CHAPTER 6

NATURAL FOREST MANAGEMENT AND NATURE CONSERVATION

CHAPTER OUTLINE

6.1 INTRODUCTION

Despite growing awareness that tropical forests are priorities for nature conservation because of all the species they support, it is clear that few countries in the tropics will be able to afford to designate more than a small proportion of those forests as preservation areas (National Parks, Strict Nature Reserves etc.). Much of the remainder of the permanent forest estate is likely to be put under some sort of management, and timber production is likely to be one of the main activities. One of the objectives of conservation, therefore, must be to try and ensure that natural forest management for timber production is carried out in such a way that most of the wildlife survives.

Natural forest management for timber production has a relatively long and successful history in Uganda compared to many other tropical forest countries. Silvicultural operations began in Budongo, Mpigi and Mabira forests as early as the 1930s (Dawkins, 1958). The emphasis of management has been the maintenance and enhancement of the natural forests' timber production potential; different silvicultural "treatments" have been tried and at least some of these have proved successful in meeting this objective. But here we address two questions:

- What has been the effect of natural forest management on wildlife?
- How can adverse effects be minimised and positive effects maximised, so that production forests can also act as conservation areas?

This second point is also addressed in Chapter 7.

6.2 WHAT DOES NATURAL FOREST MANAGEMENT INVOLVE?

Natural forest management has usually been based on *selection* systems, in which selected timber trees are felled and the forest treated in various ways to ensure a future yield of the same timber trees. The first felling (*salvage*) yields many large-diameter trees, many of them commercially overmature. This felling is also intended to remove *undesirables*. Subsequent treatments include the use of *arboricides* to poison further undesirables (an example of *refining*), and, in some cases, *enrichment planting* of desirable species. Subsequent fellings yield more uniform but smaller size-classes of selected timber trees. Both monocyclic silvicultural systems (i.e. returning to log once during the time it takes a commercial tree to reach commercial maturity from having been a seedling or sapling) and polycyclic ones (i.e. returning to log more than once during the same growth cycle, so that trees that were immature on one visit will have reached maturity by the next) have been tried in Uganda. Many forests were to have been converted from polycyclic to monocyclic under a plan initiated in the 1960s (Philip, 1962), to reduce wastage and residual damage.

6.3 IMPACTS ON THE FOREST ENVIRONMENT AND MICROCLIMATE

Wildlife may be affected either directly or indirectly by logging or other natural forest management operations. Box 6.1 highlights some of the more readily discernible impacts that may affect the forest environment in general.

Tree-felling creates artificial gaps in the canopy, allowing light to penetrate to the forest floor. This is little different from a natural treefall, but in managed forest the proportion of gaps can be greater, as can the average gap size (see Section 6.4.2). This affects various aspects of the forest microclimate, which in turn affect which species can live in the gap, since the niches of different species encompass different preferences for humidity, temperature, light levels and so on (see Section 5.4.1). Figures 6.1 and 6.2 come from a study in south-west Ghana, and compare air temperature and relative humidity near ground-level in closed forest and in a large clearing.

These figures illustrate that, whereas night-time conditions of microclimate are similar, in the daytime a clearing can become far warmer and less humid than an equivalent area under forest. This affects the kind of tree species that can become established there, and thus the composition of the forest in the years to come. The larger the clearing (up to a point) the more the resultant forest composition will differ from the original. If we decide that the species that establish in humid, shady conditions are particularly important for nature conservation, then we should make sure that they are catered for in management plans so that some areas remain unlogged.

Box 6.1
Some of the impacts of logging on the natural forest environment

- Compaction of soil by machinery and skidding, making it unfavourable for seedling establishment
- Creation of large gaps in the canopy, favouring regeneration of pioneers and climbers, altering the microclimate and increasing the chance of wind throws, erosion and fires
- Damage to non-target trees by machinery and falling trees, leading to long-term mortality of damaged trees
- Loss of trees in the way of skidder tracks and loading bays
- Soil erosion and siltation of water-courses due to exposure of soil
- Hydrological changes due to blocked water-courses during road construction
- Disturbance to wildlife by noise and general activity
- Increased hunting pressure and risk of encroachment along logging and skidding tracks
- Decrease in abundance of timber trees above minimum diameters, with knock-on effects on other species and an overall change in forest tree species composition
- Changes in abundance and distribution of animals according to how their habitats are affected by logging

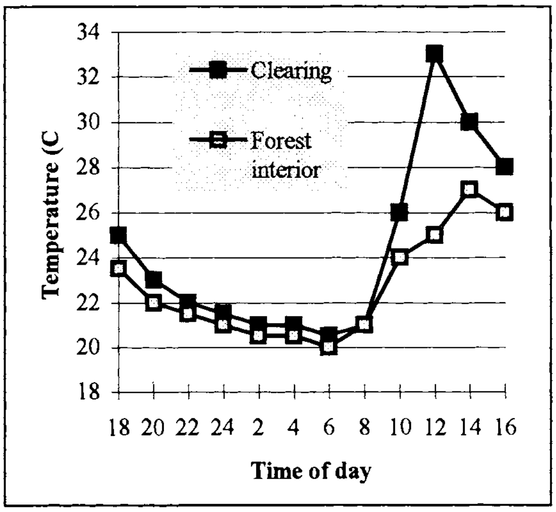

Figure 6.1. Daily cycle of air temperature in a rainforest in south-west Ghana. After Longmann and Jenik (1974).

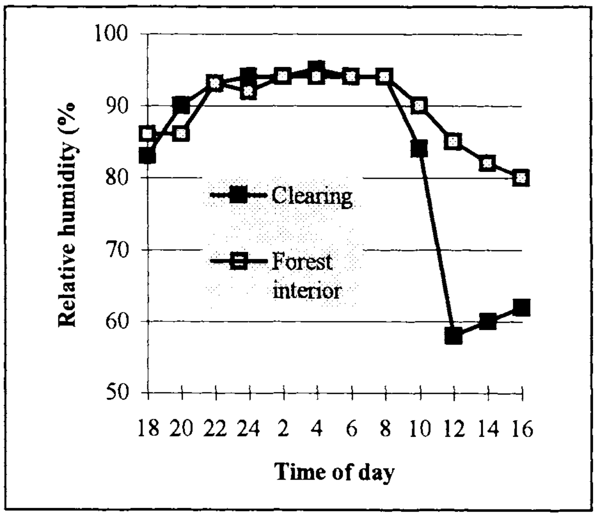

Figure 6.2. Daily cycle of humidity in a rainforest in south-west Ghana, on an unusually dry day. After Longmann and Jenik (1974).

