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# SOUTHEAST ASIAN PRIMATES: SOCIO-ECOLOGY AND CONSERVATION

**David J. Chivers**
*Wildlife Research Group (The Anatomy School) and Selwyn College, University of Cambridge, United Kingdom*
*Email: djc7@cam.ac.uk*

***ABSTRACT.*** — Primates and rainforests in Southeast Asia are declining rapidly. Over 40 years their ecology and behaviour have been documented, along with the loss of forests. Conservation needs to embrace protection of key habitats, especially watersheds, and sustainable management of large areas, so that 50% of the land area can be kept forested. Shifting cultivation and selective logging have roles to play, but monocultures are a real threat. Translocation and reintroduction have increasing roles to play in preventing extinction. Education of peoples, locally and globally, and of governments, are crucial.

***KEY WORDS.*** — primates, socio-ecology, evolution, conservation, rehabilitation and reintroduction, sustainable management, education

## INTRODUCTION

I used to be an optimist, but in recent years I have become a pessimist. Whatever we scientists do is proving ineffective and endangered wildlife, especially the primates, near the top of the pyramid of production, are now spiralling to oblivion. I report on 40 years of increasing gloom.

For the first 20 years, we showed through our research the needs of the various primates—the widespread gibbons, langurs and macaques—in the forests, in terms of food and space and how to conserve them. For the last 20 years, there have been widespread and vigorous campaigns, in the North and South, to implement such measures, which originate with the local people and local scientists. Primate populations have become increasingly fragmented and threatened with extinction. Inevitably, given my research career, gibbons are central to this discussion.

## THE PROBLEM

While the needs of the human population are paramount, the health and extent of the natural ecosystems are very relevant. Large areas of forest—at least 40% of the land area in monsoonal countries—are essential to maintain water and soil balance crucial for human welfare. In Borneo, only 7% of the forests are in National Parks, 10% in Kalimantan, 3% in Sabah, 15% in Sarawak, and 1% in Brunei, 5.1 million ha in all (4.6 million ha in Kalimantan) (WWF, 2005). Despite the escalating devastating floods and soil erosion seriously impairing the quality of human life, governments are being far too slow in rectifying the damage, even though it has been shown conclusively that forests are more valuable economically in the long term, than being cut down for the one-off sale of timber, with replacement by 'ecological deserts' of monoculture. They are also locally devastated by mining for coal and gold. The rains are increasingly less frequent but much heavier.

Indonesia, with which I am most familiar over the last 25 years, is a vast country (see Marsh, 1987: fig. 1). The forests of Sumatra and Borneo are key islands for the welfare of Indonesia and the world—crucial 'lungs' for the planet, along with the equatorial forests of Africa and South America. Global warming is attributed in part to forest clearance, including the changes that are induced in Pacific currents. Increasingly frequently, El Niño Southern Oscillation (ENSO) events cause unusually long periods of drought, highly atypical of the humid tropics, with serious fires on peat burning for weeks or months, with concomitant damage to human welfare, not just to the local population, but with serious effects on health from persistent smoke across the region, widely disrupting air travel. Malaysia has protested vigorously, yet it was their logging companies that started on Indonesian forests, both legally and illegally, once supplies in the Peninsula were seriously depleted.

In 1975 about 74% of the land area of Borneo was forested; by 2005 this figure had plummeted to about 50%, and it is probably around 44% today and predicted to be only 33% by 2020 (WWF, 2005). Illegal logging was rife but controllable, but after 1999, when control of the forests was handed over to the provinces by central government, instead of sound management of their own forests, the corruption and illegal clearing of forests escalated, despite the efforts of central

government—hence my current despair. Around 2003 about 80% of the timber exported from Indonesia was estimated to have been illegal.

Central government, however, confused the issues. On the one hand they signed an agreement with Malaysia and Borneo to protect the 'Heart of Borneo' (22 million ha, 25% of the island's land area) and to manage it sustainably (although the 23 small areas marked for protection are inadequate), on the other they issued many concessions in this crucial area for open-cast coal mining, gold mining and oil-palm plantations (often several for the same location!). The significance of the Heart of Borneo is to protect the watersheds of the three main rivers of the island: the Barito draining to the south, the Kapuas flowing west, and the Mahakam flowing south-east (Fig. 1). To prevent further devastation would improve the lot of the majority of the people of Borneo, including those living on the numerous small rivers flowing south.

Sumatra has comparable problems, augmented by the horrific earthquakes and tsunamis of increasing frequency and intensity. The same is true with increasing severity as the years pass across Asia—southern China, Vietnam, Laos, Cambodia, Thailand, Myanmar, Bangladesh, India and Sri Lanka—especially during the monsoons.

