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Logging for the ark

Improving the conservation value of production forests in South East Asia

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Contents

Abstract

In order to maintain the high levels of biodiversity and the ecological functions of tropical forest landscapes in South East Asia, production forests need to be managed in a more sustainable way. Numerous initiatives already exist in the form of codes of practice, criteria and indicators, and certification schemes in the countries of South East Asia, but to date such guidelines and standards have been vague and have lacked quantitative targets. Reduced-impact logging (RIL) is a concept related to techniques and practices that aim to achieve environmentally sound timber harvesting; the concept has gained broad acceptance in the tropics. As yet, however, RIL guidelines have focused mainly on environmental aspects such as soil and water, and have taken the flora and fauna into account to a minor degree only. In this report, detailed recommendations are made to help forest managers take account of biodiversity conservation in dipterocarp logged-over and primary natural forests where mechanised logging is practised. The recommendations are based on those made in the CIFOR publication *Life after Logging,* further developed through three workshops held under a joint project between the Swedish University of Agricultural Sciences, CIFOR and the Forest Science Institute of Vietnam. The recommendations are linked to the different phases of the forestry cycle: i.e. planning (inventories of sensitive species and habitats, delimitation of set-aside areas and riparian buffers), infrastructure (logging camps, roads, bridges, skid-trails, landings), logging (retention of critical structures, micro-habitats, key resources, felling techniques, harvesting intensity, site-adaption), post-logging (understorey slashing, rehabilitation of log-landings and stream crossings, re-forestation), and monitoring (biodiversity inventories). Issues related to hunting, fire, invasive species, domestic animals, traffic, and logging and conservation for local people are also covered.

Introduction

Purpose and context

The recommendations made in this report aim to improve the conditions for biodiversity conservation in the selectively logged production forests of South East Asia, a region which is one of the most important hot spots for global flora and fauna and which is at the same time suffering from a very strong demand for timber. Selective logging is common practice in the natural forests of South East Asia. Under this system only a small proportion of the trees in a production forest are harvested, at more or less regular intervals, usually 20–40 years. Secondary managed forests, i.e. those that have been harvested at least once, are ecologically important components of current forest landscapes, and most will probably become even more significant in the future in view of the anticipated increased demand for wood products.

The report highlights the situation in Indonesia and Vietnam, mostly because of the long history of research activities in Indonesia and the funding opportunities in both countries, and, not least, because different types of forest management models and forest policy systems are found there, representative also of other countries in the region. Plantations, i.e. fast-growing and intensively tended forests of usually exotic species, are not discussed in this report, although many of the components and approaches suggested could also be transferred to such forests.

The recommendations are based on the assumption that quite small adjustments to day-to-day forestry activities will substantially benefit the flora and fauna of production forests. They are intended for the use of those who work with selective forestry on the ground, regardless of whether they are involved in planning, logging and maintenance, or follow-up activities. It is hoped that the practices suggested will eventually be used as a matter of course and integrated into manuals and guidelines for the management of South East Asia's forests.

Background

The need for sustainable forest management is clearly recognized throughout South East Asia as its tropical rainforests contain high levels of biodiversity and fulfil important ecological functions both locally and globally. At present, however, large-scale implementation of sustainable forest management (SFM) is not general practice. Deforestation rates are still high in many South East Asian countries. Illegal logging and habitat destruction continue to be a cause for concern, despite logging bans in a number of countries. However, some countries have made progress, and in the past 20 years there has been a marked increase in the number of instruments and tools designed to enable, lead to and achieve SFM. The initial impetus was provided by the Rio Earth Summit in 1992, which highlighted many problems in the forestry sector, particularly in the tropics where poor logging practices were leading to rapid deforestation and loss of biodiversity.

In South East Asia, instruments and tools for SFM are increasingly being used, both at the government level, as part of new forestry legislation, and at the forest management unit (FMU) level. Most of the tools and guidelines, such as Criteria and Indicators (C&I), Codes of Practice (CoPs) and reduced-impact logging (RIL), focus on improving silvicultural and operational aspects of forestry management, such as concession planning, directional felling, road design and waste management, but in terms of biodiversity only the primary effects of logging are addressed. Other tools, such as the Forest Stewardship Council (FSC) certification scheme, also address the primary impacts of logging on biodiversity, but their concern for High Conservation Values (HCVs) gives them additional value. However, although good in intention, few of these tools and guidelines address biological issues to the extent that is required to provide replicable guidance or steps on how to survey, monitor and retain species diversity in production forestry areas and the wider forested landscape (Meijaard *et al*. 2005; Meijaard and Sheil 2007a).

In Indonesia, scientists from the Center for International Forestry Research (CIFOR) and other research institutions in Borneo have published *Life after Logging* (Meijaard *et al*. 2005). This book synthesizes a vast amount of research in the area of wildlife and logging and provides a guide to biodiversity considerations

in logging concessions, including species-specific guidelines. An Indonesian-language version of the book has recently been published, and this makes its recommendations available to a much wider audience of practitioners (Meijaard *et al*. 2006a).

The management recommendations made in Life after Logging

Various activities led to the recommendations that were finally published in *Life after Logging*. The emphasis was on forest management practice and the potential to make it more compatible with wildlife (i.e. vertebrate) conservation. The reason for this is that plant conservation concepts remain poorly developed in this region, and most conservation agencies, as well as most conservation research programmes, have been wildlife oriented.

Initially, as part of a collaboration between the CIFOR and the Wildlife Conservation Society – Indonesia Program (WCS-Indonesia), existing data sets on the effects of logging on Bornean wildlife, especially those species that have been identified in the Malinau District of East Kalimantan, were gathered and evaluated.

All available literature (published and unpublished) on the relevant Bornean species was sought out and reviewed. Published and unpublished material was also sought through broad consultation with local and international experts. Opinions were also sought from these experts on why species were or were not sensitive to different types of interventions. The analysis included 280 publications and reports based on studies carried out in Borneo and a similar number of publications based on research carried out elsewhere in South East Asia, but with relevance to Bornean wildlife. Wider global literature was also considered when it appeared relevant.

Hunting, forest fragmentation and many other factors that are sometimes neglected as logging impacts were specifically taken into consideration. Based on this information, an overview of the sensitivity of Bornean wildlife to logging was obtained, providing a basis for interpreting the general ecological effects of selective logging on wildlife populations. This knowledge was translated into practical recommendations for forestry management. In addition, species-specific requirements, such as the availability of tree hollows or breeding habitats for amphibians, were analysed. Knowledge of these requirements, combined with an assessment of their relative importance for different species groups, made it possible to give specific management recommendations for the protection of these forest features.

The final list of recommendations has three principal origins: established elements of good practice drawn from the literature, recommendations derived from the review of wildlife sensitivities and a number of more speculative suggestions (e.g. on traffic) where there is a gap in the available literature. In some cases the recommendations draw on other aspects of our own research – several are derived from work with local people in Malinau, e.g. the recommendation to prevent unnecessary understorey slashing. In some cases our own judgement was used to choose between contradictory recommendations (e.g. 'roads should go around large trees' was considered to be less important than the idea that 'roads should be as short as possible').

Guidelines often require some kind of stated limits, especially within the framework of certification standards. Setting these limits reflects a compromise. Why fell only trees over 60 cm diameter (rather than perhaps 65 cm or 55 cm)? Or limit felling only on streams wider than 1 m, or on slopes of more than 50%? Many of the specific criteria proposed derive from the authors' judgement in consultation with those who work in forest management.

From Life after Logging *to the present document*

Parallel to the work on the *Life after Logging* publication, another project involving the Swedish University of Agricultural Sciences (SLU), CIFOR and the Forest Science Institute of Vietnam (FSIV), financed by the Swedish International Development Agency (SIDA), was being undertaken. The purpose of this project was to develop biodiversity-oriented guidelines for tropical forestry in South East Asia, focusing on Indonesia and Vietnam.

Because of the very large amount of work already undertaken on *Life after Logging*, and Indonesia's being relatively advanced in the field of logging codes, RIL and certification, as well as the scarcity of relevant information for Vietnam in the literature, it was decided that

the project should continue through a series of workshops, building on the *Life after Logging* recommendations and drawing on expert judgement from Indonesian and Vietnamese researchers and forest practitioners.

Three workshops were held, the first in March 2003 in Ho Chi Minh City, Vietnam. At this workshop, biodiversity scientists and forest practitioners from Vietnam, Indonesia, CIFOR and SLU discussed factors of importance to biodiversity in tropical forests, e.g. habitats, structures, stand and landscape factors. At the second workshop, held in February 2004 at CIFOR headquarters in Bogor, Indonesia, attended by some of the biodiversity scientists from the first workshop and Indonesian forest practitioners, this knowledge was translated into an example of practical guidelines for more biodiversity-friendly tropical forestry. At the third workshop, held in January 2006 in Hanoi, Vietnam, a subset of the recommendations drafted after the Bogor workshop was discussed by representatives of government organisations, forest enterprises, NGOs and scientific institutions.

A compilation and analysis of current biodiversity guidelines for sustainable forest management in South East Asia was also carried out, as part of the SIDA project, (Dennis *et al*. 2007); this shows how many of the recommendations presented in this document are relevant outside Indonesia or Vietnam.

The recommendations and guidelines – the core of the present paper – are the results of both projects: the CIFOR publication *Life after Logging* (Meijaard *et al*. 2005) and the SIDA-financed project. The recommendations build on those presented in *Life after Logging* but are further developed and examples are given for Indonesia and Vietnam. Nevertheless, we consider these recommendations valid for a large part of South East Asia. Some recommendations were dropped because they were considered not useful or practical by most of the practitioners consulted. Other recommendations were added because they are linked to major forest management certification schemes.

The final list...

In some senses the list of recommendations is a 'wish list', but it is a pragmatic list, based on validation by forest practitioners. Some recommendations may be costly, but many are not. A brief outline of the ideas and arguments behind each guideline is provided and we encourage each of the recommendations to be challenged or improved upon in circumstances in which they are inappropriate or when ideas and understanding change. More review and data gathering will always be needed, regulations can always be improved or adapted, and the details of any change could be argued *ad nauseam*, but what is bad for wildlife and what can and should be done about it is already known.

Some recommendations that were considered not useful or totally impractical have been dropped. This remains a point of discomfort for us, as what might appear unwieldy and impractical in some cases can turn out to be easier and more useful than anticipated. For example, the proposition that concession holders should prepare and improve nesting holes to benefit hornbills may sound far fetched, but a recent report from Thailand shows that it can be done, and that it does benefit hornbills (Poonswad *et al*. 2004).

Forests in focus

The recommendations are directed towards natural forests and the focus is on logged-over and primary forests with mechanised logging as the main forest operation method. Hill dipterocarp forests (Indonesia) and evergreen moist forests (Vietnam) are the main target forest types. However, many of the proposed measures are general and applicable to a wider range of forest types.