6.4 IMPACTS ON TREES AND VEGETATION

Although Uganda's natural forests contain several hundred tree species, relatively few have been favoured as timber trees. For instance, those that are listed in the top two timber grades and which occur in Budongo Forest are given in Box 6.2. In practice, even fewer species are in regular use. In Budongo, for instance, despite attempts by the Forest Department to force sawmills to diversify, the proportion of mahogany removed compared to other tree species has remained more or less constant since the 1930s (Plumptre et al., 1994).

6.4.1 Impacts on the target tree species

In some cases, management has resulted in the depletion of stocks of timber species, such that a few are now becoming rare. Internationally, many tropical timber species are threatened by over-exploitation, (FAO, 1986) although as yet only a few (such as the mahoganies, *Cordia milleni* and *Milicia excelsa*) are threatened in Uganda (see Section 3.3.5 for more details).

Many timber species will regenerate successfully in logged forest, but only if seed trees are left to ensure an adequate source of seeds. In Budongo Forest, for instance, most *Entandrophragma* spp. trees do not start producing seeds until they are over 80-100 cm dbh; for *Khaya anthotheca* the figure is about 70 cm dbh (Plumptre et al., 1994). Thus if all such trees are harvested as soon as they reach a diameter of 70 cm dbh, there may not be sufficient seeding trees remaining to ensure that the species regenerates, and enrichment planting may be necessary. In other cases, however, management has ensured that stocks of timber trees are maintained, or even enhanced. In Budongo, *Maesopsis eminii* not only seeds profusely well before reaching 70 cm dbh, but it also regenerates well in gaps. Unlike mahoganies, enrichment planting is seldom necessary. Of course enrichment planting of timber species can, if taken to extremes, eventually result in a forest structure that is almost as uniform and even-aged as a plantation.

6.4.2 Impacts on non-target tree species and vegetation

During felling, whether by mechanised logging or pit sawing, it is not just the target tree that is affected. Many other trees and shrubs in the vicinity, comprising future timber trees and many other species, may also be damaged or destroyed. How much of the surrounding vegetation is affected depends on the intensity of harvesting, but also on the care taken (for instance, climber cutting, directional felling and careful planning of skidding tracks and roads). Figure 6.3 compares tree mortality in three African production forests with similar intensities of harvesting. In these particular cases, up to 65% of trees are damaged during the removal of just 1% of the trees. It may be assumed that higher levels of damage correspond with greater subsequent domination of the regeneration by pioneers. The Ugandan study (in Kibale Forest) shows the highest rate of damage, at over six times the rate of the Gabon study. This emphasises the importance of good planning and management of harvesting operations (see Chapter 7).

Table 6.1 takes a closer look at the Kibale study area, and compares various aspects of vegetation in unlogged, lightly logged and heavily logged forest. From this study, it is clear that the immediate impacts of logging here include a reduction in basal area and stem density (hardly surprising), an opening up of the canopy, an increase in the average gap size, and a drop in the number of tree species present. Seedling regeneration may be suppressed, and heavy logging produces larger impacts than light logging.

Box 6.2
The top two grades of timber trees in Budongo Forest, Uganda (Plumptre et al., 1994)

- *Albizia* spp.
- *Alstonia boonei*
- *Aningeria altissima*
- *Entandrophragma* spp.
- *Antiaris toxicaria*
- *Celtis durandii*
- *Celtis mildbraedii*
- *Celtis zenkeri*
- *Chrysophyllum* spp.
- *Cordia milleni*
- *Cynometra alexandri*
- *Diospyros abyssinica*
- *Dombeya mukole*
- *Funtumia* spp.
- *Guarea cedrata*
- *Hallea stipulosa*
- *Holoptelea grandis*
- *Khaya anthotheca*
- *Lovoa trichilioides*
- *Maesopsis eminii*
- *Milicia excelsa*
- *Morus lactea*
- *Myrianthus arboreus*
- *Olea welwitschii*
- *Trichilia dregeana*
- *Zanthoxylum* spp.

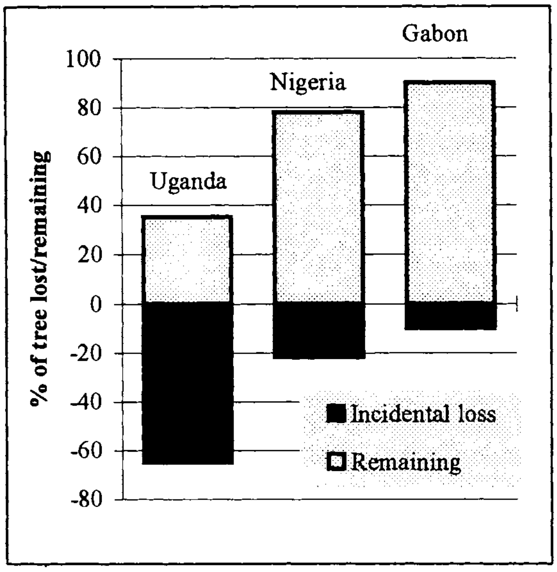

Figure 6.3. The proportion of trees >30 cm dbh remaining or damaged, following logging at an intensity of 1% in three African production forests. Data are from Johns (1985) for Uganda, from Redhead (1960) for Nigeria, and from White (1992) for Gabon.

Studies elsewhere suggest that a certain amount of canopy opening, whether by logging or other silvicultural treatments, can increase productivity and tree species diversity.

Thus the aim of good management need not necessarily be to minimise canopy opening, rather to optimise it. This is the theoretical basis behind many silvicultural operations in Ugandan natural forests. Figure 6.4 examines this phenomenon more closely, by looking at changes in productivity of forest recovering from differing intensities of logging in Indonesia.