## EVOLUTIONARY BACKGROUND

The Sunda Shelf formed from the coming together of various micro-plates, mostly (but not all) Laurasian in origin, with volcanic activity largely confined to zones of subduction near its margins. It owes its uniquely rich fauna (and flora) to an admixture of presumed autochthonous elements with immigrants, first from the Indian sub-continent (the Siva-Malayan fauna) and then, later from China (the Sino-Malayan fauna) (see Marsh, 1987: fig. 1). Chivers (1977) proposed a model of gibbon evolution, relating to the frequent changes of sea level during the latter part of the Pleistocene, as ice formed and the Sunda Shelf was exposed as one land mass, and as the ice melted and the Shelf was flooded, leaving a number of islands. The isolated gibbon populations speciated, wholly or at that time partly, and then migrated when land bridges were restored (Fig. 2). The key point is that, after the initial spread of three of the genera into different parts of the Sunda Shelf, gibbon speciation occurred within the Shelf (Fig. 3), with subsequent, sequential spread back to the mainland, with the hoolock (fourth genus, in the van); species did not spread out from the Asian mainland, as had previously been supposed. The pileated and lar gibbons followed, and the Kloss, Bornean and Javan gibbons originated on the edges of the Shelf, with agile and lar in the 'centre'.

The timing of speciation events has been greatly revised by research since 1977, though the relative sequence of events may still be valid. During the periods of lowest sea level, the centre of the Shelf dried out, and current distributions of living species are most readily explained if the key rainforest relicts, into which gibbons and other forest animals retreated and out of which they spread when sea level rose, were in eastern Indo-China and southern China, northeast Borneo, west Java, north Sumatra and southern Burma, as well as the Mentawai Islands.

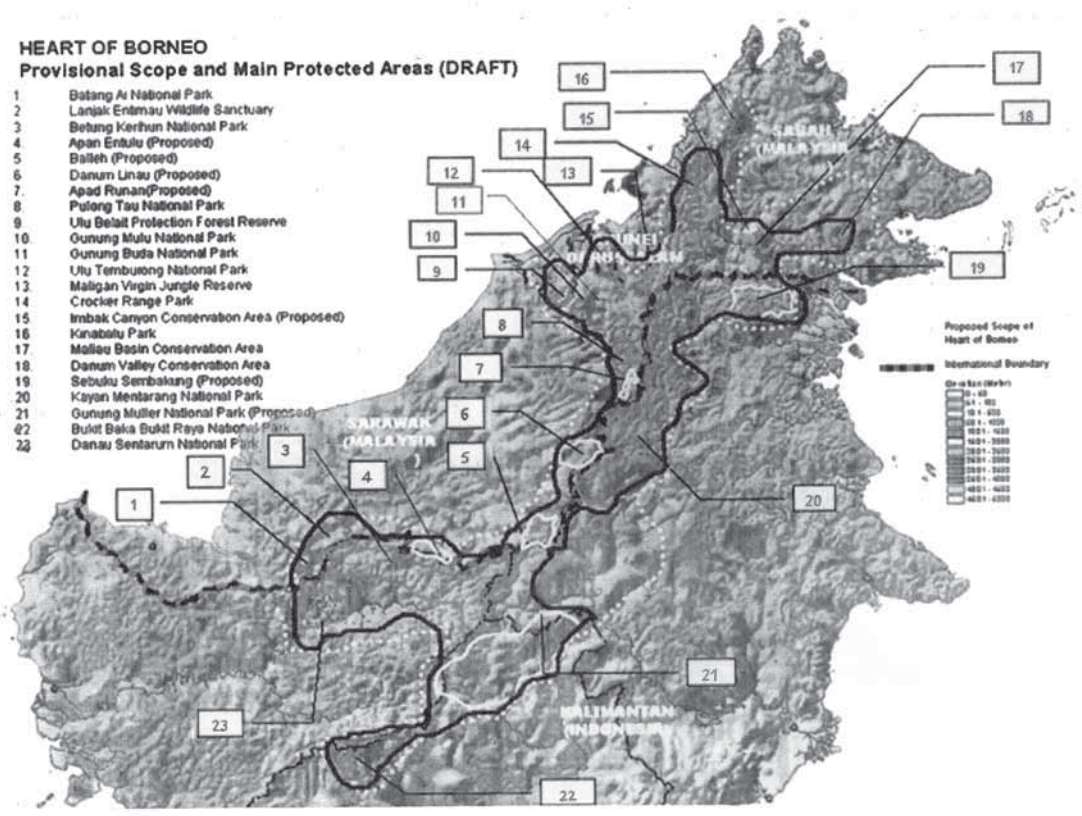


Fig. 1. Heart of Borneo (WWF, 2005). © WWF, Germany, reproduced with permission.