Forestry systems and users of the recommendations

Logging intensities and forestry practices vary greatly among South East Asian countries, from very large concessions in Indonesia and Malaysia with large-scale harvest operations and a high degree of mechanisation to small forest holdings with low-intensity use and usually considerably less advanced technologies in, for example, Vietnam, Myanmar and Cambodia. The area of primary forests has been decreasing rapidly for many years, leaving behind areas with secondary forests in different stages of regeneration and with different degrees of tree cover. In all, there are hundreds of millions of hectares in the region covered by forests that are being or that in the future will be harvested using

mechanised logging operations. These forest landscapes are invaluable to the rich and unique biodiversity in this part of the world. The significance of the flora and fauna would be enhanced if forestry were more carefully planned, prepared and carried out. Thus, the ultimate goal of the recommendations is to contribute to future forest landscapes with high species richness and viable populations of plants and animals, and at the same time provide for efficient and sustainable timber extraction.

The recommendations were based originally on insights gained into ecological conditions gained on Borneo, results of the work carried out to produce *Life after Logging*, and in this version they were most directly applicable to Indonesian (and Malaysian) forestry on Borneo. Through the funding received to undertake a joint project involving Sweden, CIFOR and another country in South East Asia, it was possible to include Vietnam, which was chosen because of the contrast between concession practices there and those on Borneo. Thus, the hope is that the recommendations might be useful not only to concessions holders but also to the wide range of foresters in the countries of South East Asia.

A brief history of logging in the tropics

Until the end of World War II, logging operations in tropical forests were for the most part unmechanized, relying largely on human and animal power. As such, they involved only small areas of forest and had little impact on the resource. Nevertheless, some of the best early work on management of tropical forests emphasized the importance of careful logging to protect future crop trees. An example of this is the management system for teak developed by Sir Dietrich Brandis in Burma (Dawkins and Philip 1998) during the second half of the nineteenth century.

Beginning in the 1950s, industrial logging of tropical forests became widespread as the worldwide demand for timber increased dramatically as a result of rapid postwar economic expansion. Mechanized logging technologies developed in the industrialized countries were quickly introduced into the tropics, and both the scale and intensity of operations changed substantially. Tropical foresters began to recognize that many industrial logging operations were leaving forests in a seriously degraded condition (e.g. Dawkins 1958; Nicholson 1958; Redhead 1960; Wyatt-Smith and Foenander 1962; Fox 1968). Some authors, most notably Dawkins (1958), went so far as to suggest that selective harvesting of moist tropical forest might be incompatible with the goal of sustained-yield management because of the excessive damage to residual vegetation that resulted from mechanized logging. At the same time, other tropical foresters (e.g. Bruenig 1957) had begun to develop and test prescriptions for mechanized logging that would minimize damage to residual vegetation and soils and thus foster sustained-yield forest management. Even so, comparisons over time by authors such as Fox (1968), Nicholson (1979), Ewel and Conde (1980), Marn and Jonkers (1982), Estève (1983), DeBonis (1986), Jonkers (1987), Hendrison (1989) and Bruijnzeel and Critchley (1994) suggested that as increasingly powerful machinery was being introduced into tropical forests the scale of damage to soils and residual vegetation was rising proportionally.

By 1992, when the UN Conference on Environment and Development convened in Rio de Janeiro, it had become clear that at least in some instances the mechanization of logging operations in the tropics posed a serious threat to the long-term sustainability of the resource, particularly if impacts on non-timber values were added to the equation (Dykstra and Heinrich 1992). Around the same time, the first publications were beginning to appear in which the term 'reduced-impact logging' was used (e.g. Putz and Pinard 1993). Somehow this term and its acronym, RIL, proved more broadly acceptable than 'environmentally sound timber harvesting', an alternative that was being promoted by the UN Food and Agriculture Organization (FAO) Forestry Department (e.g. Dykstra and Heinrich 1992). The Tropical Forest Foundation introduced the related term 'low-impact logging', but this was not generally adopted by environmentalists who seemed to feel that 'low-impact' and 'logging' were mutually exclusive terms. The more neutral term 'reduced-impact logging' (RIL) was quickly picked up and widely used, both in technical articles and in news releases. The concept of forest management technologies that reduce logging impacts appeared to resonate not only with foresters but also with the general public

and perhaps most importantly with influential environmental organizations such as WWF and the World Conservation Union (IUCN). As a consequence, RIL gained a legitimacy that foresters themselves could never have provided.

Also around this time, a concerted effort was underway on a variety of levels to assess the effectiveness of tropical forest management and to develop and implement guidelines to improve management practices. Influential publications stemming from this activity included Poore *et al*. (1989), ITTO (1990), Poore and Sayer (1990), FAO (1993a) and FSC (1994, revised 2000). Building on these efforts, a number of initiatives were undertaken to develop CoPs for logging in tropical forests. Many of these CoPs borrowed heavily from guidelines developed for Australian tropical forests during the 1970s and 1980s (Queensland Forest Service undated; Ward and Kanowski 1985). An early effort was the *Fiji National Code of Logging Practice* (Fiji Ministry of Forestry 1990), developed with assistance from the International Labour Office. By 1996, FAO had published a 'model' code of forest harvesting practice (Dykstra and Heinrich 1996), and this spurred a large number of efforts by tropical countries to develop their own CoPs, often with assistance from FAO, the International Tropical Timber Organization (ITTO), the European Union, or bilateral development-assistance agencies such as the German Agency for Technical Co-operation (GTZ), USAID (United States), Australian AID, French Cooperation, DFID (United Kingdom), and others. FAO's Regional Office for Asia and the Pacific subsequently worked with its member governments to develop the *Code of Practice for Forest Harvesting in Asia-Pacific* (FAO 1999) and is also assisting with the development of national CoPs as extensions to the regional CoP.

To a large extent, the RIL technologies that are being promoted for adoption in tropical forests have been developed in temperate forests and are utilized as a matter of common practice there. In this sense they represent nothing new. Because of the differences between tropical and temperate forests, however, many of these practices require significant adjustment in order to be economically and technically viable in the tropics. Also, protection of non-timber values in areas where local populations utilize non-timber forest products requires considerable evaluation and planning. Although it varies somewhat with the local situation, RIL in tropical forests generally requires the following (see, for example, Sist *et al*. 1998):

- Pre-harvest inventory and mapping of individual crop trees;
- Pre-harvest planning of roads, skid trails and landings to provide access to the harvest area and to the individual trees scheduled for harvest while minimizing soil disturbance and protecting streams and waterways with appropriate crossings;
- Pre-harvest vine cutting in areas where vines bridge tree crowns;
- The use of appropriate felling and bucking techniques, including directional felling, cutting stumps low to the ground to avoid waste, and optimal crosscutting of tree stems into logs in a way that will maximize the recovery of useful wood;
- Construction of roads, landings and skid trails so that they adhere to engineering and environmental design guidelines;
- The winching of logs to planned skid trails and ensuring that skidding machines remain on the skid trails at all times;
- Where feasible, the use of yarding systems that protect soils and residual vegetation by suspending logs above the ground;
- The conduct of a post-harvest assessment in order to provide feedback to the concession holder and logging crews and to evaluate the degree to which RIL guidelines have been successfully applied.

Why do biodiversity considerations matter when logging tropical forests?

Tropical forests are the most biodiverse terrestrial ecosystems on earth. It is estimated that tropical forests originally covered 6–7% of the global land area and supported 50% of all plant and animal species (Primack and Corlett 2005). South East Asia is exceptional both for hosting 4 of the 25 global biodiversity hotspots (i.e. areas with very high proportions of endemic species) – Indo-Burma, Sundaland, Wallacea and the Philippines – which cover the whole region (Myers *et al*. 2000) and also for its very high rate of forest habitat loss (Sodhi and Brook 2006). South East Asia has already lost the majority of its original vegetation and unfortunately this process is continuing. In the four hotspots that cover the whole of

South East Asia, only 3% of primary vegetation remains in the Philippines, 5% in Indo-Burma, 8% in Sundaland and 15% in Wallacea (Primack and Corlett 2005).

There are several reasons why this ongoing erosion should be halted and why plants and animal species should be saved for the future. First, they represent an irreplaceable resource for humanity, providing the foods, medicines and raw materials necessary to sustain life. Second, access to a rich natural world and a diversity of species is a quality of life that adds to human harmony and wellbeing. It is a source of inspiration for art, music and other cultural forms. Third, many people agree that plants and animals are in need of respect since they are forms of life and there is no way to recreate a lost species.

The traditional method of preserving biodiversity in tropical forests has been to set aside areas for conservation and, according to FAO statistics, about 11% of the world's forest area is in protected areas as classified by IUCN; in South and South East Asia, this proportion is close to 20% (FAO 2005). Strictly protected areas are never likely to be large enough to conserve all species (Fimbel *et al*. 2001), and many of the existing protected areas (e.g. in Sumatra or Borneo) are illegally logged or encroached by cash crops, thereby losing their original biodiversity value (Curran *et al*. 2004). Forest areas maintained for timber production represent therefore an opportunity for biodiversity conservation if protected for alternative land uses (Meijaard and Sheil 2007b, also see Asner *et al*. 2006 for a discussion of what happens when this does not occur), both because a large part of the populations of forest species inevitably depend on the composition and dynamics of such forests and because properly managed production forests also play an important role in supporting and connecting protected areas.

There are already promising examples of forestry guidelines in South East Asia in which consideration is given to environmental conditions (e.g. Klassen 2005). Nevertheless, there is a need to further develop these guidelines for biodiversity. Actual 'best practices' appear insufficient to ensure that logging damage to forest biodiversity is adequately minimised because they largely ignore recent advances in conservation biology and ecological research. Although research sometimes seems to fail in targeting, analysing and solving important conservation problems (Meijaard and Sheil 2007c), in the disciplines of ecology and conservation biology there are several concepts and theories of fundamental importance to the understanding of tropical forest biodiversity and its preservation (see Appendix 1 for a description of and discussion about some conservation biology concepts and theories).

It is vital that knowledge of ecological conditions and interactions is taken into account when environmental guidelines for forestry are formulated (Lindenmayer *et al*. 2006). Doubtless there remains a very great deal to discover and reveal regarding the biodiversity of the tropical rainforests. However, there is already adequate knowledge for high-quality biodiversity guidelines and advice to be formulated. Optimally, such guidelines should be integrated into and be an clear part of the instructions that cover each step in the forestry cycle: planning, logging, maintenance and follow-ups.

Instruments for Sustainable Forest Management

A number of international organizations have provided the impetus for the development and adoption of improved national codes of practice (CoPs) for timber harvesting and forest unit management across South East Asia. Some of these CoPs contain biodiversity guidelines. Foremost amongst these organizations is the Food and Agriculture Organization of the United Nations (FAO), through its regional office in Bangkok, which has been pivotal in supporting national CoPs through the Asia-Pacific Forestry Commission (APFC)[1] (FAO 1999). The International Tropical Timber Organization (ITTO) has also been active since the early 1990s in promoting C&I for sustainable forest management.

[1] The APFC provides extensive support to countries in the region by developing regional guidelines for best management practices and by building capacity for the implementation of these guidelines at the national and local levels.

Codes of Practice

The APFC has taken a leadership role in supporting the formulation of COPs for forest harvesting in the region. The principal effort focused on the development and implementation of a regional *Code of Practice for Forest Harvesting in Asia-Pacific* (FAO 1999). This CoP provides practical guidance for moving toward sustainable forest management, with particular emphasis on timber harvesting in natural forests. Associated activities have included awareness raising, garnering of political support, information exchange, training, and development and implementation of national CoPs. Most major timber harvesting countries in the region have developed, or are working towards, the establishment of national COPs and the application of reduced-impact logging (RIL). Political support for the process was enhanced by formal Association of South East Asian Nations (ASEAN) endorsement of a Regional CoP in 2001.