The figure suggests that, whereas intensive logging results in forest degeneration (negative growth) (due to the growth of climbers, herbs and shrubs that suppress tree seedlings), light logging can indeed enhance growth. In this example, a logging intensity that destroyed 9% of the trees (a level similar to that recorded in the Gabon study above) resulted in a higher growth rate than one that only destroyed 4% of the trees (a level of disturbance perhaps more typical of many natural unlogged forests). But at logging intensities where 23%-76% of the trees were destroyed (similar to the Ugandan study above), forest degeneration resulted. In Kibale Forest, it was suggested by Skorupa and Kasenene (1983) that a logging intensity that resulted in a basal area reduction of 25% was about the maximum that would allow the forest to recover to its natural turnover rate within a few years. Above this, treefalls were found to continue well after logging at a rate several times the background rate for neighbouring unlogged forest. In other words, **high rates of logging precipitate long-term changes in forest dynamics.**

Table 6.1.
Effects of logging on vegetation in Kibale Forest, Uganda.
Data from Skorupa (1986) and Tabor, Johns and Kasenene (1990)

Variable	Unlogged	Lightly logged	Heavily logged
Total basal area (m^2/ha)	36	27	19
Total stem density (no./ha)	256	267	125
Large stem density (no./ha)	25	12	8
% canopy cover> 9 m	87	65	45
% canopy cover> 15 m	72	50	32
Average gap size (m^2)	256	467	1307
Tree species richness (av. no./100 stem sample)	26	23	18
Tree species density (av. no. in 20 5x50 m plots)	25	23	14
Seedling regeneration	Good	Good to fair	Poor

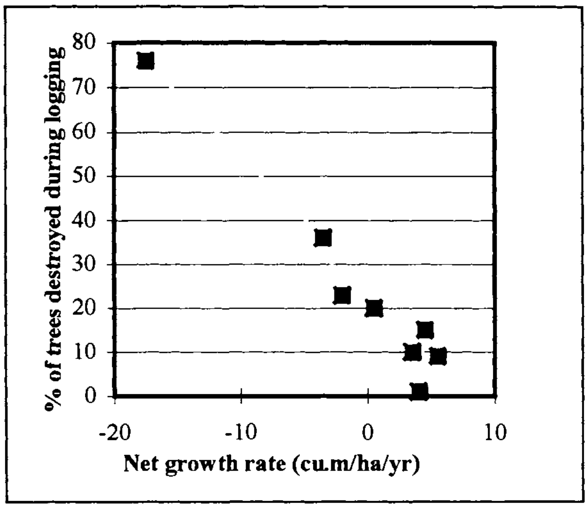

Figure 6.4. The effects of different levels of felling damage on subsequent growth of tropical forest, from a study in Indonesia. All points to the left of the zero on the horizontal axis indicate that forest degeneration is occurring. After Miller (1981).

Even if felling damage is not so great as to cause forest degeneration, the species composition of the forest may change greatly following logging or silvicultural treatments. In general, pioneer tree species (see Section 5.6.31) will be favoured in the resulting regeneration, while non-pioneer species will be disfavoured, at least for the first few years. This is demonstrated for a study of regeneration following logging in Ghana in Figure 6.5. In Budongo Forest, the "mixed forest" type has increased at the expense of "ironwood forest" over the past four decades, probably as a result of arboricide treatment and logging in the latter forest type (Plumptre et al., 1994). This was the main aim of silviculture in Budongo, although ironically it does not seem to have resulted in better mahogany regeneration.

Figure 6.6 compares the tree species composition of logged and unlogged areas in Kalinzu forest. The data-set suggests that logging can be good for some species but bad for others. In particular:

- Pioneer and "weed" species become more frequent; some of these are seemingly absent from unlogged plots.
- Climax species become less frequent, sometimes seemingly to the point of local extinction. Extinction seems particularly likely for species which are already rare in unlogged forest.
- The number of species or species-groups may change (e.g. a decrease from 48 to 42 at Kalinzu).

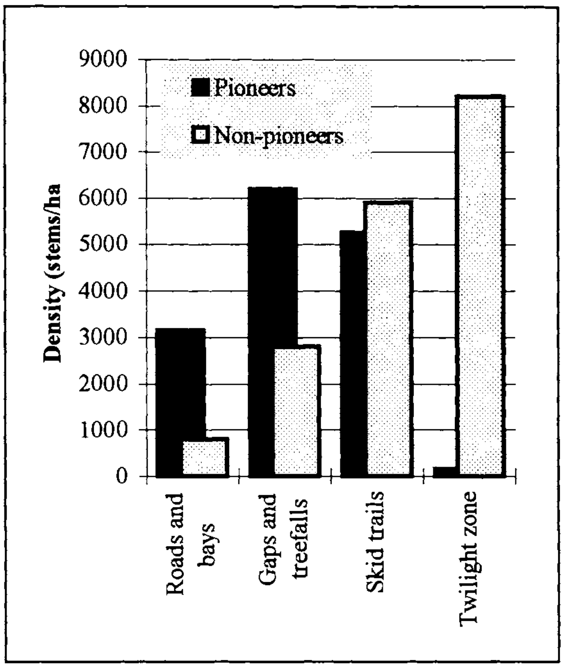

Figure 6.5. Density of regenerating pioneer and non-pioneer trees in different categories of forest in a logged area of Bia South Game Production Reserve, Ghana. After Hawthorne (1993) "Twilight zone" refers to the area of unlogged forest beyond the immediate influence of any of the preceding three categories. Regeneration of pioneers is greatly increased in categories affected by logging, and regeneration of non-pioneers suppressed.

When interpreting data such as these, it must be remembered that they are derived from plots rather than whole forests. This means that all the "extra" species that appear in logged forest have not appeared from nowhere, but must have always been present at low levels in the forest but were so rare (perhaps only occurring in occasional gaps or along the forest edge) that they were missed by the sampling process. This means that they are not of great conservation concern, as they can probably survive in a forest whether it is managed or not. The only situation in which they might risk being lost is if the forest reserve was unmanaged and very small, in which case there may not be sufficient gaps at any one time to support all the gap species (Johns, 1985).