There has been thorough re-analysis of all morphological and behavioural characters of gibbons by multivariate techniques (Geissmann, 1993). It had been difficult to resolve whether siamang, concolor or hoolock is the most primitive (see above), but the most parsimonious picture has the hoolock gibbon branching off first, followed by concolor and then siamang and Kloss, and then Mueller's, moloch, pileated, lar, and agile. Patterns vary according to whether one uses cranial and dental, pelage, song or all variables. Similar scenarios can be devised for the langurs, for which seas and rivers are also barriers to spread, but the macaques are not so restricted and the same two species occur across most of the Sunda Shelf.

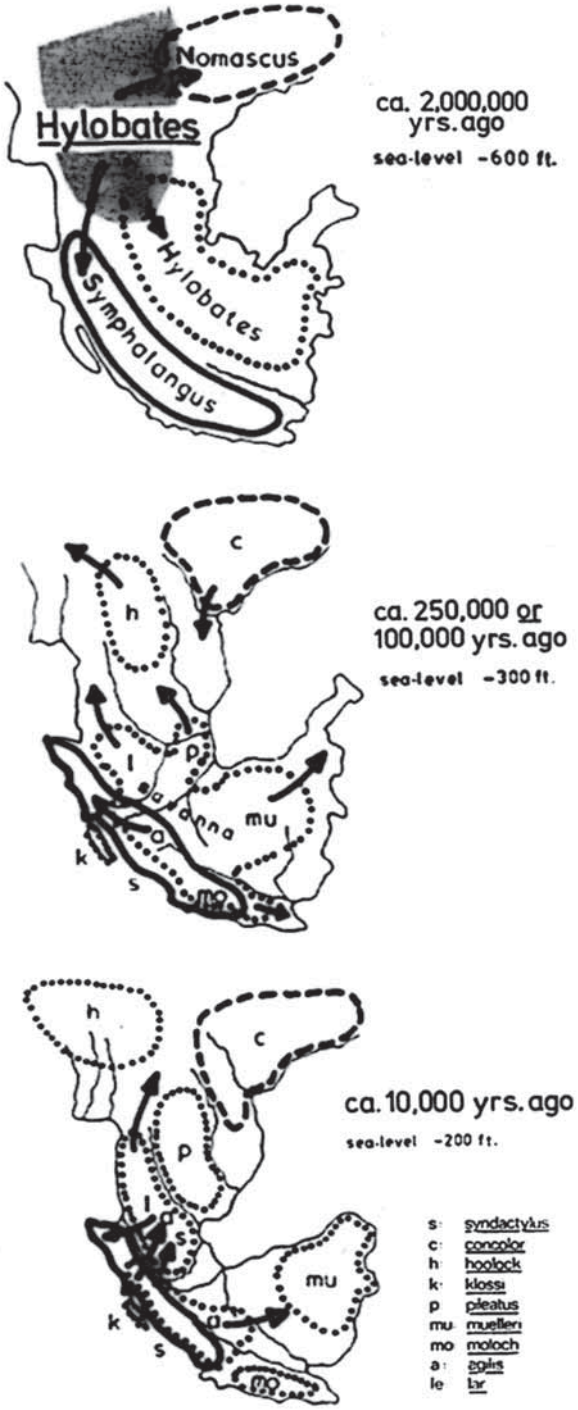


Fig. 2. Late Pleistocene movement of gibbons leading to speciation (Chivers, 1977).

## THE PRIMATES AND THEIR SOCIO-ECOLOGY

The primate communities at any given locality in Southeast Asia (and South Asia) generally comprise at least two species of macaque *(Macaca)*, two species of langur (*Trachypithecus* and *Presbytis*; and the occasional odd-nosed monkey *Nasalis*, *Pygathrix* or *Rhinopithecus*), and one or two species of ape (Hylobatidae, *Pongo*), in addition to the nocturnal slow loris (*Loris*) and tarsier (*Tarsius*). They are closely integrated and complementary.

The macaques live in large multi-male multi-female social groups in overlapping home ranges and subsist mainly on fruit, the langurs live in one-male groups in smaller territories and are adapted to leaf-eating, but also consume varying amounts of unripe fruit and seeds, and the gibbons are monogamous, territorial and frugivorous (ripe fruit; Table 1). The orang-utan is also frugivorous and semi-solitary, based on a harem system, and tarsiers are monogamous, territorial and insectivorous, with the loris more frugivorous. Gibbons and langurs live higher in the forest canopy, with macaques at the forest edge and also on the ground.