Forest management CoPs are usually developed within the context of umbrella legislation that enables the establishment of rules, standards, and a planning, approval and permitting system. CoPs are generally formulated at three levels. The first level is a set of national rules or regulations, linked to forest legislation, setting broad management direction and laying out those forest management practices that apply nationwide. The second level is a set of legal forest standards for each major forest zone, establishing long-term forest and ecosystem management objectives for the zone and the nature and rates of acceptable use. Both rules and standards are legally enforceable mandatory requirements. The third level of a CoP is generally a set of planning and operational guidelines providing direction to the forest management unit (FMU) or concession planning process.

A recent appraisal of the CoP uptake in ASEAN countries shows that development and implementation have not yet been universally successful across the region, for a number of reasons including the fact that national CoPs have not been sufficiently flexible to cater to differences in local physical and social conditions, and because in several countries political instability, weak law enforcement, illegal logging and trade, and the increased demand from wood-processing industries have hampered the implementation of national CoPs (Asia-Pacific Forestry Commission 2006). To date, only four ASEAN countries have produced a national CoP: Cambodia (1999), Indonesia (2000), Myanmar (2000) and Lao PDR (2005). Vietnam is currently developing national CoPs for forests and plantations respectively (Asia-Pacific Forestry Commission 2006).

The stated aim of the Indonesian CoP, *Principles and Practices for Forest Harvesting in Indonesia,* for example, is to provide guidelines or regulations on harvesting timber in natural production forests (Ministry of Forestry of Indonesia 2000). *Principles and Practices for Forest Harvesting in Indonesia* concentrates on 'what should be done' rather than 'how to do the work'. The 'how to' is the mechanism by which the actions described in the document are actually implemented in the field and involves, for example, RIL guidelines and silvicultural prescriptions for various forest types. The *Principles and Practices for Forest Harvesting in Indonesia* should be implemented by: (1) developing Guidelines for Implementing Reduced Environmental Impact Logging (RIL); (2) providing training for all those to be involved, from manager to machine operator; and (3) managing effectively in order to: maintain future resource-use options, maintain biodiversity and regeneration processes, and ensure that economic returns are maximized while protecting environmental and social values.

Using the Indonesian CoP as an example it can be seen that there is reference to ecological and biodiversity aspects. Under 'Operational Planning' there is a discussion about identifying areas within production forests that should be excluded from harvesting because of their (ecologically) sensitive nature. The guidelines stress the importance of maintaining biodiversity and soil and water quality, and that conservation of biodiversity is dependent on the maintenance of habitat, enhancement of opportunities for re-colonization of logged-over areas and by linking areas excluded from harvesting to allow genetic interchange. This may be achieved by:

- setting aside reserves within production areas large enough to maintain viable populations of plants and animals;
- retaining areas of unlogged forest in order to maintain habitat diversity. These areas should connect patches of forest as corridors which will not be logged;

- retaining habitat trees for wildlife in production areas where appropriate;
- protecting rare and endangered species and communities in production areas by modifying harvesting regimes or maintaining sections of unlogged forest;
- securing representation of forest types to be adequately preserved in conservation forests;
- creating databases on the distribution of plants and animal species within forest areas; this is also useful for benchmarking purposes.

Exclusion areas are areas excluded from harvest. Exclusion areas may be declared protected areas under any national or provincial statutes; areas of cultural importance; declared areas of ecological or scientific importance; areas that exceed specified altitude or slope limits; and areas specified under legislation or regulations for local community land use practices, including the protection of village/town water supply catchments.

In the CoP for Indonesia the primary effects of logging on biodiversity are addressed to a certain extent, but the secondary effects are not.

Primary effects include but are not limited to:
- direct destruction of species or their habitat that occur in, on or under harvested trees;
- a reduction in food resources resulting from the removal of biomass;
- fragmentation of once-contiguous forest landscapes;
- disturbance;
- canopy fragmentation; and
- damming of rivers and streams.

Secondary effects include
- increased hunting pressure in concessions as a result of improved access to remote parts of the forest and better links between forests and markets, as well as the presence of more people in the forest;
- increased run off leading to river siltation; and
- increased soil compaction and erosion.

Thus, the CoP addresses wildlife issues in general terms but falls short in translating these into clear practical guidelines on how to address biodiversity issues in timber concessions. It does, however, provide a basis for governments to define specific forestry regulations regarding specific aspects of biodiversity management in concessions.

Criteria and Indicators

One of the key global strategies for the promotion of sustainable forest management (SFM) is to develop and implement C&I for SFM as a means of benchmarking and measuring progress towards specific and holistic objectives. Within the Asia-Pacific region this process is well established in a number of countries. The ITTO pioneered the development of criteria for SFM, with its member countries endorsing ITTO Criteria for Sustainable Tropical Forest Management in 1992. The ITTO C&I principles and indicators were used as the basis for the Malaysian and Indonesian forest certification schemes, and used in the initial development of the Forest Stewardship Council (FSC) principles and criteria (Bennett 2004).

In 2006, IUCN (the World Conservation Union) produced draft guidelines which were intended to update and replace the 1993 ITTO Guidelines for the Conservation of Biological Diversity in Tropical Production Forests (ITTO 1993; IUCN 2006). The production of these updated guidelines by IUCN coincided with the production of ITTO's own updated C&I (ITTO 2005). The 2006 IUCN guidelines are intended to complement other ITTO guidelines covering different aspects of the management of tropical forests. However, they relate only to the ITTO guidelines that were produced between 1998 and 2002, and thus these IUCN guidelines do not yet take into account changes that appear in the 2005 ITTO guidelines. The two sets of guidelines are largely complementary. The difference, according to IUCN (2006), is that 'existing ITTO Guidelines aim to promote the overall improvement of the management of natural tropical forests, plantations, restored and rehabilitated forests and fire prone forests and they all address issues of importance for biodiversity conservation. However, they do not specifically focus on biodiversity. The present Guidelines are therefore intended to bring together in one place those specific actions that are needed to improve biodiversity conservation in tropical production forests.' Table 1 compares the ITTO and IUCN biodiversity guidelines against the biodiversity recommendations made in *Life after Logging* (Meijaard *et al*. 2005).

Table 1. ITTO C&I for Biodiversity and IUCN Biodiversity Guidelines compared with *Life after Logging* biodiversity guidelines (Meijaard *et al.* 2005)

Recommendations/aspects to be considered by concessions	*Life after Logging*	*ITTO C&I for Biodiversity 1993 & 2006*	*IUCN Biodiversity Guidelines 2006*
Planning before logging			
Survey and impact assessment	Yes	Yes	Yes
Conservation planning	Yes	Yes	Yes
Operational planning	Yes	Yes	Yes
Maintaining landscape connectivity and watershed protection	Yes	Yes	Yes
Minimising damage during logging and related operations			
Roads and infrastructure	Yes	No	Yes
Protecting reserved areas	Yes	Yes	Yes
Minimizing damage in production areas	Yes	Yes	Yes
Maintaining habitat complexity and diversity	Yes	Yes	Yes
Keeping keystone resources	Yes	Yes	No
Post-logging operations	Yes	No	Yes
Minimising indirect impacts and threats			
Hunting and extraction	Yes	No	Yes
Fire	Yes	No	Yes
Exotic and invasive species	Yes	No	No
Domestic animals	Yes	No	No
Traffic	Yes	No	No
Pollution	Yes	No	No
Logging and conservation for local people			
Develop forest practices that honour local rights	Yes	Yes	Yes
Implementation and vigilance			
Monitoring	Yes	Yes	Yes
Legal aspects, and implementation and control	Yes	Yes	Yes
Awareness and training	Yes	Yes	Yes
Species-specific suggestions			
Provide management recommendation on a species-by-species basis	Yes	No	No
Recommendations for government planning			
The need for a wildlife master plan	Yes	No	Yes
Land tenure agreement	Yes	Yes	Yes
Fragmentation	Yes	Yes	Yes
Hunting and fishing	Yes	No	Yes
Law enforcement	Yes	No	Yes
Effective implementation	Yes	Yes	Yes

Criterion 5 of the ITTO 2005 C&I deals with biological diversity. Under this criterion there is specific mention of procedures for biodiversity conservation in tropical production forests: 'Management measures in production forests can make an important contribution to the conservation of biodiversity by contributing to forest quality and making conservation in neighbouring protected areas more effective.' The document refers to detailed guidelines incorporated in recommended actions 8–17 of the ITTO Policy Development Series No 5 (ITTO 1993), which were produced in 1993. These guidelines, however, are phrased in relatively general terms. Many of the guidelines have by now been incorporated into national forest management guidelines, at least in those countries were such guidelines exist (see specific country sections (Appendix 2) for details).

The IUCN 2006 guidelines focus on measures that favour biodiversity. They are based on the recognition that there is no 'single best way' of managing forests. IUCN uses 'Ecosystem Approach Principles' as adopted by the Convention on Biodiversity in 2000, which state that all situations are different and that there are multiple ways of managing forests, all of which can be considered sustainable and all of which have impacts on biodiversity. The Ecosystem Approach Principles themselves take as their starting point the notion that biodiversity conservation approaches have to be a matter of societal choice and that decisions should be devolved to local stakeholders to the extent that this is possible. It is for these reasons that in developing the guidelines IUCN has attempted to distinguish two levels of intervention: 1. General approaches to forest management that will have wide application in ensuring that biodiversity values are maintained and should be universally adopted, and 2. A much broader set of technical suggestions that managers and decision makers might draw upon in designing locally applicable guidelines, CoPs, regulations and silvicultural practices.

The IUCN Principles, Guidelines and Recommended Actions (IUCN 2006) specifically assign the main responsibility for any of their recommended actions as follows: (1) government forest and environment agencies, (2) specialized biodiversity organizations, international NGOs, research institutes etc., (3) local NGOs, civil society and community organizations, (4) forest managers, concessionaires etc., and (5) educational and technical training institutions. This is helpful as it allows the development of clear plans with responsibility assigned to those institutions that are most capable or likely to address the recommended actions. Unfortunately, although the recommended actions are fairly detailed, many of them are phrased in rather vague terms and leave potential users with the question of how these actions should be implemented. The guidelines therefore fall short of their goal to provide technical suggestions to managers and decision makers that would allow them to develop locally applicable management regulations. It would be useful to combine the more detailed recommendations provided by Meijaard *et al*. (2005) with the broader IUCN guidelines where there are gaps in specific management recommendations. Unfortunately, concession managers and policy developers are unlikely to develop specific regulations unless these are spelled out in detail by another entity. For instance, a (hypothetical) guideline 'to minimize the barrier functions of roads to animal dispersal' could be significantly strengthened by stipulating that 'main roads should have narrow sections every 50 m where road width is a maximum 7.5 m and tree canopies meet overhead'. The development of such detailed guidelines requires collaboration between forest practitioners ('Is such a regulation feasible and safe?'), researchers ('Would such a regulation indeed benefit animal dispersal?'), and government ('Would the government be willing to translate the recommendation into legislation?').