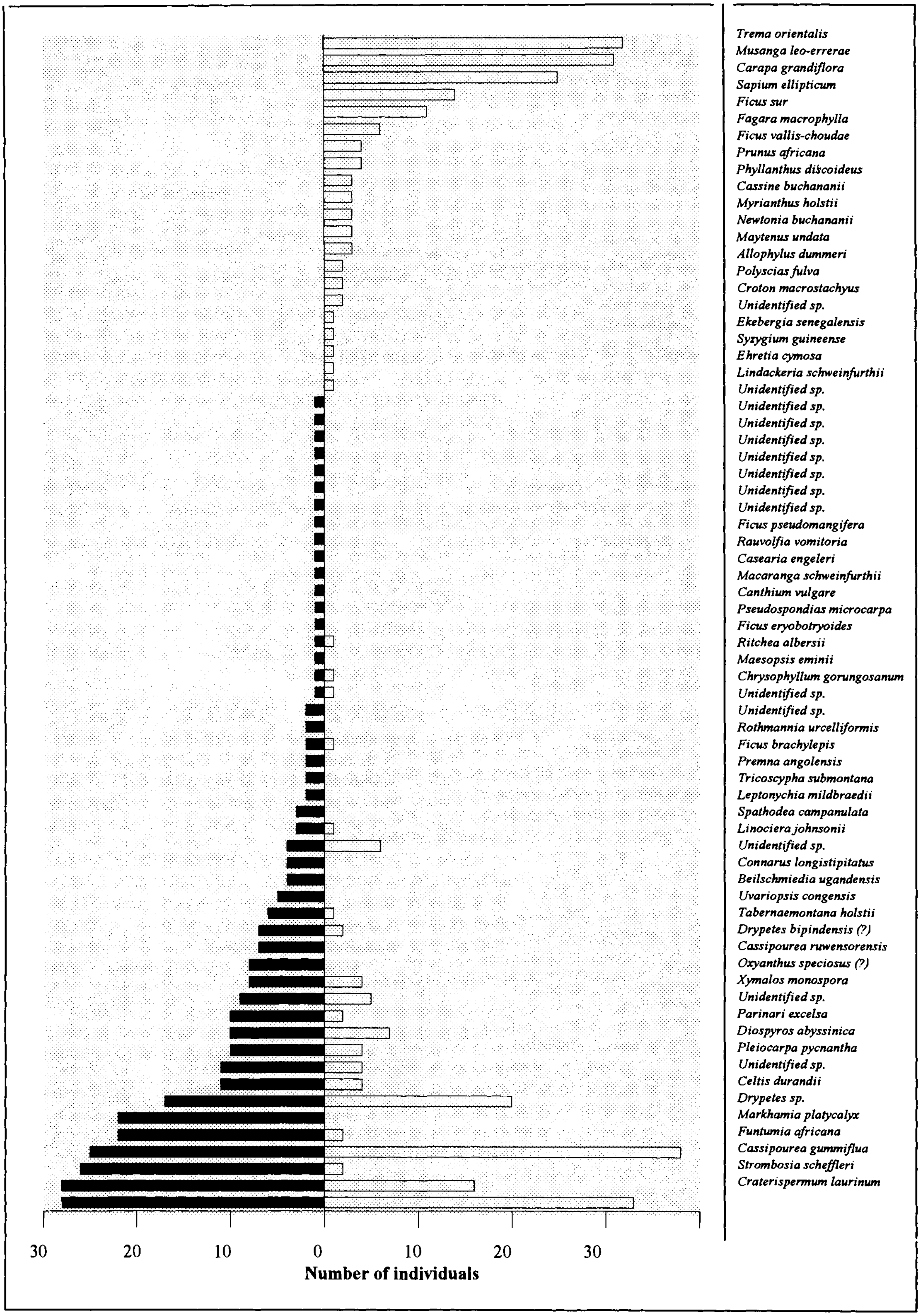

Figure 6.6. The number of trees of 69 species in 1 ha plots in adjacent areas of relatively undisturbed (left) and mechanically logged (right) Parinari *forest in Kalinzu Forest, Uganda. Data from Kisubi (1991).*

In a logged or otherwise disturbed forest, any truly additional species are likely to be either non-forest species that find temporary homes in clearings, or more worryingly, invasive exotic species (see Section 8.4), which benefit from the disturbance and may, in the long term, cause the extinction of many native species. In the forests of the East Usambaras, for example, Sheil (1994) notes that whereas undisturbed forest now harbours 19 species of naturalised exotic plants, disturbed forest and forest edge harbours almost double that number (36). He concludes that *"timber harvesting options that might [otherwise] be compatible with sound conservation are likely to be severely diminished by the presence of aggressive exotics"*. It is likely that the spread of the invasive exotic *Broussonetia papyrifera* in Budongo is enabled by forest disturbance associated with logging and pit sawing.

Regarding species that seem to disappear following logging, whilst it is possible that they may still exist at low densities in logged forest, they are still of greater conservation concern. It may be that, even if they can survive in logged forest for a generation or two, they may not persist for longer than this. For such species, many of which are likely to be slow-growing shade-tolerators, their main chances of survival are in undisturbed nature reserves.

The *"**intermediate disturbance hypothesis**"* (Connell, 1978), that states that species diversity within a given patch should be highest at intermediate frequencies or intensities of disturbance. But what is meant by "intermediate" varies from ecosystem to ecosystem, and from forest type to forest type. Natural forest management has most chance of being compatible with conservation of tree species if it is carried out at such a rate that gap creation mimics the natural disturbance regime of the forest in question, and does not exceed that rate too much (Denslow, 1980). If it does exceed the natural rate, then the forest will probably change in structure and composition: there will be some winners, but also losers. However, as Hobbs and Huenneke (1992) note, it is worth remembering that in most reserves, the "natural" disturbance regime is now unlikely to persist because reserves have become isolated or have lost certain species (such as elephants) that used to cause natural disturbance; thus a management decision that must be made is what disturbance level to maintain and how.

6.5 IMPACTS ON MAMMALS

6.5.1 Impacts on primates

Primates (monkeys, chimpanzees, gorillas, pottos and bush-babies) are important members of tropical forest ecosystems in Uganda. As well as forming a large and very visible biomass, many are also important as dispersers of tree seeds because of their often frugivorous diet. For many people, they are the very essence of a tropical forest. Partly for these reasons, primates have been well studied in many tropical forests, and there is a large amount of information concerning their conservation status and the impacts of forest management on their populations. In Uganda, long-term studies have been carried out at Budongo and Kibale Forests.

At Budongo, studies by Plumptre et al. (1994) have demonstrated that three out of the five species of diurnal (daytime-active) primates exist at statistically significantly higher densities in logged forest than in unlogged forest, as Figure 6.7 shows. The remaining two species occur at roughly similar densities in logged and unlogged forest. In Kibale forest, however, where there are seven native species of diurnal primates, studies (Skorupa, 1986; Johns and Skorupa, 1987) suggest that five species show a statistically significant decrease with logging, one (black-and-white colobus) shows a significant increase and one (blue monkey) seems relatively unaffected (Figure 6.8).

