt that unless I spend a lot of time and effort investigating the different theories that have been proposed regarding human evolution in Sundaland, I would probably not be able to get an objective grasp of the matter. As time was limited during this research I decided not to investigate the issue in too much detail. Also, by not working on human mammals, I was able to investigate several other species for which in many cases there were large numbers of recent and fossil specimens available that could easily be accessed, while also taking DNA samples was relatively easy. Through this I have gained a good understanding of the relationships between genetic and morphological evolution and how this relates to changes in palaeoenvironments. Such knowledge will be valuable to interpret human evolution in future research. And finally, I do not feel a particular affinity with the

human species (apart from being a member myself); there is no urgent need to investigate how humans came to Sundaland and survived and multiplied. As pointed out above this need is much greater for other species unless we accept their near-future extinction.

Despite the above, the model that I presented here can tell us something about under what circumstances *Homo* arrived and evolved in Sundaland. It appears that *H. erectus* benefited from the increased environmental fluctuations that characterize the Pleistocene, as this seems to be the time when it started its dispersal from Africa. Probably the availability of open habitats and plenty of large game animals played a role in this. Assuming that *H. erectus* arrived in Java some 1.5 Mya, it probably did so at times of low sea level when the hypothesized land bridge between Java and Malaya was mostly emergent. At that time there was probably no connection to Sumatra, and *H. erectus* may have initially bypassed that island. From palaeoenvironmental reconstructions of Trinil (Huffman 1999) it appears that *H. erectus* primarily used lacustrine or coastal habitats and rather open vegetation types; it presumably avoided closed rainforests. We know little about the palaeoenvironments of Borneo at that time, but it is likely that during the Middle Pleistocene such open habitats also existed on Borneo (as is for instance indicated by the presence of *Hippopotamus* fossils from that time). During the Middle Pleistocene, *H. erectus* could thus also have existed on Borneo and on Sumatra (the latter had by then probably become reconnected to Malaya). During the Middle Pleistocene, Java became isolated and *H. erectus* evolved in isolation leading to differentiation from mainland forms (e.g. Groves & Lahr 1994; Antón et al. 2002). Heaney (1985) discussed the likelihood of *H. erectus* occurring in the Philippines, which he suggested to have been possible only if they arrived by deliberate construction of rafts and dispersal across sea channels. Considering that Palawan was probably connected to Borneo in the Middle Pleistocene, it is possible that *H. erectus* dispersed to that area. For further dispersal to the rest of the Philippines, rafting would have been required.

The out-of-Africa migration of *H. sapiens* occurred some time after 160 Kya (Stringer 2003; White et al. 2003) at a time of generally low, but fluctuating sea levels (see Fig. 3.3). *H. sapiens* probably arrived on Java some 70 Kya, seemingly as part of the

Punung Fauna. It is interesting to note that the Punung Fauna is characterized by rainforest species, although open area grazers also occurred. I suggested here that this fauna originated from Sumatra and it is possible that *H. sapiens* also dispersed through this island. Interestingly, if Drawhorn's (1994) orangutan hypothesis is proven correct and an Asian orangutan replaced the original Sumatran species *P. duboisi* in the late Middle Pleistocene, then it becomes likely that *H. sapiens* crossed from Malaya to Sumatra at the same time as the Asian orangutan. This may also have been the time when *Sus scrofa* dispersed into Sundaland, again a species of forest or forest edge.

It is yet unclear whether *H. sapiens* encountered *H. erectus*, or whether the latter species had then already become extinct. Although we will not know this for sure until fossil remains of both species have been found together, it seems unlikely that *H. erectus* survived the many environmental fluctuations of the Pleistocene only to become locally extinct just before the arrival of *H. sapiens*. More likely the two species co-existed on Java, eventually leading to the extinction of *H. erectus*. The environment at that time was increasingly becoming dominated by grasses and open areas (see Chapter 3), but it is unclear how this could have negatively affected *H. erectus*. Resource competition, and possibly direct interactions or disease may have contributed to the demise of *H. erectus*; with two similarly sized species on a relatively small area some form of confrontation would have been unavoidable.

Eventually, *H. sapiens* survived on Java and from then on the species started to alter its environment. Presently some 200 million people live in western Indonesia, together with some 7.9 million head of cattle and buffaloes, almost 700 million chickens, 7.3 million sheep, and 3.3 million pigs (FAO 2003). *H. sapiens* and some of these symbiotic or mutualistic species have been very successful in evolutionary terms. The one million dollar question is whether we will become the victim of our own success.