Overall, the IUCN Principles, Guidelines and Recommended Actions (IUCN 2006) are complete and provide a good basis for developing more specific management regulations. However, they share one weakness with most other forestry guidelines in having little to say on community issues. The IUCN 2006 document is a useful guide. It offers important suggestions, especially on integrated data management (databases etc.), legislation development, and the development of partnerships, in addition to other recommended actions mentioned above. The main role of these guidelines is likely to be a political one. By persuading ITTO member countries to agree to the generally phrased guidelines a platform is created on which more detailed commitments can be enforced at the national level.

Reduced Impact Logging

RIL consists of technologies and practices that are designed to minimize environmental impacts associated with industrial timber harvesting operations (Sist *et al*. 1998; Tropical Forest Foundation 2006). RIL is part of a shift in forestry methods worldwide towards promoting sustainable forest management. In order to standardize the definition, application and verification of RIL, the Tropical Forest Foundation is now in the process of developing a detailed set of C&I applicable to the South East Asia situation (Tropical Forest Foundation 2006).

Biodiversity considerations do not yet figure greatly in RIL recommendations, which focus on minimising damage to residual stock,

regeneration, soil properties and water courses. In the Indonesian/Malaysian situation, RIL recommendations that explicitly mention the environment are: pre-harvest planning of roads, skid trails, and landings to provide access to the harvest area and to the individual trees scheduled for harvest while minimizing soil disturbance and protecting streams and waterways with properly engineered crossings; and the development of written environmental and operational standards to guide planning and operational activities and the integration of these standards into the company structure (Tropical Forest Foundation 2006)). RIL also recommends marking, recording and mapping of protected species, but only of tree species. The RIL guidelines also recommend the identification and mapping of ecologically sensitive sites such as special wetland habitats, cave habitats and nesting trees during the 100% inventory.

The recent debate about the adequacy of RIL as a tool to minimize damage to residual stands is a good example of the need to consider forest ecology issues before making generic recommendations. While it is always environmentally beneficial to minimize unnecessary damage, more intensive silviculture should not be discouraged in tropical forests in which regeneration and growth of commercially valuable timber species requires such treatments (Frederickson and Putz 2003). Sist and Brown (2004), in answer to Frederickson and Putz (2003), argue that '… tropical forest silviculture for the sustainable management of its resources is much more complex than the manipulation of gap size... Recent research has shown that RIL techniques are necessary for sustainable harvesting but not sufficient on their own to guarantee that it occurs (especially when based solely on minimum diameter felling limits).' The reality is likely to lie between the two and to depend largely on the interaction between the ecology, dynamics and harvesting regime of the forest types under consideration.

Certification

Catalysed by increasing deforestation in tropical forests, forest certification emerged in the early 1990s as an instrument for promoting sustainable forest management. Certification was envisaged as a market-driven mechanism that promoted sustainable forest management by establishing standards for forest practices and management that guarantee a certain level of management performance, by enhancing marketing opportunities for products from sustainably managed forests, and by promoting public education about improved forest management, for both producers and consumers. In some parts of the world, the FSC system has helped to develop national standards through national and regional working groups which build consensus amongst a wide range of people and organizations involved in forest management and conservation. For governments certification is a mechanism for improving SFM, whilst also improving national image.

There are seven certification schemes currently in existence. The WWF's Global Forest Trade and Network website (www.forestandtradeasia.org) presents a good description of the various systems, however only three are of relevance to South East Asia. The most widely accepted and used of all international certification schemes is that developed by the FSC in 1993. Currently, within South East Asia, only three countries have FSC-certified natural forests: Indonesia (four private concessions covering 739,216 ha); Lao PDR (one private concession and one community forest covering 44,985 ha); and Malaysia (one private mixed forest of 4,147 ha, and one public concession of 55,083 ha). Thailand and Vietnam have two and one certified plantations respectively.

Only two countries in the region have developed and implemented their own national certification schemes. Indonesia was very quick off the starting blocks in 1992 when it established the Indonesian Ecolabelling Institute (*Lembaga Ekolabel Indonesia* LEI). This was followed in 1998 by Malaysia, which created the Malaysian Tropical Timber Council (MTTC). In Myanmar, a Timber Certification Committee is in the process of developing a National Certification Scheme, although there is no concrete information about its status.

Forest Stewardship Council

The FSC is an independent, non-profit, non-government organization that provides standard setting and accreditation services for companies and organizations interested in responsible forestry. The FSC forest management standards are based on 10 Principles of Forest Stewardship (see www.fsc.org for a complete list). The FSC supports the development of

national standards that implement their principles and associated criteria at the local level. FSC also provides Chain of Custody (CoC) standards for manufacturers and processors of forest products.

The FSC system has a number of principles that are relevant to wildlife conservation and management[2]. Principle 9 on the Maintenance of High Conservation Value (HCV) Forests has been designed to ensure the conservation of critical sites and habitats in accord with a coarse filter approach to wildlife conservation and management (Bennett 2004). This is supplemented by Principle 7 on general forest management planning with criteria that require environmental safeguards based on environmental assessments, plans for the identification and protection of rare, threatened and endangered species, and maps describing the forest resource base including protected areas. Criterion 6.2 states that 'inappropriate hunting, fishing, trapping and collecting shall be controlled', however there is little guidance on what actually constitutes 'inappropriate'.

It should be noted that there has been some strong criticism of the FSC system and process (Counsell & Loraas 2002). In Indonesia, there has been criticism of the certificates awarded: in particular, criticisms of a concession in Riau Province included the allegation that the concession was converting (clearing) forest when its certificate was awarded. There have also been criticisms of the Malaysian Timber Certification Council (MTCC) system in Malaysia in relation to indigenous rights and tenure, and in Lao PDR criticisms are related to CoC issues, amongst other matters.

High Conservation Value Forests

The concept of HCVs was added to the FSC forest management principles in the late 1990s as Principle 9 and deserves special mention here. HCVs include environmental and social values that are considered to be of outstanding significance or critical importance. Examples may include concentrations of endangered species, protection of a stream that is the sole source of water to a local community, or a site with special religious significance.

Although first defined by FSC, the HCV forest (HCVF) concept is increasingly being used by other initiatives for mapping, conservation and natural resource planning and advocacy. The concept is also being used by companies establishing precautionary purchasing policies and in the discussions and policies of government agencies. FSC has identified the need for widely available and consistent guidance in defining, identifying and managing HCVFs. The HCVF toolkit developed by ProForest (Jennings *et al*. 2003) provides a framework that can be used by standard-setting groups and others to define the HCVs within their country, and gives guidelines to forest managers on how to identify, manage and monitor HCVFs. In the absence of national standards, the toolkit can also be used directly to identify and manage HCVFs.

Definitions of HCV have been changed many times, either to adapt them to the local situation or in attempts to improve them. Different sources have been consulted to gain an understanding of the different versions of the ProForest methodology, general toolkits (Jennings *et al*. 2003), a toolkit adapted for use in Indonesia (ProForest/Smartwood 2003), and the Lao PDR draft guidelines on HCV/HCVF assessment (SUFORD 2006). The Nature Conservancy East Kalimantan Programme also produced a practioners' guide to managing HCVF in Indonesia, with special reference to East Kalimantan (Meijaard *et al*. 2006b).

Indonesian Ecolabelling Institute

The Indonesian Ecolabelling Institute (LEI) is an independent foundation which was developed by an independent working group of forest NGOs and academics. It was envisaged, at least in part, as a means for the Indonesian environment movement to ameliorate the worst effects of Indonesia's destructive large-scale logging concession system (Down to Earth 2001). LEI developed its own set of C&I, based on the ITTO guidelines for SFM. In Indonesia, companies have a choice between either FSC or LEI certification. However, LEI does not yet have international recognition, which means that it has less prestige than FSC in the international market place. The systems are different: for example, in relation to the plantation forestry sector: companies with plantations established on land that was still forested after 1994 do not qualify for FSC

[2] http://www.fsc.org/en/about/policy_standards/princ_criteria

certification but are eligible for certification under LEI.

Malaysian Timber Certification Council
The MTCC was created in October 1998. The Council grew out of a joint initiative by the Malaysian Ministry of Primary Industries and the then Malaysian Timber Industry Development Council, now known as the Malaysian Timber Council. The MTCC is an independent organization established to develop and operate a voluntary national timber certification scheme in Malaysia in order to provide independent assessments of forest management practices as well as to meet the demand for certified timber products.

The MTCC timber certification scheme began operation in October 2001 using a phased approach. The standard currently used for assessing FMUs for the purpose of certification is the Malaysian Criteria and Indicators for Forest Management Certification – MC&I (2002). The MC&I (2002) are a result of the collaboration between the MTCC and the FSC that was initiated in 1999. Since the beginning of 2006, the MTCC Certificate has been awarded to nine FMUs covering an area of 4,730,774 ha. The list of Principles and Criteria is identical to that of the FSC. Further details on the MTCC system can be found at www.mtcc.com.my.

Forest Certification and Biodiversity
One of the deficiencies of certification in terms of wildlife conservation and management is that certification is a site-based tool, which means that the role of certification in influencing the wider landscape beyond the one concession is limited. The range of one species is not fixed to a lone certified forest in an area surrounded by uncertified forests. This is particularly true in areas where logging concessions may be small in size, therefore governments should not rely heavily on the image of certified forests as the key to SFM and forget that overall, appropriate, land-use planning is the key to managing forested landscapes sustainably and maintaining biodiversity.

Most criteria related to biodiversity are concerned with protecting sites important for flora and fauna but do not take into account the wider affects of logging on wildlife, such as hunting and fragmentation, across the FMU. In reality, protected areas within the FMU will always be small compared to the area allocated for production. Wildlife is affected in many ways as a result of logging, depending on the intensity and frequency of the logging, however the most insidious problems for wildlife are the secondary effects of logging, most notably the dramatic increase in hunting and human presence in the forest (Bennett 2000). This is because more people, both workers as well as outsiders, have access to the forest through increased points of access. These problems are reflected in FSC principles 6.2 and 6.3, which state that, 'Safeguards shall exist which protect rare, threatened and endangered species and their habitats (e.g. nesting and feeding areas). Conservation zones and protected areas shall be established, appropriate to scale and intensity of forest management and the uniqueness of the affected resources. Inappropriate hunting, fishing, trapping and collecting shall be controlled…Ecological functions and values shall be maintained intact, enhanced, or restored, including: a) forest regeneration and succession; b) genetic, species and ecosystem diversity; c) natural cycles that affect the productivity of the forest ecosystem.' Bennett (2000, 2004) and Schulte-Herbrüggen and Davies (2006) provide a good critique of certification schemes and wildlife conservation.

Actual logging practices in humid rainforests of Indonesia and Vietnam

Indonesia
Forestry in Indonesia is carried out under a system of concessions; this system was established in 1970 by Government Regulation No.21/1970 and forms the basis for the management of natural forests in Indonesia. Under the Concession System, private sector companies are allocated felling rights to an area of natural forest for a fixed period (generally 20 years). Concessionaires harvest timber under a forest management plan which establishes an Annual Allowable Cut, the silvicultural system to be used, a minimum diameter felling limit and the felling cycle.

The concession system has evolved over the past 35 years. Additional regulations and decrees have been added in response to changing circumstances in the forest industry and in world markets, the evolution

of development objectives under each Five-Year Plan (*Repelita*), problems of forest management supervision, experience gained and lessons learned. As a result, the number and complexity of concession regulations and decrees has made enforcement difficult for the Ministry of Forestry and compliance a complicated process for the concessionaires (Gray and Hadi 1989).