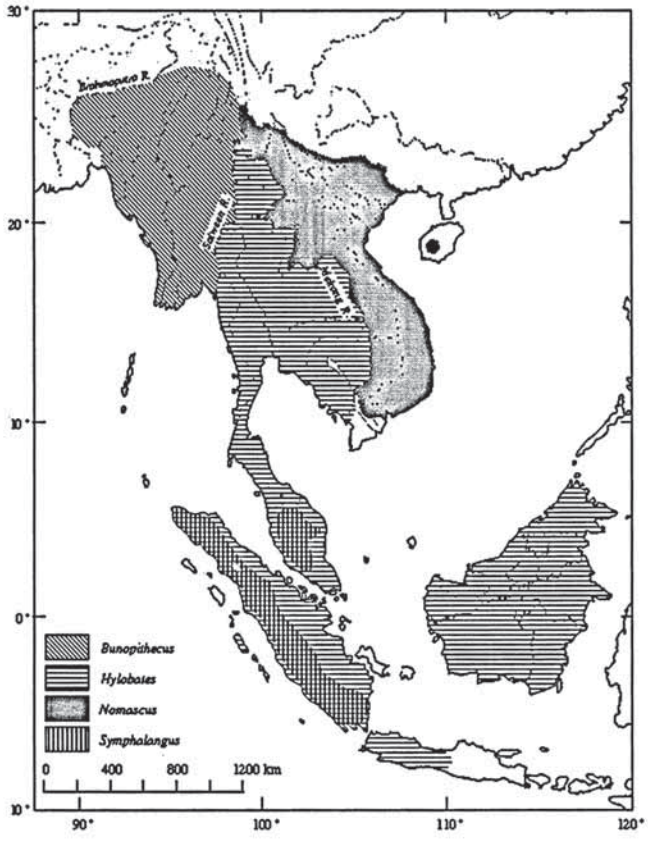


Fig. 3. Distribution of gibbon genera (Geissmann, 1995), after information in Chivers (1974), Chivers & Gittins (1978), Ma & Wang (1986), Fooden et al. (1987), and Zhang et al. (1992).

Table 1. Ecological grades in Malayan forest primates (Chivers, 1986).

| | **Loris** | **Tarsier** | **Macaques** | | **Langurs** | | **Gibbons** | | **Orang Utan** |
|---|---|---|---|---|---|---|---|---|---|
| | *Nycticebus coucang* | *Tarsius spectrum* | *Macaca fascicularis* | *Macaca nemestrina* | *Presbytis obscura* | *Presbytis melalophos* | *Hylobates lar* | *Hylobates syndactylus* | *Pongo pygmaeus* |
| Habit | Nocturnal | Nocturnal | Diurnal | | Diurnal | | Diurnal | | Diurnal |
| Habitat | Forest edge | Forest edge | Forest edge | Forest | Forest | Forest edge | Forest | | Forest |
| Positional behaviour | Slow climber | Vertical cling and leap | Quadrupedal-run, walk trees + ground | | Quadrupedal/leaping | | Suspensory-hang, climb, brachiate | | Quadrumanual climb + swing |
| Social organisation | Solitary | Monogamous territorial | Multimale polygyny multilevel | | One-male polygyny occ. territorial | | Monogamous territorial | | Solitary |
| Group size | 1 | 4 | 23 | 33 | 14 | 12 | 4 | 4 | 1.5 |
| Body weight | | | | | | | | | |
| Adult female (kg) | 0.7 | 0.1 | 3.5 | 7 | 6.5 | 6.5 | 5.5 | 11 | 40 |
| Group wt. (kg) | 0.7 | 0.3 | 73 | 74 | 72 | 60 | 16 | 31 | 60 |
| Biomass (kg $km^{-2}$) | 15 | 23 | 180 | 45 | 240 | 286 | 29 | 97 | 100 |
| Diet | Frugivore (Faunivore) | Faunivore | Frugivore (Faunivore) | | Folivore/frugivore | | Frugivore/folivore | | Frugivore |
| leaves (%) | 0 | 0 | 20 | 13 | 56 | 39 | 30 | 48 | 28 |
| fruit (%) | 71 | 0 | 63 | 74 | 43 | 58 | 61 | 44 | 58 |
| animals (%) | 29 | 100 | 17 | 13 | 1 | 3 | 8 | 8 | 14 |
| Day range (km) | 0.49 | 0.201 | 1.08 | ~3.0 | 0.76 | 0.95 | 1.67 | 0.87 | 0.64 |
| Home range ($km^2$) | 0.05 | 0.012 | 0.40 | ~8.3 | 0.30 | 0.21 | 0.55 | 0.32 | 1.50 |

1 While mean values are given (for comparative simplicity), such behavioural scores can be very variable over an annual cycle and between groups of the same species.
2 Estimate

## CONSERVATION

Conservation embraces, in the field, both the total protection of key areas (e.g., watersheds, rare/unique ecosystems, refuge of key animal/plant species) and management of forests for the benefit of animals (and plants), as well as people (Table 2). Forest clearance is the greatest threat to the survival of primates and many other animals, and to human welfare. For local and global environmental and economic welfare one needs to keep close to 50% of tropical countries forested; once the area dips below that proportion climatic changes and water and soil problems seem to escalate catastrophically. Since few countries seem able to afford to keep more than l0% of their forests totally protected, the remaining 40% needed has to be managed for sustained yields of a wide variety of products (Myers, 1983, 1984).