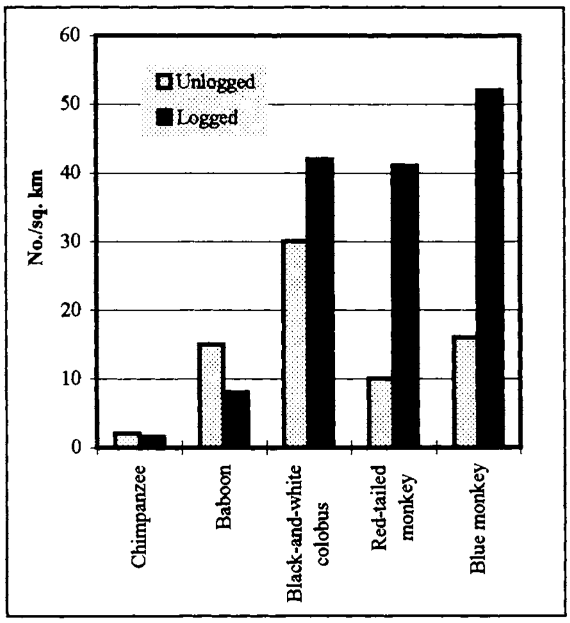

Figure 6.7. The impacts of logging on primates in Budongo Forest, Uganda. After Plumptre (1994).

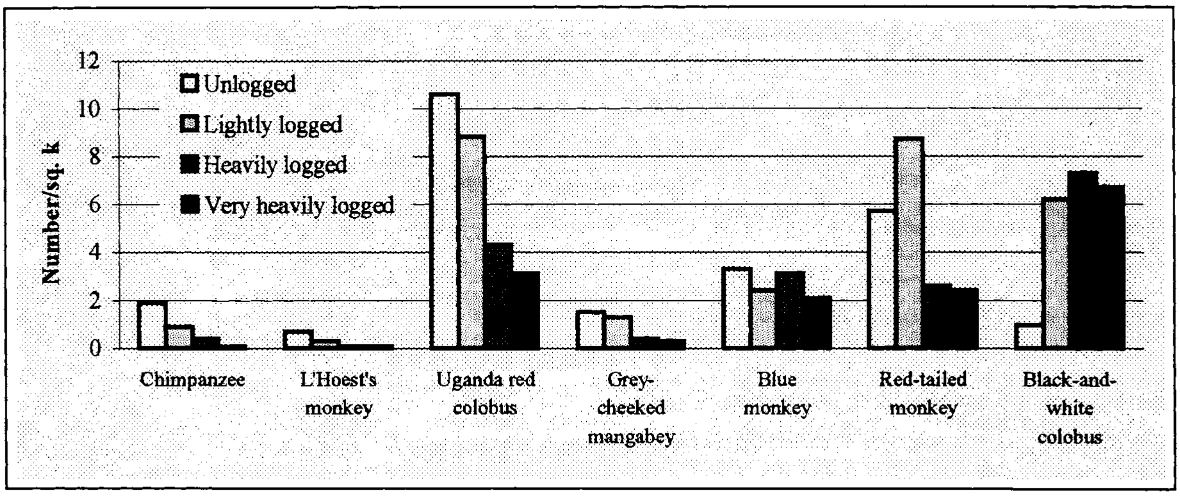

Figure 6.8. The impacts of different logging intensities on primates in Parinari*-dominated areas of Kibale Forest, Uganda. Lightly logged forest implies 25% loss of basal area and 20% loss of canopy cover. Heavily logged implies 45% loss of basal area. Very heavily logged implies 50% loss of basal area and >40% loss of canopy cover. All surveys were conducted 9 to 16 years after logging. After Skorupa (1986).*

Circumstantial evidence from Kalinzu Forest (Howard, 1991) suggests that all diurnal forest primates there are three to five times commoner in logged forest than in unlogged. It has been suggested that the main reason for the differences between Kalinzu and Kibale Forests is that one of the main colonising tree species in gaps created by logging in Kalinzu is *Musanga leo-errerae*, a species which has fruits that are much favoured by primates. This tree is not such a feature of gaps in Kibale Forest, where its place is taken by *Trema orientalis* (see Figure 6.7), a species that does not produce sought-after fruits.

In Budongo Forest, logging and silvicultural operations have tended to increase the area of mixed forest at the expense of ironwood forest. Mixed forest seems to be able to support higher densities of some primates than ironwood forest (Plumptre and Reynolds, 1994), because there are more fruiting trees of more species available year-round, especially figs (a common pattern in logged forest, Earl, 1992), and because production of young leaves (on which black-and-white colobus feed) is higher.

Looking further afield to other parts of Africa, recent studies in Gabon (White, 1992) suggest that whereas western lowland gorillas increase following logging (because they feed on herbaceous vegetation which also increases), chimpanzees decrease significantly, probably because the main fruiting trees that provide them with most of their food decrease. Lowland gorillas were also found to increase in logged forest in Cameroon (Blockhus et al., 1992), while mountain gorillas in Zaire also seem to benefit from limited tree-felling in their montane forest habitat (Murnyak, 1981). Meanwhile, Thomas (1991) showed that in the Ituri forest of eastern Zaire most primates occurred at higher densities in secondary forests; a similar pattern occurs on Tiwai island, Côte d'Ivoire (Oates et al., 1990). The main conclusions to be drawn from these studies are:

- Logging benefits some species (if increased population density can be said to be a benefit), while other species suffer.
- Whether a species benefits or not depends in part on its food preferences and whether these increase or decrease as a result of logging.
- The same management can have different impacts on primates in different forests.

It is worth noting, however, that the species in Budongo that seem to benefit from logging are all widespread primates under no threat of extinction. It may be that they are widespread for the very reason that they are tolerant of disturbances. In Kibale, however, the species that are adversely affected include several (L'hoest's monkey, Uganda red colobus and chimpanzee) that are rare or threatened (see Section 3.3).

6.5.2 Impacts on other mammals

Few other mammals have been as well studied as the primates. In Budongo Forest, preliminary findings suggest that ground-living rodent species richness is greater in unlogged forest than in logged forest (Musamali, pers. comm. 1994), while data for squirrels shows no clear pattern (Plumptre et al., 1994). In Kibale, heavily logged forest was found to contain more rodents and more rodent species than unlogged forest (Kasenene, 1980), and this was thought to be having harmful effects on tree seed and seedling survival. Bongos (a forest antelope) were found to increase in logged forest in Ghana (Blockhus, et al., 1992), and probably many other grazers and browsers will do likewise, assuming hunting pressure does not increase.