Modifications to the silvicultural system in Indonesia have been developed over time. The first logging system (Indonesian Selective Logging – *Tebang Pilih Indonesia*, TPI), introduced in the 1970s, was replaced in 1993 by the Indonesian Selective Logging and Planting System (*Tebang Pilih dan Tanam Indonesia,* TPTI).

In the TPTI system, all trees with a diameter at breast height (dbh) greater than 50 cm (Production Forests) or 60 cm (Limited Production Forests) may be felled. The system is based on a fixed 35-year felling cycle. Management activities during this period can be divided into three main groups: pre-harvest, harvest and post-harvest activities, as detailed in Table 2.

Under the TPTI system, each forest concession is obliged to establish a department of silviculture and a separate department of logging. The department of silviculture should be sufficiently supplied with facilities, funds and infrastructure, and should be led and staffed by forestry-educated personnel who understand the science and practice of silviculture.

The TPTI system takes the view that thinning activities will accelerate the growth of individuals of selected commercial species by removing their competitors. The system specifies two general types of thinning activities: liberation felling and thinning. Both activities entail the removal of non-commercial and poor quality commercial competitors to ensure that potential crop trees are available for the next felling cycle. This can be done by either felling or poisoning.

Since the concept of reduced impact logging (RIL) was introduced and implemented in some forest concessions several years ago, there has been some criticism of the thinning and liberation treatments prescribed under TPTI. Thinning operations appear not to be necessary when RIL is well implemented. Responding to these issues, the Ministry of Forestry has issued a decree, SK No. 274/VI-PHA/2001, stipulating that all timber companies in Indonesia must implement RIL in their concessions (see Table 3 for comparison).

More recently, scientists (Sist *et al*. 2002, 2003) have shown that for RIL to be effective there needs to be a limit to the number of trees to be felled per hectare. This recommendation now forms part of an improvement made to the TPTI by means of a recent decree by the

Table 2. Management activities during a 35-year felling cycle

No.	Activity	Timing (year)	
1.	Organization of working area	Et-3	Pre-harvest
2.	Forest inventory before logging	Et-2	Pre-harvest
3.	Forest opening	Et-1	Pre-harvest
4.	Tree felling (commercial species)	Et0	Harvest
5.	Liberation	Et+1	Post-harvest
6	Inventory of residual stand	Et+1	Post-harvest
7.	Production of seedlings	Et+2	Post-harvest
8.	Enrichment planting	Et+2	Post-harvest
9.	Maintenance/tending	Et+3	Post-harvest
10.	Advanced tending		Post-harvest
	Liberation	Et+4	
	Thinning	Et+9	
		Et+14	
		Et+19	
11.	Forest protection and research	Continual	Post-harvest

Et = Harvest

Table 3. Comparison of 1993 TPTI and 2001 RIL decrees

Element	TPTI Decree	RIL Decree
	No. 151/Kpts/IV-BPHH/1993	No. 274/VI-PHA/2001
Management commitment (Standard Operational Procedure, Standard and System)	Not specifically mentioned	Emphasized but without further detail of what kinds of activities should be carried out
Forest inventory before logging (including vine cutting)	Detailed procedures for forest inventory mentioned	Refers to forest inventory in TPTI (without mentioning cutting vines)
Topography and tree mapping	Tree mapping is required but there is no mention of a topographical map	Both activities are described as very important requirements with appropriate operational scale
Skid trail planning	Mentioned in general only	Emphasized as very important
Skid trail location	Not mentioned	Suggested
Establishing skid trail before felling	Not mentioned	Suggested
Tree felling	Only general mention about better ways of felling trees	Directional felling suggested
Skidding	Mentioned in general only	The importance of reducing damage by implementing proper skidding and using winches are discussed
Skid trail deactivation	Not mentioned	Suggested
Monitoring of post-harvesting activities	Post-harvest monitoring described in systematic detail for 100% logged-over forest (inventory of residual stand)	No detail given – more emphasis placed on the need for evaluation and monitoring

Directorate General of Forest Development in Indonesia stating that concession companies are required to apply low-impact harvesting techniques in mixed dipterocarp forests, and must limit extraction rates to 8 trees/ha ≥ 60 cm dbh (Forest Liaison Bureau 2002).

Vietnam

Unlike in Indonesia, the forestry sector in Vietnam is organized as state-owned public enterprises to which a State Forest is assigned. After the Vietnam-America war, forest policy focused on production, and in the 1990s Vietnam was second only to Thailand as the premier wood-exporting country in South East Asia, exports going mainly to the EU and Japanese markets. Concern about long-term sustainability resulted in reduced logging quotas and a move towards more community-based forest management, manifested in the 1993 Land Law and the Forest Protection Law of 1999 (Sterling *et al*. 2006).

Since October 1993, the management of the forestry sector has operated under the terms of Decree No. 388/HDBT, which involves 599 State Forest Enterprises (SFEs), each controlling its own economic activities.

- The Ministry of Forestry directly manages 128 forest business units (69 SFEs, 20 forest product processing factories, 12 forest product business companies, 6 seed companies and 17 forest service enterprises)
- Provincial People's Committees directly manage 471 forest business units (343 SFEs, 81 forest product processing enterprises, 32 forest product companies, 1 seed company and 14 forest service enterprises).

A revised law on Forest Protection and Development (No. 29/2004/QH11) was adopted by the National Assembly in 2004 and came into force in April 2005. Forests in Vietnam are divided into three categories: (i) special-use forest, (ii) protection forest, and (iii) production forest. The SFEs are under the supervision of the Ministry of Agriculture and Rural Development (MARD) and Provincial Committees. They are now undergoing some

restructuring according to their type of forest resources (production or protection forest). Timber exploitation is regulated by MARD Decree No. 40/2005/QD-BNN, issued on 7 July 2005, which states that the provincial Forestry Departments should submit all necessary documentation relating to their plans for harvesting all the natural forests in their province to the MARD for agreement. The provincial Forestry Departments then design the harvest and production plans for each of the SFEs. The intensity of harvesting is decided according to the estimated forest stock, as follows:

Estimated stock (m^3/ha)	Range of felling intensity (%)
91–150	18–23
151–200	24–28
201–300	29–33
>300	34–38

The minimum felling diameter varies according to the timber group (there are eight timber groups; group 1 includes very hard 'ironwoods').

Timber group	Minimum felling diameter limit
1–2	45 cm
3–6	40 cm
7–8	30 cm

With regard to threatened species, the Government of Vietnam issued Decree No. 32/2006/ND-CP on 30 March 2006 (replacing a decree issued 10 years earlier) providing for the management of endangered, precious and rare plants and animals from Vietnam's forests. This decree divides endangered, precious and rare forest plants and animals into two groups (species in group I are those strictly banned from exploitation and use for commercial purposes; species in group II are those with restricted exploitation or use for commercial purposes). It is prohibited to exploit, hunt, trap, catch, cage, slaughter, transport, process, advertise, trade in, use, store, import and export endangered, precious and rare forest animals in contravention of the legal provisions. The decree also specifies the conditions and permits required for exploitation, transportation, storing, processing and trading of endangered, precious and rare forest plants and animals exploited from nature and products thereof, and provides for the rights and obligations of forest owners toward special-use forests and the said plants and animals.

The government also issued Decision No. 186/2006/QD-TTg on the Regulation of Forest Management. This concerns the management, protection, development and use of special-use forests, protection forests and production forests, including land areas with and without forests which have been assigned, leased or planned for forestry purposes by the state. According to this Decision, which comprises 5 chapters and 43 articles, forest owners may carry out ecotourism business activities, lease forest environment or utilize land-use rights and the economic value of biodiversity resources and landscapes of special-use forests to enter into joint ventures with others to carry out ecotourism investment activities therein. Investment projects on ecotourism activities in special-use forests must be formulated and submitted to competent state agencies for approval.

In the recently announced National Forest Strategy for the years 2006–2020 production aspects are again given increasing weight. One goal is that the forestry sector's contribution to the national gross domestic product should at least double by 2020, from 1% to 2–3% (Government of Vietnam 2007). Forestry management should increasingly be allocated to other interest groups beside the state, such as private enterprises, communities, cooperatives, households and individuals. The strategy also envisages that responsibility for forest protection and conservation rests not only on local authorities and law enforcement agencies but increasingly also on forest owners, local managers and local users (Government of Vietnam 2007).

Overall, RIL remains a new idea for Vietnam; there is still no legislation supporting RIL in the country. It is noteworthy that in the new National Forest Strategy neither the term 'reduced-impact logging' nor RIL is mentioned (Government of Vietnam 2007). In the recent past the Vietnamese forestry sector was involved in a project supported by FAO to train people working in Provincial Forestry Departments and Forest Enterprises in RIL. The idea was to try to apply RIL in some SFEs as a model, hoping that suitable regulations relating to RIL would subsequently be issued for wider application in Vietnam. To date, only *Reduced Impact Logging Guidelines for Indonesia* (Elias *et al*. 2001), translated into Vietnamese, provides a uniform set of minimum standards for logging practices and explains

the mechanism by which the standards can be applied in the field.

Recommendations for forest managers, with special emphasis on Indonesia and Vietnam

The aim of the recommendations is to ensure a high, profitable yield of timber while at the same time to creating and maintaining good conditions for the rich and invaluable flora and fauna of South East Asian forest landscapes. Thus the recommendations made are examples of multi-purpose use of the forest resource. Examples are provided from one country, Indonesia, where large-scale and highly mechanised logging is practised in some concessions, and another, Vietnam, where forest management is generally less intense and less technically advanced. The reason for choosing Indonesia and Vietnam was not only that they demonstrate contrasting forestry practices but also that research activities are ongoing in Indonesia and that funding opportunities exist in both countries. Moreover, Indonesia and Vietnam both manage forestry systems in a way that is practised in other countries in the region, hence the recommendations should be of interest in a wider geographical context. These are the first recommendations of their kind, and future improvements are likely and also necessary as awareness of biodiversity issues increases, research develops and the suggestions made are tested in practice.

It is essential that government officials or forest managers are already knowledgeable about basic reduced-impact logging (RIL) practices before they embark on more complicated issues such as biodiversity adjustments and landscape approaches to sustainable forest use. This is unfortunately not yet the case in Indonesia or Vietnam, although new societal or market (certification) demands have definitely raised awareness among government officials and forest managers about the need to use more environmentally friendly practices such as RIL.

Forest managers have certain rights to remove timber, but they also have responsibility for their concessions; this must include the responsibility for addressing and confronting threats to the forest and its wildlife. This is not a minor responsibility, and it poses questions that managers may not feel well equipped to answer. Guidance – on identifying and dealing with the main priorities – is scarce. It is not possible to make rules and regulations that cover all eventualities. Management will always involve dealing with conflicting priorities, local insights or innovations. A clear vision is needed. To ensure that forest biodiversity is managed according to ecological principles, the primary goals are:

1. to maintain large, well-connected forest landscapes (including unlogged areas) containing as complete as possible a range of local forest types, and to maintain the key landscape elements of the landscape and the wildlife resources within it;
2. to identify the major threats to forest wildlife in this landscape and take steps to address them.