Managed forests provide a buffer zone for protected forests, which provide replenishment of plants and animals. Thus, the shapes and sizes and spatial relationships of such areas need to be planned carefully, on the basis of systematic research, much of which still has to be conducted. The third part of the strategy is to use to maximum efficiency the land already cleared of forest or so degraded that its role as forest cannot be redeemed.

The loss of income from timber (pulp and sawn) through such practice has to be balanced (easily exceeded in the long-term) by income from other (not minor) forest products. This is another key subject for investigation, so that the exploitation of such forests, and the benefits for humans, can be maximised through knowledge of key animal-plant relations promoting the regeneration of such resources. The target has to be less damage to the forest and more produce, on a sustainable basis. Project Barito Ulu in the centre of Borneo is one effort to provide the necessary information (Fig. 4); the aims were to identify those fruit-eating animals that are crucial for seed dispersal of tree species of commercial value for foods and medicines, waxes and resins, rather than for tree species for timber, as those are mainly wind dispersed.

What is needed is the improved protection of watersheds and national parks representing all ecosystems, especially the richest, lowland ones, with the efficient, sustainable management of large buffer zones, and the more productive use of land already cleared of forest (Chivers, 1986, 1989). Such a strategy should ensure that viable populations of all primate taxa survive in perpetuity, but it will not be easy.

***Selective logging.*** — Selective logging represents a compromise between human and animal needs in the long term, but it will only work if timber extraction is very light and carefully controlled. This approach has been developed in numerous sites, especially in Sungai Tekam by Johns (1986, 1987), under the management of the Forest Department and Forestry Research Institute Malaysia (FRIM). Even if only 10 trees per hectare are extracted (4% of trees), 45% of the total stand (68% of plant biomass) can be damaged during access, felling and extraction. Johns continued to monitor the changes as the forest regenerates. It is the larger and more frugivorous species of animals which are the most vulnerable, but their populations should recover fully within 20 to 30 years (if there is no further interference). For example, gibbons and langurs adapt their foraging strategies by eating more leaves, as fruit availability declines in newly-logged forest. Gibbons maintain their territories, but the stress affects their breeding. Langurs may emigrate temporarily from the disturbed area, and there is increased mortality of immature monkeys (because of travel difficulties across gaps), which adds to the breeding loss.

Selective logging enhances the diversity of microhabitats characteristic of the mosaic of successional stages of climax forest; it is these colonising plants of immature forest which provide more nutritious foods, less defended chemically. Bird communities maintain much the same trophic structure, but species composition may be changed markedly: dietary generalists survive better than insect- and fruit-specialists, whose food supply may be much disrupted temporarily. Mosaics of primary and logged forest can maintain viable populations of the large wide-ranging hornbills.

Thus, the persistence of primary forest in an area may be crucial to the survival of certain animal species, and it is the relationships between these two types of forest that need to be investigated urgently. Additional information on the effects of selective logging is available from West Malaysia from the surveys of primary and variously disturbed forest (Marsh & Wilson, 1981) and from East Kalimantan (Wilson & Wilson, 1975). In contrast to the tolerance of gibbons and langurs, orang-utans and proboscis monkeys are seriously affected by selective logging.