The case of elephants has been rather better documented in Uganda, because they were an unwelcome beneficiary of the Forest Department's silvicultural operations in Budongo. Earlier this century, Budongo was said to be the headquarters of a herd of elephants estimated at 5000 head (Swynnerton, 1924), of which perhaps 500 may have been a resident herd of the forest-dwelling subspecies (Langdale-Brown et al., 1964). Langdale-Brown et al. (1964) wrote that *"elephants are particularly fond of the succulent herbaceous tangle that springs up in accidental or man-made gaps, and will visit such places repeatedly, each time breaking off the tips of any young saplings, trampling down any seedlings, and assuring the perpetuation of this 'elephant climax tangle' "*. It is thus not surprising that the Forest Department sought to eliminate elephants from Budongo, as illustrated by this quotation from the second revision of the Budongo working plan (Trenaman, 1955), which had as one objective *"to nurture, **with the exception of the larger game**, specimens of the characteristic living communities in Budongo in their natural state"*. Even in 1970, elimination was still seen as the goal, as this quotation from Laws, et al. (1970) illustrates: *"the presence of elephant is incompatible with timber production...the only solution is the elimination and exclusion of elephants from the forest"*. Between 1925 and 1965, at least 15,000 elephants were shot in Bunyoro by the Game Department (Laws, et al., 1970), and by the 1980s they were effectively extinct in Budongo. Thus, although elephants could theoretically benefit from natural forest management, in practice in Budongo they certainly did not. In parts of West Africa, elephants could similarly benefit from logging, but are prevented from doing so by hunters that follow the logging roads deep into the forest.

6.6 IMPACTS ON BIRDS

Studies on birds are not as common as for trees or primates, and most studies have been carried out outside Africa. Preliminary findings in Budongo suggest that hornbills are significantly commoner in unlogged forest, and that forest recovering from logging in the 1950s or 60s is more favourable for hornbills than forest logged more recently (Plumptre et al., 1994). Other studies in Budongo (Owiunji, pers. comm. 1993) suggest that most, but not all, species of birds found in unlogged forest also occur in logged forest.

Figure 6.9 presents more comprehensive data from a study of forest in Amazonian French Guyana (Thiollay, 1992). In this study, many more species show a decline in abundance following logging rather than an increase, and this decline seems to persist at least ten years after the logging event. Species that were most severely affected were mostly those associated with the understorey of tall mature forest; less severely affected were species associated with the forest canopy or with small gaps and vine tangles. Small frugivorous birds, and birds associated with clearings or edges, generally increased.

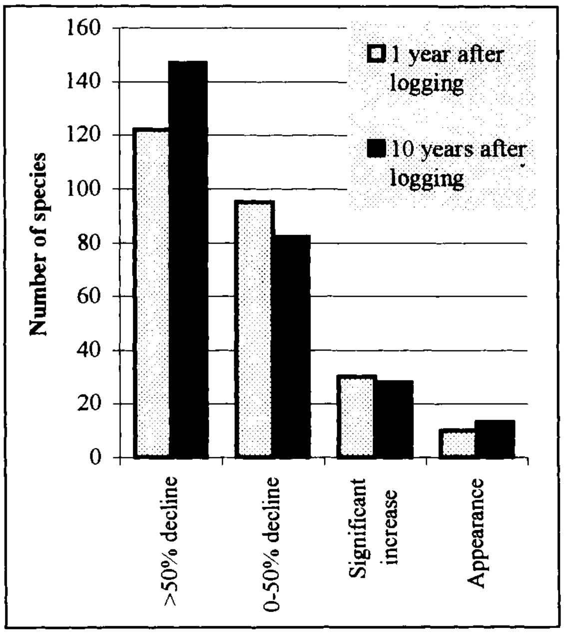

Figure 6.9. The impacts of logging on population density of forest birds in French Guyana, one year and ten years after logging. After Thiollay (1992).

Unfortunately the study has not been going on long enough to determine whether the declines are eventually reversed.

Two further studies that recorded declines in bird species richness are from West Malaysia (Johns, 1985) and Sabah (Payne and Davies, 1982). In the former, primary rainforest was found to support 195 species of bird while logged forest supported 122; in the latter the corresponding figures are 161 and 137.

As with other groups of organisms, the results of studies on birds show that it is not easy to generalise about the impacts of natural forest management. Some species may benefit, while others may lose out. From a conservation point of view, we need to be particularly concerned about any species that decline, particularly if this decline seems to be permanent or long-term. At the moment we do not have the data to show which species are affected this way in Uganda.

6.7 IMPACTS ON INVERTEBRATES

If studies on birds are scarce, then studies on invertebrates are positively rare. This rather undermines any conclusions that we may want to draw from the studies that exist for other groups, and is all the more alarming when it is remembered that about two out of every three species on the planet are insects and an even higher proportion are invertebrates (including insects). If we want to generalise about the effects of natural forest management on wildlife, we should not ignore the invertebrates (Johns, 1992).

Invertebrates number many millions of species, and it is impossible to generalise about the effects of any human activity on them. In tropical forest, many invertebrates may be indifferent to management, and many may benefit in a similar way to pioneer tree species or the more generalist primates. Moderate levels of forest disturbance seemed to have no effect on dung beetle assemblages in Kibale Forest, Uganda (Nummelin and Hanski, 1989) nor in forest in Sabah, Malaysia (Holloway et al., 1992). Similarly, species richness in leaf-litter ants in Ghana showed no significant differences between primary forest, secondary forest and cocoa farms (Belshaw and Bolton, 1993). However, in a study in Cameroon (Watt, unpubl. 1995.), leaf-litter ant species richness was higher in disturbed forest than in undisturbed, while butterflies showed the opposite trend, albeit weakly (Figure 6.10).