Habitat heterogeneity and structural diversity are amongst the most important factors determining species-rich communities in natural forest settings, and the maintenance of these factors is important. Interventions may also be directed towards conserving specific resources or features (e.g., food trees, lianas, salt licks, caves, clean rivers) of importance for certain taxa. Such measures are relevant in the identification of larger areas that might be excluded from any harvesting, and in the designation of harvesting zones. Except when considered relevant to the purpose, classic RIL concepts and procedures covered in other sources, such as planned skid trails and directional felling, are not included (see Elias *et al*. (2001) for a clear and practical guide to RIL based on the Indonesian Selective Logging and Planting System (TPTI), or Dykstra and Heinrich (1996) for more generic recommendations).

The following recommendations should be viewed as biodiversity-friendly additions to, and as added support for, current RIL practices. We rate each of the management recommendations as either '**mandatory**' (included or to be included in the law), '**strongly recommended**' (generally requested by certification bodies) or '**recommended**'.

Minimising direct threats and logging damage

Before granting logging rights

The obligation to conduct an Environmental Impact Assessment (EIA) has been compulsory in Vietnam since the promulgation of the Law on Environmental Protection in 1994, but this obligation appears not to be reflected in the forestry law or in actual forestry practices, probably because most forest enterprises have been established for many years (often since before the law of 1994). The carrying out of EIAs should, however, be considered seriously in view of the new afforestation or forestry projects in the country.

An EIA (or AMDAL in Indonesia) is normally requested under various regulations in Indonesia that are the responsibility of the Environmental Impact Assessment Agency (BAPPEDAL). There is detailed legislation laying down procedures for 'Integrated/ Multisectoral Businesses or Activities', i.e. major developmental projects which involve several sectoral interests, and, therefore, the competence of several ministries (including the Ministry of Forestry). For such projects, the EIA process involves the input of sectoral ministries as well as provincial governments, and prescribes a comprehensive procedure for appraisal at the national and regional levels. Of course, as in many other developing countries, problems remain with the actual implementation of these EIA provisions, and reports of EIA procedures being viewed as obstructive to development and therefore circumvented are not uncommon.

As one environmentalist put it, it should be as inconceivable to undertake a major forestry operation without an EIA, whatever its form, as to pull down the Taj Mahal in order to build a road.

01. An Environmental Impact Assessment (EIA) should be carried out, preferably by an independent third party, before a forestry operator is granted the right to operate on a given area, either concession or state forest (**mandatory**).

Inventory, survey and planning prior to logging

In Indonesia and Vietnam, all logging-related activities should be preceded by a forest inventory. Forest inventories (or forest surveys) are generally designed to provide a reasonably precise evaluation of the standing stock, the commercial volume and the advanced growth stock (the trees that will constitute the next harvest). In the Vietnam Forestry Development Strategy 2006–2020 the need to improve forest planning and inventory is stressed (Government of Vietnam 2007). If they are carried out to a reasonable technical standard and used as a genuine input to defining management options and alternate choices, these surveys can make a major contribution towards promoting conservation. They must, however, take into account additional biodiversity-related information and address the status of locally important species (especially non-timber forest products).

02. During forest inventories, special attention should be given to the distribution of and threats to species that are:
   a. Protected by national laws (**mandatory**);
   b. Given a high conservation status by the World Conservation Union (IUCN) (**mandatory**);
   c. Much affected by logging and associated effects – e.g. species that occur exclusively in undisturbed forests or streams (**strongly recommended**);
   d. Much used by, or significant to, local communities (**mandatory**).

   We strongly advocate a clear link between the collection of such data and the management activities that are based on them. Currently, many data are collected as a bureaucratic task whereby reports and records must exist but do not necessarily need to be incorporated into forest management planning and are therefore ignored.

As our aim is not only to improve the 'persistence' of logging- and fragmentation-sensitive plants and animals in logged-over forests but also to make practical recommendations, we favour an emphasis on spatial planning in which different alternatives are clearly anticipated, so that the consequences can be recognised and weighed appropriately. Planning should allow for remedial actions to be taken in degraded areas and a comprehensive consideration of neighbouring lands and the threats that arise from them. For example, firebreaks may be considered more important in some locations than the edge effect that they might create. In some cases, forest edges might be identified as

a preferred niche for a specific valued species. All such factors would have to be considered and weighed up. Plans could then be assessed as to whether they have explicitly balanced spatial integrity against other considerations, including the more generalised preferences of distant stakeholders. Once a plan is agreed upon, it becomes a statement of what can be verified. No abstract indices are necessary.

At a minimum, the planning process should ensure that known rare, unusual or sensitive habitats and species receive due attention. The process will be checked to identify which individuals and agencies contributed information to the plan and whether key expertise, including local knowledge, was omitted. An assessment would also seek evidence that both management and biological or societal concerns have influenced choices (e.g., Given the choice of options A, B and C, C was selected because…). Such specific and locally relevant statements lend themselves to direct assessment, as is already practised at the operational scale in several millions of hectares of Congo Basin forests (Nasi and Forni 2003).

03. Any logging should be preceded by carefully designed management planning that includes silvicultural and logging rules, engineering data, demarcation of production and protection areas, hydrography and road network. This planning exercise should be carried out sufficiently prior to logging (6 months for main infrastructure networks, 2 months for skid trails). Logging maps, to be useful, should be at scales larger than 1:10000 and have at least 60–70% accuracy (**mandatory**).

04. Areas planned for different uses should be clearly marked on maps, signs should be established that clearly indicate the status of and the activities that are or are not allowed in forest blocks, and physical boundaries should be established in the field (**mandatory**).
However, the latter might not be practical in the case of buffer zones along streams given the large number of such streams. When the establishment of physical boundaries is impractical, clear instructions should be given to machine operators.

05. Each area designated for protection needs to be clearly delineated on the logging maps of each concession and clearly marked on the ground (**mandatory**).
This is essential in order to prevent the 'protected area' from being moved around the concession and thereby being logged, while still being protected on paper. Flexibility should be allowed in order to avoid asking operators to mark areas still very remote from any field operation; such areas should, however, be delineated on maps and marked when operations approach.

06. Planning dispersed annual felling coupes throughout the forest can help facilitate regeneration and permits the migration of wildlife disturbed by logging. It does, however, make road planning, supervision and oversight more complicated and should be considered on a case-by-case basis (**recommended**).

07. Planning procedures should allow an assessment of which sensitive or important species are priorities in any particular forest area, and how their long-term survival can and should be safeguarded. Such procedures need to be periodically reviewed and amended according to new information and the predicted risks for particular species (**strongly recommended**).
This should allow habitats of protected or sensitive species to be managed in a way that prohibits activities detrimental to their survival (note that this does not necessarily imply that logging is prohibited in these habitats).

08. The occurrence of sensitive or important species and their key habitat requirements (e.g. particular grazing areas, salt springs, etc.) should be recorded on a database and a Geographical Information System (**recommended**).

09. Some forests (e.g. High Conservation Value Forests – HCVFs) may be assigned a compulsory biodiversity goal related to the specific values of their particular location (e.g. a certain concession could have a relatively high number of a specific rare species) and their management plans would then be required to address threats relevant to these HCVs (**recommended**).

10. If the conservation of certain species is planned, species-specific management, expert guidance, local knowledge and ecological research, together with how these management interactions affect the protection of other species, must be considered prior to logging (**strongly recommended**).

Maintaining connectivity

As explained by conservation biology basics (see Appendix 1), maintaining corridors of interior forest should have positive effects on the fauna (Marcot *et al*. 2001). Many species that respond negatively to fragmentation – and thus could benefit from the presence of corridors – are largely confined to undisturbed forest (Lovejoy *et al*. 1986; Laurance 1991; Stouffer and Bierregaard 1995; Bierregaard and Stouffer 1997). Many forest-dependent birds (Bierregaard *et al*. 1992) and mammals (Laurance 1990; Goosem 1997) have been shown to avoid even narrow (50–100 m wide) clearings, especially if the clearing is maintained as open habitat (Stouffer and Bierregaard 1995; Malcolm and Ray 2000).

11. A minimum percentage of the forest (e.g. 10%) should be designated for protection as a network of connected unlogged patches that could serve as refuges or as sources of species for re-colonising the surrounding logged-over areas (**strongly recommended**).

These areas excluded from logging can include areas where logging is not practicable, compulsory protection areas (e.g. 'gene pool' areas in Indonesia; watershed protection forests in Vietnam) and riparian buffers, but should contain a sample of all existing ecosystems within the geographical boundaries. We recommend retaining a connected protected area network based on two elements: reserved areas and linking corridors. All these corridors and reserved areas should be mapped and maintained as previously stated.

Note that in Vietnam, the very small size (as little as 9000 ha) of some forests managed by state enterprises makes the application of such a rule largely irrelevant. In one case, the state forest is 41 500 ha, 29 000 ha of which are designated for protection following criteria set by the administration. In such a case asking for the exclusion of more parts of the area left for production appears unrealistic.

In Indonesia, current regulations require the establishment of logging exclusion zones (riparian buffers) to protect streams, rivers and other water bodies. How these regulations should be applied is, however, far from clear as there is considerable inconsistency between different guidelines on river and stream buffer zones and how they are to be applied. In Vietnam, there is an *a priori* partitioning of state forests into various functional types, one of which pertains to watershed protection and where logging is prohibited, but there is no provision for the protection of watercourses in areas designated for production. There is also a strong tendency to use valley bottoms to site infrastructure (landings and roads).

In Vietnam most rivers are less than 10 m wide and regulations regarding buffer strips are lacking. However, protection forests are often gazetted based on river or watershed protection criteria.

12. Riparian buffers of variable widths, based on maximum river width for two or more months of the year, must be maintained (**mandatory**).

Sist *et al.* (1998) recommend variable buffers, as follows

Stream or river width (m)	Buffer on each side (m)
>40	100
21–40	40
11–20	25
1–10	10
<1	None

Flexibility is needed, however, as in some cases maintaining 10-m buffers on each side of 1-m to 10-m wide streams would imply a halt to operations. In such areas, practical guidelines could be as follows:

- maintain buffers only for rivers more than 10 m wide,
- ensure directional felling to avoid debris blocking the smaller streams.

Exceptions must also be made for essential road crossings, but such crossings should adhere to minimum standards.

The maintenance of such riparian protection zones with sufficient forest buffer on either side will provide a valuable network of relatively undisturbed forest maintaining connectivity across the landscape, especially through altitudinal gradients.

A recommendation on aerial connectivity has been removed because practitioners considered it largely superfluous. It might be worth considering adding a recommendation about facilitating the ability of wildlife to cross roads (use of tunnels, hollow stems).

This point is, however, relatively minor in the context of tropical forest logging.

Maintaining habitat complexity and diversity

The need to maintain habitat complexity and diversity is also shown in the empirical observations on conservation biology (see Appendix 1): a structurally complex ecosystem is invariably more diverse than a simpler one.

13. Identify critical habitats or habitat features that should be protected in the forest whenever possible (**strongly recommended**).
To prevent this becoming an excessive burden on the concession it might be agreed that only a certain number of such sites or individuals need to be protected on a surface area basis (e.g. up to five stems and two sites per ha).

14. Maintain an adequate number of mother trees (at least one) of commercial species per hectare to ensure potential regeneration of important commercial species (**mandatory**).