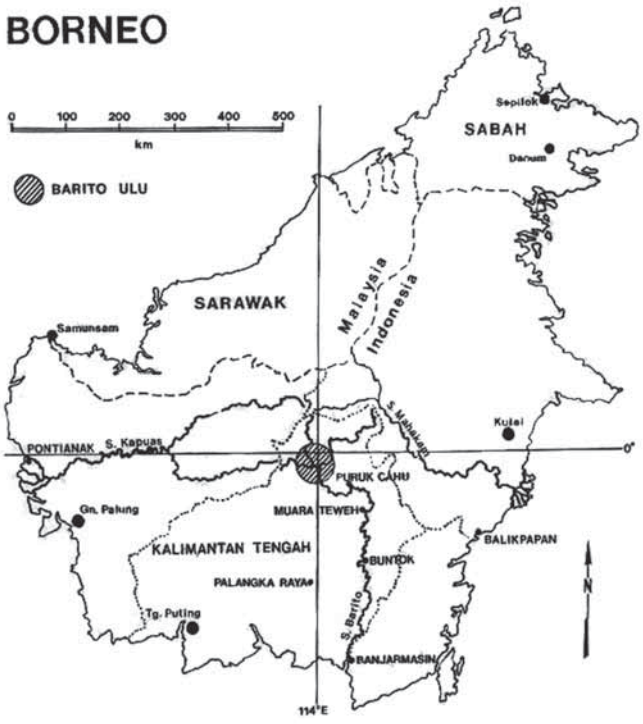


Fig. 4. Borneo: Showing provinces, major rivers and the Barito watershed (Chivers & Burton, 1988); with the main sites of long-term primate studies and Kalimantan Tengah, with main towns and rivers and the Barito Ulu study area.

Table 2. Conservation of tropical forests: Values, pressures, solutions (Chivers, 1986).

| Values (long-term) | Pressures | Solutions |
|---|---|---|
| Water and soil balance<br>Climate<br>rainfall pattern<br>atmospheric gas balance | Hunting<br>Harvesting<br>Farming | Total protection of watersheds and significant representatives of each ecosystem, especially those with high plant/animal diversity |
| 40–50% world's plant and animal species genetic diversity pivotal plant/animal links | Pet trade<br>Power<br>water<br>oil | Wide-ranging management of buffer zones to reserves for sustained yields |
| Sustainable yields<br>timber, canes, fibres, gums, waxes, resins, foods, plant and animal medicines | Selective logging<br>Clear-felling<br>for timber<br>for fuel<br>for agriculture | Agro-forestry and agriculture in areas cleared of forest, with improved efficiency |
| Education and research | | |
| Recreation | | |

***Shifting cultivation.*** — Shifting cultivation has been practised for centuries, especially along rivers, with peoples living in harmony with the forest, since the forest has recovered by the time people return. Increased population, and less forest, means that return time is so reduced that this practice is no longer sustainable.

***Monoculture.*** — Rubber plantations have a long history, especially in Peninsular Malaysia, but their effect on the forest has been eclipsed in recent years by oil-palm plantations, especially in Indonesia. Between 1998 and 2003 oil-palm estate increased from 2.54 to 3.32 million ha in Malaysian Borneo (annual growth of 5.6%, but up to 13% in Sabah,), and from 1.65 to 2.94 million ha in Indonesia (annual growth 12.4%, 15% in Central Kalimantan, 20% in East Kalimantan) (WWF, 2005). Annual forest loss in Kalimantan has averaged about 1 million ha between 1984 and 2002. The effect on the forest estate and on wildlife is proving devastating, not least for the orang-utan.

***Translocation, Captive Breeding and Reintroduction: Gibbons.*** — Mather (1992) developed the invaluable approach of analysing gibbon food trees from all previous studies to compare with the density of gibbons in each area. Kuala Lompat in West Malaysia has only 1% of the timber-tree family, Dipterocarpaceae, compared with 43% of trees in Barito Ulu, Kalimantan. Primate abundance relates to the abundance of Leguminosae, with 13% at Kuala Lompat and only 4% in Barito Ulu. At Kuala Lompat Moraceae (40 species), Euphorbiacae (25). Leguminosae (19), Myrtaceae and Annonaceae (18), Rubiaceae (15), Guttiferae (14), and Anacardiacae (12) account for 161 species, 45% of all known gibbon food species.

He shows that there is a direct correspondence between gibbon biomass and the abundance of these preferred gibbon foods (Table 3). Group size is larger in localities with more fig trees. It enables one to assess whether a gibbon population is at carrying capacity, or below (because of human disturbance) or above (because of immigration from nearby disturbed areas). The suitability of proposed sites for reintroduction or translocation can be assessed, and stocking density determined, and, where there is selective logging, the reduction in carrying capacity can be determined.

Our improved taxonomic and socio-ecological understanding of this diverse group of apes (as summarised above), and of their tropical rain forest habitat (e.g., Leighton & Leighton, 1983; Whitmore, 1984) improves our chances of their effective conservation. Clearer recognition of species and sub-species, and improved quantification of their use of resources (social structure, feeding and ranging) in relation to what is available, is essential to effective protection and/or management.

The predictions by Chivers (1977) of a drastic reduction in gibbon populations are being realised, with the Kloss, moloch and concolor gibbons the most endangered. As the clear-felling of forest declines, however, their prospects are boosted, if adequate selectively-logged forest (with low extraction rate) persists, since gibbons have shown themselves to be adaptable to such disturbance (Marsh & Wilson, 1981; Johns, 1986, 1987).