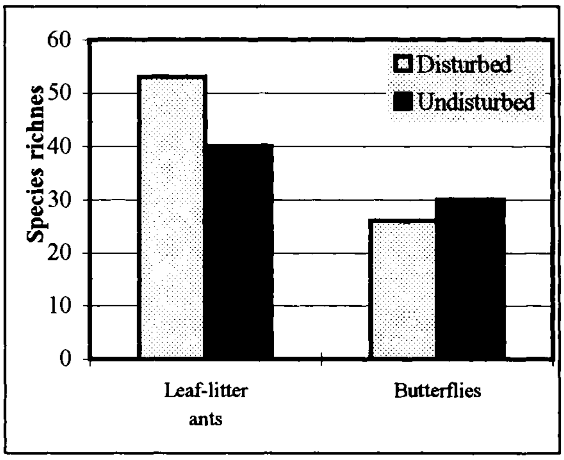

Figure 6.10. Species richness of leaf-litter ants and butterflies in experimentally disturbed and undisturbed forest in Ebogo, Mbalmayo Forest, Cameroon. From Watt (unpubl. 1995).

There is one guild of invertebrates that is most likely to be adversely affected by natural forest management, and this is the wood-feeding guild (saproxylics), which is probably the numerically most dominant guild in natural forest, at least in temperate zones. Saproxylic species (i.e. those associated with dead wood, see Section 5.5.41) are likely to suffer particularly if management progressively eliminates large old trees. Such trees are often termed "overmature" by foresters. A typical commercial forester's definition of an overmature tree is that given by Keay (1961):

- *trees which have become too large to be conveniently handled by the exploiter*
- *trees which are becoming more and more unsound*
- *trees which are no longer growing fast enough to earn an economic return*

This very negative view of overmature trees needs to be balanced by their immense importance for nature conservation, and a fourth definition might read:

- ***trees which, though old, are in their prime as habitat for a wide range of specialised species, particularly insects, other invertebrates, fungi and epiphytes***

Studies in the temperate forests consistently show that managed forests support far fewer species of saproxylics than unmanaged ones (Speight, 1989). Indeed, in Britain, where nearly all the forests are managed or have been in the past, at least 20 species of saproxylic beetles have become extinct since prehistoric times, and a further eight species are known to have become extinct in the last 200 years. At least 27 species of saproxylic insects have not been seen in Britain this century, including 13 not seen since 1950 (Warren and Key, 1989). Of the 150 woodland invertebrate species officially listed as threatened in Britain, 65% are thought to be threatened primarily by the removal of dead wood or old trees from forests (Hambler and Speight, 1995).

For the cool temperate boreal forests, where the usual management procedure is clear-felling followed by replanting or natural regeneration, the impacts on invertebrates are undoubtedly profound. In Finland, for example, it is estimated that 692 species of animal and plant are currently faced with extinction as a result of that country's forestry practices, which are theoretically among the best anywhere in this forest zone (Wright, 1995). Most of these species are likely to be invertebrates, many of them saproxylics. A similar situation exists in adjacent Sweden, where logging of old-growth forest threatens 200 forest-dwelling species of plants and animals with extinction, and a further 800 with decline. Again, most of these will be saproxylics (Taiga Rescue Network, 1992).

Given that for most groups studied, tropical forests are naturally far richer in species than temperate ones (see Section 2.3), it seems likely that long-term management of natural tropical forests for timber or firewood production could lead to the decline and perhaps extinction of hundreds or even thousands of species of saproxylic invertebrates. However, since there have been scarcely any studies on saproxylics, this conclusion remains conjectural. Support for it comes from a preliminary study by Collins (1980) who looked at termites (an important group including many saproxylic species) in Sarawak, and recorded over twice as many species in unlogged as in selectively logged forest, which itself was twice as rich in species as clear-felled forest (Figure 6.11).

However, a more recent experimental study in Cameroon (Eggleton et al., 1995) showed no consistent difference in termite species richness between essentially unlogged and old secondary (selectively cleared) tropical rainforest: if anything, the secondary forest supported more species. Even forest that had been heavily enriched thirty years previously through planting of *Terminalia ivorensis* was not significantly poorer in termite species. It was only once the forest was completely cleared (to make way for a plantation) that species richness dropped significantly, from around sixty species to around thirty.

Species diversity amongst the specifically wood-feeding guild actually seemed to be higher in old secondary forest compared to primary forest (figure 6.12). The authors speculate that this might be due to a superabundance of dead wood in disturbed forest, and further suggest that many termite species benefit from the gap-like conditions found in old secondary forest.

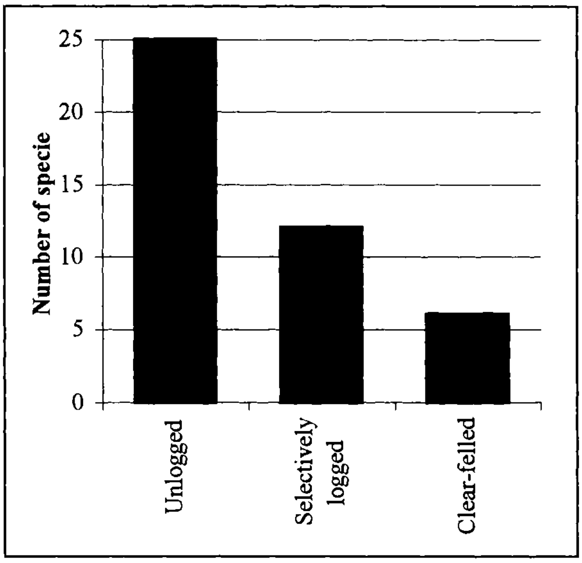

Figure 6.11. The number of termite species recorded in a day's collecting in unlogged, selectively logged and clear-felled forest in Malaysia. After Collins (1980).

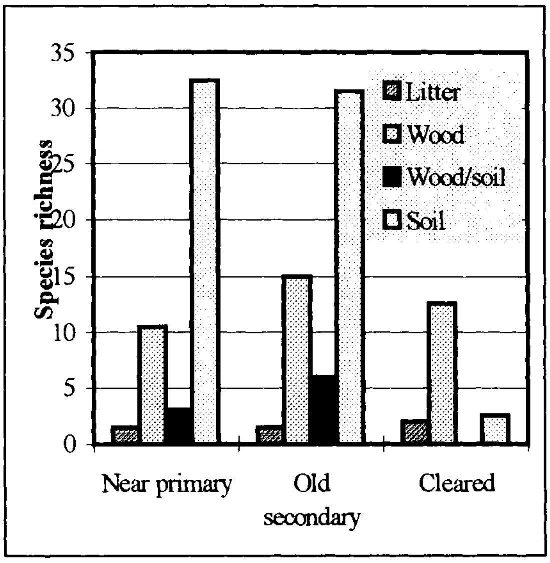

Figure 6.12. Differences in species richness amongst different feeding guilds of termites in undisturbed, disturbed and cleared forest in Mbalmayo Forest, Cameroon. After Eggleton et al. (1995).