Arboreal water is very important to a number of species. In both Vietnam and Indonesia, key sources of arboreal water are pitcher plants and hollows in certain tree species. While it is clearly difficult to plan logging around such micro-habitat features, the maintenance of large stems and the marking of pitcher plants to avoid damage is proposed. Hollow trees also provide cavities of importance to vertebrates that use them for breeding, nesting and food storage. In Vietnam, hollow trees are often places to find colonies of the stingless bees commonly harvested by local populations. According to logging company experts, if the hollow area is less than 25% of the cross-section of the area of the stem the log can be used by the industry. In well managed logging operations, trees suspected to be hollow are tested prior to felling (hit with a hammer to listen to the sound made or poked with a chainsaw).

15. Large hollow trees should be retained whenever possible (**strongly recommended**).

Note that these retained trees can also act as mother trees if they belong to commercially harvested species.

16. Incentives should be in place to avoid unnecessary felling of hollow trees: a worker who cuts an unusable log will not be paid for the log (**recommended**).

Note that large hollow individuals of some species (e.g. *Shorea laevis* in Kalimantan) are sometimes used to create crossings.

17. If endangered pitcher plant habitats are identified, the larger habitat should be given special consideration (**recommended**).

It is important to maintain stand structures that allow the continued generation of dead wood in a full range of sizes. Large, old and dead standing trees provide dead wood and suitable sites for hole and crevice-nesting birds and mammals (e.g. Styring and Hussin 2004a). Rotting tree stumps are used by species such as bats, squirrels, Sun Bear *Ursus malayanus*, trogons, forest kingfishers and forest bee-eaters (Lambert and Collar 2002).

18. Large, old or dead standing trees and rotting tree stumps that are not placed on access roads, below an area where other cut trees have fallen, or which do not pose a risk to workers should be left in place (**strongly recommended**).

Rocky outcrops and caves provide nesting and roosting spaces for a variety of species, including reptiles, birds (raptors, swifts) and small mammals, and provide refuge against predators (Bernard 2004). Limestone landscapes in Vietnam cover extensive areas, especially in the north. The forests on limestone have a high number of plant species, including many endemic species, due to their unusual, varied topography and soil conditions, causing a high habitat variation. One example of an endemic tree species is the Golden Vietnamese Cypress *Xanthocyparis vietnamensis*, which was discovered as late as 2002 (Sterling *et al*. 2006).

19. In areas where rocky outcrops (often limestone or sandstone) occur, mining of outcrops should be avoided as much as possible and any mining should be carefully regulated if it cannot be prevented (**strongly recommended**).

20. If a cave provides habitat for protected and/or rare and endangered species, prohibiting entry into caves and elimination of road building and skidding in the vicinity should be considered. If the caves are a source of birds' nests, they

should be protected as no-logging zones, in collaboration with local stakeholders (**strongly recommended**).

21. Wallows and pools over 3 m wide and sites of permanent or near-permanent water should be avoided by skid trails (**recommended**).
This will also increase operators' safety as these sites are generally unstable.

22. 'Salt springs', saline soils and sites with clays eaten by animals (located and incorporated in advance planning) should not be disturbed (**strongly recommended**).

23. Liana or vine cutting before felling, a classic RIL recommendation, should only be considered on a tree-to-tree basis (**strongly recommended**).
The advantages (potentially reduced damage) should be weighed against the disadvantages (reduced diversity and fruit availability).

24. Ideally, logs should be de-barked in situ before skidding (Nykvist *et al.* 1994) to keep vital nutrients in the system (**recommended**).

Practical procedures need to be developed; these will depend on the context and, especially, on the size of the logs. In Indonesia, where logs can be quite large, de-barking is carried out on the landing site after skidding. In Vietnam, where logs are generally smaller and are cut into 4-m pieces before skidding, de-barking is generally done in the forest.

Keeping keystone resources

Maintaining an adequate supply of food throughout the year is a necessary condition for maintaining a healthy forest fauna in the production forest. Especially important fruit resources in Indonesian and Vietnamese rainforests include figs, palms, Anacardiaceae (e.g. *Dracontomelon* spp.), Euphorbiaceae (mainly *Baccaurea* spp.), Guttiferae (*Garcinia* spp.), Sapindaceae (*Dimocarpus* spp., *Nephelium* spp.), various Fagaceae, Myrtaceae and many woody climbers, particularly Annonaceae, and less or non-seasonally fruiting species such as understorey Rubiaceae, gingers and (often) swamp area vegetation. The bark of some gum or sap-producing trees is also important as a food source for slow lorises. In Vietnam, the endemic slow loris *Nyctibecus pygmaeus* has been observed feeding on the sap of *Sapindus* sp., *Vernicia montana*, Euphorbiaceae, Anacardiaceae and *Saraca dives* (Tan & Drake 2001).

25. Retain as many large fruiting trees as possible, particularly those that fruit throughout the year (Leighton and Leighton 1983; Lambert 1991) and may be critically important for canopy frugivores during lean periods (**strongly recommended**).

26. Conserving the mid canopy structure by applying RIL techniques to minimise incidental tree damage is a good strategy for conserving a large number of palms, Annonaceae, Myristicaceae and Lauraceae (**strongly recommended**).

Figs (*Ficus* spp.) are especially important for wildlife as they provide fruit throughout the year and fulfil vital nutritional needs (see O'Brien *et al*. 1998).

27. Efforts should be made to conserve as many figs as possible, regardless of age (**mandatory**).

28. Fruit-tree groves, old fruit gardens and abandoned villages are recognised by local people as good hunting sites and provide resources for frugivores. Such sites should be protected from logging and road building (**strongly recommended**).
These areas are also generally of cultural importance for local people (see section on conservation for local people).

29. There is a wealth of indigenous knowledge regarding tree species that are important for maintaining wildlife populations. Such local knowledge should be evaluated and incorporated as much as possible into concession management (**strongly recommended**).

Minimising damage linked to infrastructure

30. Permanent logging camps, when needed, should be strategically located in the forest, as far away as practical from logging exclusion zones, especially those intended to benefit wildlife (**strongly recommended**).
However, experience in Indonesia shows that a properly managed camp near a protected area can help in environmental education and awareness raising among staff and their relatives.

In Indonesia concessions can be very large (several >100 000 ha), which necessitates extensive and permanent logging camps.

In Vietnam, in contrast, production forests are small (5–20 000 ha) and logging camps are temporary and maintained usually for less than a year.

31. Roads should be built outside riparian buffer zones and roads crossing reserved areas should be the exception not the norm (**strongly recommended**).

32. Roads, including feeder roads, should be planned carefully and constructed in a way that minimizes canopy damage and erosion (**mandatory**). Elias *et al*. (2001) and Dykstra and Heinrich (1996) provide more detailed guidance by road type:

- Road gradients should generally be less than 10% (<6°). When other disturbance is being avoided slopes of up to 20% (<12°) can be tolerated, but never exceeded, for distances not greater than 500 m (**recommended**).
- On level ground a planned 'herring-bone' layout of the roads and skid trails, and regular placement of log landing sites (Johns *et al.* 1996) reduces damage to remaining vegetation and increases harvest efficiency (**recommended**)
- Road design should minimize earthmoving as much as possible. When unavoidable, earthmoving must be done by bulldozers over short distances only and by dump trucks and loaders for longer distances (**strongly recommended**)
- On steep terrain, roads should be designed to follow ridges or be carefully designed at mid slope level following contour lines when ridges are impracticable or have special conservation value. Roads should not be built in valley bottoms or along watercourses. (**strongly recommended**)

In Vietnam, roads are often built in valley bottoms, for ease, and the adoption of new, more environmentally sound road-building models will need a serious change in approach.

33. Roads should be as narrow as it is practically possible, depending on terrain. Dykstra and Heinrich (1996) and Mason and Thiollay (2001) suggest that the maximum clearing width should be 7.5 m for major haul roads and 5 m for minor roads (**strongly recommended**).

In Indonesia (and Malysia) 'matahari felling' is the practice of pushing over all the edge trees to allow the road surface to dry in direct sunlight. This practice, generally carried out with a bulldozer, often results in overall road width well in excess of 50 m. This practice does not exist in Vietnam.

34. Halt the current 'matahari felling' practices (**strongly recommended**).

35. On steep terrain, mid slope roads should be as narrow as possible, but it is recommended that occasional wider sections be built to allow for traffic crossing and to be used as temporary log landings (**strongly recommended**).

36. Skid trails must be designed to be as short and narrow as possible, ideally following contours (**strongly recommended**) and should not be graded.
The construction of skid trails should avoid felling tall trees that would otherwise be left. They should avoid steep areas, ravines, swamps and unstable ground and minimize the number of stream crossings. Trail slopes should not exceed 45% except in cases of very steep terrain and for short distances. If a trail crosses a stream, a bridge or culvert should be constructed. Roots, branches and vegetation should be retained on the skid trail as much as possible (DFID 1999). The use of these harvesting residues in areas with much mechanical traffic will reduce soil compaction and aid forest regeneration (Brearley *et al.* 2003). Bulldozers or skidders with narrow blades should be used in skidding operations.

37. Log landings should be sited in relatively flat areas (with a slope of <10% or <6°) or on hill tops, away from streams and watercourses, and outside protection zones (**mandatory**).
As suggested above, traffic crossing areas on mid slope roads can also be used as landings, thereby removing the need to cause additional disturbance in the area. This also implies some drastic changes in the way forest enterprises operate in Vietnam, where such infrastructure is generally located near valley bottoms.

38. Construction of feeder roads and skid trails should be done in dry weather and only shortly before felling starts (**strongly recommended**).

Good quality water is essential for humans living downstream, and many amphibians, fish, some reptiles, birds and vertebrates such as otters depend on clear water to breed or feed. Proper drainage systems that feed into vegetated areas and well constructed and well maintained bridges and culverts are important in keeping streams clear.

39. Bridge construction should allow floodwater to pass without damaging the structure. Abutments should be well anchored to prevent them from being washed away (**strongly recommended**).
See Elias *et al.* (2001) for details.

40. Roads and landings must be shaped so that water runs off into the vegetation and not directly into main watercourses; silt traps and flumes should be installed where they are needed (**strongly recommended**).
This is best achieved by diverting drain outflows into surrounding vegetation at least 50 m above a main watercourse (Elias *et al.* 2001).

41. Drainage culverts should be installed to facilitate water flow and cleaned regularly (**strongly recommended**).
This will also facilitate crossings by terrestrial animal species (see, e.g. Clevenger *et al.* 2001) and add to the biodiversity-friendly aspects of concession management.

42. All roads and skid trails should be engineered to drain effectively; berms (raised ridges) must not be created on the sides as they prevent from water draining off the track (**strongly recommended**).

43. Ponds caused by improper roads or trail crossings, or other site engineering impacting local drainage, should be avoided (**strongly recommended**).
In some cases, however, such artificial ponds might have some use as water tanks for fire protection or as recreational areas for fishing. If old enough, they might also gain some interesting biodiversity value, harbouring a specific fauna and flora. This should, however, not be an excuse for inadequate road design.