Little progress has been made in developing techniques of translocation (to move social groups from doomed to protected habitat) presumably because of the physical difficulties involved, and the lack of empty suitable habitat (but see Cheyne & Brule, 2004). It remains a possible solution where populations become critically endangered, but adequate preparation, care (with veterinary supervision) and monitoring are essential.

Captive breeding worldwide provides invaluable publicity (of the plight of rain-forest animals) and education, with fund-raising opportunities for conservation activities. It also helps to conserve the gene pool, with meticulous stud-books. The prospects of reintroduction to the wild habitat are gloomy,

Table 3a. Density of fig trees and gibbon biomass (Mather, 1992).

| Site | Figs ha$^{-1}$ | Groups km$^{-2}$ | Group size | Biomass (kg km$^{-2}$) |
|---|---|---|---|---|
| Sepilok, Sabah | 0 | 1.5 | 2.7 | 24.0 |
| Tanjung Puting, Kalimantan | 1.0 | 2.9 | 3.0 | 34.8 |
| Siberut, Mentawai Islands | 1.3 | 2.1 | 3.7 | 42.0 |
| Sungai Tekam, W. Malaysia | 2.0 | 2.5 | 3.3 | 32.6 |
| Danum, Sabah | 2.3 | 2.1 | 3.5 | 25.2 |
| Pasoh, W. Malaysia | 4.0 | 2.1 | 4.0 | 33.6 |
| Kutai, East Kalimantan | 6.6 | 3.6 | 4.0 | 57.6 |
| Kuala Lompat, W. Malaysia | 8.0 | 4.1 | 4.0 | 65.0 |
| Ketambe, N. Sumatra | 27.0 | 4.3 | 4.5 | 98.0 |

Table 3b. Abundance of gibbon food trees and gibbon biomass (Mather, 1992).

| Site | Food Trees (% of plot) | Gibbon Biomass (kg km$^{-2}$) |
|---|---|---|
| Sepilok, Sabah | 11.2 | 24.0 |
| Danum, Sabah | 12.9 | 25.2 |
| Sungai Tekam, W. Malaysia | 20.6 | 31.6 |
| Tanjung Puting, Kalimantan | 23.2 | 34.8 |
| Kuala Lompat, W. Malaysia | 24.2 | 33.6 |
| Siberut, Mentawai Islands | 34.8 | 42.0 |

given the costs involved and the lack of available habitat (but see below for orang-utans). If habitat is available, it is much more cost-effective and successful to translocate social groups from doomed forest fragments to any under-stocked protected forest. The prime effort must be to protect natural habitat and to conserve wildlife within it.

Kalaweit in the Bukit Baka National Park in Central Kalimantan offers a ray of hope. Facilities are being developed to accommodate confiscated gibbons, to form pairs, and when ready, to reintroduce them to protected forest. A possible area is being developed nearer to Palangka Raya, provincial capital of Central Kalimantan (Cheyne & Brule, 2004).

***Translocation, Captive Breeding and Reintroduction: Orang-utans.*** — Even more emotive, if that is possible, is the plight of the orang-utan. In about 1950 there were about 30,000 orang-utans in Sumatra and 200,000 in Borneo. Today there are less than 7,000 in Sumatra and less than 50,000 in Borneo (Fig. 5); more have died in the last 30 years than are alive today! Orang-utans were present in 21 localities in 1992, but by 2002 they were extinct in 8 of them, probably because of hunting (WWF, 2005).

Thus, numbers are declining through 50,000 for the two species and there are more than 1,000 in captivity, rescued from devastated and burned forest and from plantations, and confiscated from smugglers and pet-owners. Given the decline in the wild, these animals could be crucial to the survival of the species. Programmes of rehabilitation have been under way for nearly 20 years, in Bukit Lawang and Ketambe in Sumatra, and Tanjung Puting, Wanariset and Nyaru Menteng in Kalimantan, and Sepilok in Sabah. Now another centre has been established in North Sumatra and one in Sarawak. In most locations reintroductions have been carried out, with varying, but improving, degrees of success. This has to be a critical activity to help ensure the survival of the orang-utan. It depends on thorough veterinary care and training for life back in the wild, long-term monitoring and effective protection of the forest…all of which are gradually being achieved.