What this or other short-term studies cannot show, however, is the **long-term** implications of forest management/disturbance. What would happen to the secondary forest if it was managed in such a way that it never regained the structure of primary forest? Will it always have a superabundance of dead wood, and a structure similar to the gaps found in primary forest, or will there be times when these conditions are not present? Would secondary or enriched forest still be able to support a full complement of species if there was no primary forest adjacent to it for colonisation? Would enriched forest continue to support so many species into the second, third and subsequent cycles of planting and harvesting?

Conclusions that can be drawn from insect studies to date are:

- As with other groups, some species will benefit while others will lose out, but the proportion of losers may well be higher than in better-studied groups.
- Declines and extinctions may be imperceptible over a single logging cycle, but may accumulate over many cycles and eventually lead to mass extinctions.
- Because of the degree of uncertainty due to lack of study, we should be cautious in extending findings from studies on other groups of animals or plants to invertebrates.

6.8 FOREST MANAGEMENT PRINCIPLES

Boxes 6.3 and 6.4 are guidelines that were drawn up by the International Tropical Timber Organisation (ITTO) and the World Conservation Union (IUCN) in 1982 to address biodiversity conservation issues in forests managed for timber production (Blockhus et al., 1992).

6.9 SUMMARY

- Natural forest management is based on the premise that manipulation of the forest can enhance its productivity for timber.
- In manipulating the forest, we alter its ecology in ways which may seem subtle to us as humans but which can be profound for some other species that depend on the forest.
- Some species are affected directly, and immediately, while others are affected indirectly and over a longer period.
- Some species benefit from natural forest management. Timber trees are meant to be the main beneficiary, but other species that favour the conditions created by natural forest management can also benefit. These species can normally continue to survive in managed forest.
- We know that other species do not benefit from natural forest management; many decline significantly and some may be driven to extinction. For this reason, we will always need protected areas where there is no human intervention.
- What we know about natural forest management so far enables us to be cautiously optimistic about its impacts on wildlife generally. However, it will only be successful if carried out carefully and if the results are monitored, and we should err on the side of caution because we still know very little about its effects on most species, especially in the long-term.

6.10 FURTHER READING

Blockhus, J.M., Dillenbeck, M., Sayer, J.A. and Wegge, P. 1992. *Conserving biological diversity in managed tropical forests.* IUCN, Gland.

Johns, A.D. 1992. Species conservation in managed tropical forests. In: Whitmore, T.C. and Sayer, J.A. *Tropical deforestation and species extinction.* Chapman and Hall, London.

Plumptre, A.J. and Reynolds, V. 1994. The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology*, Vol. 31: 631-641.

Box 6.3
Basic principles governing the relationship between natural forest management and the conservation of forest wildlife (Blockhus et al., 1992)

1. Any disturbance of a forest, natural or man-induced, will alter it as a habitat for animal and plant species. Small-scale disturbances may enhance structural, floristic and faunistic diversity. Large-scale disturbances tend to simplify the ecosystem and result in loss of biological diversity.

2. The management of forests for timber production requires modification of the natural ecosystem to increase the yield of commercial species. Inevitably, some of the original forest species are then lost. Total aerial biodiversity may remain similar as other species colonise but because the colonisers are common and widespread and the displaced species are old-growth specialists, many with restricted ranges, the net result is a qualitative change in diversity favouring generalist species at the expense of old-growth specialists.

3. Detailed information on the ecology of all forest species and on their response to disturbance is not available. The safest strategy for conserving biological diversity is therefore to establish large undisturbed protected areas covering representative samples of all forest types.

4. Few countries are able to allocate sufficient areas to total protection to guarantee the preservation of all animal and plant species and their intraspecific genetic variation. In most countries, totally protected areas do not exceed 4%-8% of national territory and individual areas are generally small. When species exist only in small isolated populations, they are susceptible to extinction caused by random environmental events and genetic deterioration. If natural forests are only retained in small isolated protected areas, then many species will inevitably be lost.

5. Forests managed for timber and/or non-timber products do provide habitats for many, in some cases the majority, of the plant and animal species found in pristine, unmanaged forests. The number of species persisting is dependent on a variety of factors, predominantly on the degree of intervention and modification of the original ecosystem. In some cases of low-intensity utilisation, forests may, at least in the short term, have greater diversity than undisturbed ecosystems. Species composition will have changed, however, and some rare or specialised species may be lost.

6. Even though managed forests do not provide the requirements of all pristine forest species, they have a particularly important role in providing a buffering function around protected areas. This will especially benefit wide-ranging species, that are often able to persist in large production forests while they cannot persist solely in small isolated national parks and reserves. Because production forests are an extension of total forest area, although of a modified form, they will allow the existence of larger population sizes of such species than would be expected in protected areas alone. Production forests as buffer zones around natural forests will further act to minimise a severe problem in small protected areas.

Box 6.4
Natural forest management principles for the conservation of forest wildlife (Blockhus et al., 1992)

1. Certain forestry practices maintain the biodiversity conservation value of managed forests. These include the use of selective systems which take out small numbers of trees per unit area on a regular basis. These are often, though not always, more conducive to biological diversity conservation and to sustaining the functioning of the ecosystem than systems under which a larger proportion of trees are removed simultaneously during logging. Minimum intervention systems are more likely to sustain both timber yields and biodiversity values.

2. Animal and plant species will recolonise logged forest much more rapidly if small areas of all forest types are protected as biological resource reserves or refugia (strict nature reserves). These should be in addition to forest areas that are inoperable for physical reasons, as these will usually represent different forest types.

3. Many animal and plant species are adapted to old-growth forests. The survival of these species is favoured if some areas of forest are managed on very long logging cycles. The value of areas of forest managed on long rotations will be greater if they are located so as to act as sources of colonists for intervening areas managed on shorter rotations.

4. Animal and plant species cannot survive for long in isolated fragments of forest. Small, isolated production forests and protected areas will have little value for biological diversity. The value for biological diversity of both categories of land will be greatly enhanced if they are located in large contiguous blocks. Internal zoning can be used to achieve the optimum balance between production and conservation objectives.