***Education.*** — Education is essential at various levels, as successful programmes in many countries demonstrate (e.g., Rwanda, Brazil, Peru, Costa Rica, Malaysia, and Indonesia). In the long term, education of local people (whose lives are most immediately affected by destruction of forests) and the young (the next generation) the world over is essential. Most critical, however, is the need to influence the decision makers of today—the governments of tropical countries (who now mostly see what has to be done) and, more importantly, the governments of "user countries" and the

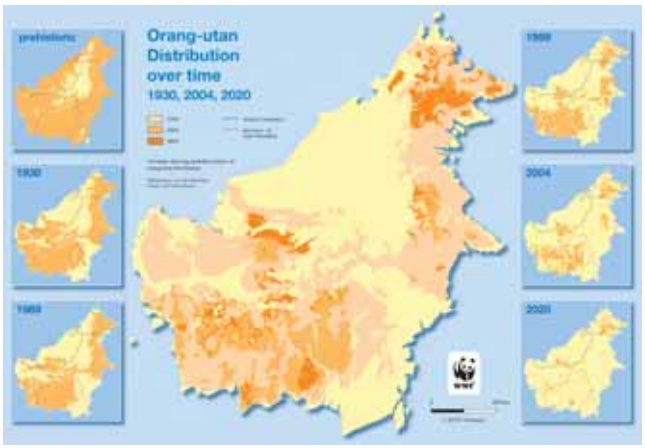


Fig. 5. Decline of the Bornean orang-utan since 1930 (WWF, 2005). © WWF, Germany, reproduced with permission.

heads of international and national commercial concerns—so that policy and activities are changed rapidly, to avert impending catastrophes. Values have to be changed, and resource flow significantly altered, if this planet is not to be irreparably damaged. An international network concerned with disseminating this inter-disciplinary bio-environmental approach could have a critical role to play in this process (Chivers, 1989).

***Threatened primates.*** — 'Indo-China' is the key to gibbon conservation; indeed to all primate conservation (it contains about 8 of the 20 most endangered primates in the world). The four crested gibbon species in the north (*Nomascus concolor*) in southern China are seriously threatened, but the most endangered are the Hainan (China) and Cao Vit (north-east Vietnam) gibbons (*Nomascus nasutus*), with less than 20 individuals. Efforts are being to ensure that they all flourish. The rarer they are, the more effort the local people can be encouraged to give. The northern and southern white-cheeked gibbons in Vietnam and Laos (*Nomascus leucogenys*) are also struggling, but the yellow-cheeked gibbon (*Nomascus gabriellae*) in southern Vietnam and Cambodia seems to be the most numerous of the genus.

The other most endangered gibbons, because of habitat loss, are the Javan or silvery gibbon (*Hylobates moloch*) (surviving only in the west of island) and the Kloss gibbon on the Mentawai Islands (*H. klossii*). The status of the hoolock gibbon (*Hoolock hoolock*) is unknown in Myanmar, and perhaps a cause for serious concern; numbers in Bangladesh and eastern India are not large, and are being depleted rapidly. The pileated gibbon (*H. pileatus*) is restricted in Thailand and, increasingly, in Cambodia. Otherwise, the more widely-distributed siamang (*Symphalangus syndactylus*), lar, agile, and Bornean gibbons (*H. lar*, *H. agilis*, and *H. muelleri*) are present in good numbers where forest remains, even in selectively-logged forests.

Several langur species (*Trachypithecus* spp.) and, in particular, several of the odd-nosed monkeys (*Rhinopithecus* and *Pygathrix* spp.) are also close to extinction.

## CONCLUSIONS

The rainforests of the tropical regions of Asia, Africa, and the Americas play a vital role in the maintenance of environmental stability for the whole planet. They are being depleted at an alarming rate, to the detriment of the long-term economy of the countries concerned, as well as to their climate. Such irreparable damage will continue so long as there continues to be such disregard of the consequences, and so long as there is so excessive a net flow of resources from tropical to temperate countries—from the South to the North. The key forested countries are Brazil, Zaire and Indonesia; they hold at least one of the keys to human welfare on this planet.

Such forests must be maintained in perpetuity for the benefits of the countries in which they occur, and for the whole planet. These benefits are economic, as well as climatic, which must give hope for success. Evidence increasingly shows that 40–50% of the land area of the countries involved need to be maintained under tropical forest. Total protection of the main watersheds ensures water and soil balance for the full extent of the river to the sea, and a significant contribution to plant and animal diversity.

Protection of the richest lowland ecosystems increases significantly the protection of genetic diversity (biodiversity). Such protection rarely exceeds more than 10% of the land area. Management of forests covering 30–40% of the land area is essential for achieving the needs specified above. Sustainable use of a wide range of forest products, rather than excessive exploitation for timber, will ensure far greater economic returns in the long term. Thus, both climate and trade will benefit the whole planet through the right balance of protection and sustainable use.

In the long term, education of local people (whose lives are most immediately affected by destruction of forests) and the young (the next generation) the world over is essential. Most critical, however, is the need to influence the decision makers of today—the governments of tropical countries and, more importantly, the governments of "user countries" and the heads of international and national commercial concerns—so that policy and activities are changed rapidly, to avert impending catastrophes.

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