Minimising stand damage during logging and related operations

44. Planned reserved areas and linking corridors must be managed as follows (after Elias *et al.* 2001):

a. No trees to be felled within exclusion areas and their buffer zones (**mandatory**);
b. Machine access is prohibited, except where planned roads cross the area. All such roads and watercourse crossings must be well engineered and streams carefully protected (**strongly recommended**);
c. No earthworks or spoil from earthworks is to fall within the exclusion areas (**strongly recommended**);
d. No logging debris is to be pushed into the exclusion areas, particularly into water courses (**strongly recommended**);
e. Trees should be felled away from buffer zones and watercourses (**strongly recommended**).

Reducing incidental damage will generally lessen the impact of logging on vertebrates. Forest damage along tractor skid trails and loading or landing sites should be reduced as much as possible. Heavily damaged areas are usually colonized first by vines and later by pioneer tree species that are generally not a good food resource for frugivores and that hamper forest regeneration. Most arboreal mammals are affected by large gaps in the canopy (see Putz *et al*. 2001 for a review), and maintaining a relatively intact and interconnected canopy/mid canopy would benefit these species. Experiments in East Kalimantan have demonstrated that logging damage can be significantly reduced if RIL techniques are used below a felling intensity of 10 trees/ha (Sist *et al*. 2003). A spacing of at least 35 m between felled trees would theoretically achieve this density. Further work is required, however, to determine whether such a rule can be reliably and practicably applied in the field.

45. Minimum diameter felling limits are not enough to prevent overharvesting and ensure RIL efficiency. There should be an upper ceiling for harvesting intensity (**mandatory**).
For hill dipterocarp forests in Indonesia, we recommend, following Sist *et al.* (2003), limiting harvesting to less than 10 commercial trees/ha within a limited dbh range, which permits the use of lighter machinery and should not be a significant production constraint. Very large trees are often difficult to fell and extract without splitting or damaging non-target trees; they are usually reproductive, can serve as seed trees, and are more likely to be rotten or hollow than smaller trees.

In Vietnam, the situation is different as an upper limit of harvest is established as a percentage of the standing stock. Studies are needed, however, to measure to what extent these rules really prevent over-harvesting. The exact dbh or standing volume percentage range should be determined depending on species traits, forest structure, terrain and available processing facilities.

Specifying the best configuration of directional felling involves more than ease of skidding and winching or reduction in residual damage, and choices remain debateable. Dispersed gaps have the advantage that felled trees will not be tangled (Johns *et al*. 1996), and that the resulting openings will be relatively small, but felling so that crowns fall on top of each other (or into existing gaps) can reduce the total amount of canopy damage (Malcolm and Ray 2000), although such large multi-tree gaps are in general undesirable.

46. Commercial trees should be felled in the direction of least damage to the residual stand (**strongly recommended**).
Decisions on felling direction need to be taken on a case-by-case basis, depending on terrain and local conservation or management objectives.

It is important to keep soil and forest floor disturbance to a minimum as many invertebrates, reptiles and amphibians use the soil as a refuge (Fimbel *et al*. 2001) and as forest regeneration is generally severely hampered by soil compaction and topsoil disturbance.

47. In areas of very shallow soils or patches of white sandy soils, it would be advisable to refrain from felling trees regardless of the economic benefits of the logs as the land is generally unable to recover vegetation of any value (Chunkao 1978) (**recommended**).

48. The use of skylines can be considered in especially sensitive areas: for instance, if a rare, easily disturbed key species occurs (**recommended**).
This technique is more expensive than ground skidding on all but the most difficult terrain (Aulerich *et al*. 1974 in Pinard *et al.* 2000). The potential risks/benefits ratio for biodiversity need also to be carefully assessed as the conservation value of opening up areas that might otherwise remain unlogged remains uncertain.

49. Plan different activities for dry and wet weather periods to minimize erosion and soil compaction (**strongly recommended**).
Extraction should not take place during wet periods in areas that are particularly sensitive to disturbance (Pringle and Benstead 2001), and ground skidding should be avoided during very wet periods (Mason and Putz 2001).

50. When timber is dragged out, bulldozers or skidders should normally move with their blades up (Malcolm and Ray 2000), so no slash piles are created and disruption of the forest floor is less severe (**strongly recommended**).

51. Operating slope limits should ideally reflect local knowledge and conditions. Experts suggest a maximum slope of 50% (<27°) for felling and a skid trail gradient maximum of 35% (<20°) up to 40% (<22°) under especially favourable soil conditions only (**recommended**).

52. On very steep terrain, winches should be used as much as possible to drag timber towards larger skid trails from where they are further transported by skidders (**strongly recommended**).

53. Heavy machinery used in road building (e.g. the Caterpillar D7) should not be used in skidding operations as it causes unnecessary damage and its operational costs are higher than those of lighter machinery (**strongly recommended**).

54. Skidders should reverse out of skid trails, and teams should explore extraction routes on foot rather than from the cab (**mandatory**).

55. Low-impact extraction methods that can considerably reduce soil compaction, erosion and damage to non-harvested vegetation should be explored (**recommended**).
These methods include extraction by draught animals (e.g. buffalo in Northern Vietnam), lighter machinery (agricultural tractors) or machinery with broad rubber tyres.

Post-logging operations

The closure of roads in order to restrict access to forest areas by vehicles and reduce pressure (mainly related to hunting) is often suggested as a post-logging operation. This

recommendation, although fairly logical, is nevertheless difficult to apply in most cases because of the importance of forest roads for the people living in remote forested places. Nevertheless it would seem possible to close some roads on a temporary basis or even to completely close minor roads that have no economic or practical values for local development.

56. After an annual felling coupe is finished, access to some roads should be barred (even temporarily) so that animals can migrate undisturbed and human pressure is reduced (**strongly recommended**).

57. If and when roads are no longer in use they should be closed to avoid entry by vehicles (Mason and Thiollay 2001) (**strongly recommended**).

In Indonesia, the TPTI system prescribes slashing of ground vegetation to speed up regeneration. We argue that this is generally worse than the logging itself as the extreme terrain in hill dipterocarp forests means that logging is patchy. Ground-tending crews, however, work on foot and slash everything, which removes a great deal of vegetation from the forest and is perceived by local people as excessively damaging to many valued non-timber resources (Sheil *et al*. 2003a, b). This almost certainly has a negative impact on many terrestrial animal species (see, for instance, Bernard 2004). In theory, operators can be fined for not slashing ground vegetation as prescribed, however in practice this activity is already ignored in many concessions.

58. Understorey slashing practices, where they exist, should be carefully reviewed and abandoned when not specifically required for safety or forest regeneration (**mandatory**).

59. Placing cross-drainage on very compacted areas will ensure proper drainage of these areas (**strongly recommended**).

Rehabilitation of areas severely degraded by logging operations (log landings, feeder roads, quarries, etc.) is one of the measures aimed at a) reducing soil erosion and sedimentation and b) maintaining or increasing vegetation diversity for wildlife conservation purposes. If forests are well managed large-scale reforestation should be unnecessary, but protecting the much-degraded sites from erosion is important. There should be systematic post-logging rehabilitation of log landings and stream crossings – primarily to reduce soil erosion. In cases where roads or landings will not be used in future harvest cycles, effort needs to be made to re-forest them. Such rehabilitation of deforested or severely degraded land can serve a useful conservation purpose (e.g. Goosem and Tucker 1995; Dunn 2004). This is especially likely when such rehabilitation makes use of a variety of native tree species that are both of value to the timber industry and to wildlife, and increases connections between original forest areas, or serves to buffer forest edges.

60. Top soil deposits on quarries and landings should be redistributed over the entire area (**recommended**).
One should note, however, that this might be difficult to implement and that use of a cover crop might be needed to avoid topsoil runoff.

61. Rehabilitation with replanting, if needed, should be carried out continuously as harvesting based on each landing is completed, rather than waiting until the whole compartment has been worked over (**strongly recommended**).

62. Areas with no remaining tree cover should be replanted with local species and mimic a natural re-colonization as far as possible (**mandatory**).

In Kalimantan (Indonesia) this might include a succession of cover crops (preferably Leguminosae) followed by vigorous pioneer species such as *Trema* spp. or *Peronema canescens* able to persist and grow in bright open conditions, followed again by native tree species that are important for wildlife (*Parkia* spp., *Baccaurea* spp., *Nephelium* spp., *Ficus* spp., *Mangifera* spp. and *Pithecellobium* spp.) or for timber and wildlife (*Tetramarista glabra*, *Meliosma sumatrana*, *Artocarpus* spp., *Aglaia* spp., *Dysoxylum* spp., *Durio* spp.). Another option (practised by the Sumalindo Company) is to plant domesticated fruit trees (durian, jackfruit) after the cover crop.

In Vietnam, potential species that could be used are *Canarium album*, *Talauma gioi*, *Michelia mediocris* and *Cinnamomum obtusifolium* (Central Highlands and North) and some dipterocarp species (South). A list

of species (containing both exotic and local species) suitable to be planted is defined by the Ministry of Agriculture and Rural Development (MARD) according to nine ecological zones, although local species should be favoured as much as possible.

Minimising indirect impacts and threats

Hunting and extraction

Hunting, associated with logging, places additional pressures on wildlife and other components of biodiversity. There need to be clear regulations concerning wildlife hunting and trading in the forest area gazetted for logging. Zone boundaries and meanings must be clearly identified on the ground and recognised by all local actors. Similarly, all regulations and local agreements concerning the use and protection of species or sites must be known by all resource users, who should be guided by, or seek to enforce, them. It must be noted, however, that logging companies do not have direct control of local people living in the area and that prohibiting hunting for local people can be somewhat conflictual, even unethical. However, the presence of the company should, at least, not increase the actual levels of hunting. The following applies mainly to Indonesia, where subsistence hunting by locals and commercial hunting is still widespread in forests newly opened by logging. In Vietnam, the problem appears less acute because of the very strict regulations on firearms and the fact that the common fauna is already largely extinct, leaving only protected species to hunt and risking high penalties. Nevertheless, wildlife consumption and trade are considered a very serious threat to Vietnamese biodiversity, ranked as more critical than logging (Anonymous 2005). Protected species are poached (especially the group of rare wild bovid species present in the remote mountainous areas), but these illegal activities do not appear to be strictly linked to logging operations. Commonly traded wildlife species include wild pigs *Sus* spp., sambar deer *Cervus unicolor*, bears and primates (Anonymous 2005). The illegal trade in wildlife meat within Vietnam was estimated in 2002 at 3 million tons, an economic value three times larger than the budget of Vietnam's chief wildlife enforcement body, i.e. the Forest Protection Department (Sterling *et al*. 2006).

Suggestions (modified from Bennett and Robinson 2000 and Fimbel *et al*. 2001) for how to curtail unsustainable hunting in forest concessions include:

63. Hunting of protected species must be prohibited, and sanctions should be imposed on staff by the company independent of possible official legal action against poachers. Staff at all levels should be informed of the species that are protected or subject to trade restrictions (**mandatory**).

64. Commercial hunting by employees should be forbidden throughout the concession, even for common species (**mandatory**).

65. Prohibit and enforce bans on trade in all wildlife and animal parts, particularly of protected, rare, endemic, endangered, threatened, vulnerable, or slowly reproducing species within, from and to production forests (**mandatory**).

66. If subsistence hunting is to continue by employees, especially in the case of local indigenous people, clear procedures and checks are required to ensure that the process is not abused (**strongly recommended**).

67. Zones where hunting or trapping is forbidden should be established within the forest (**mandatory**).
These zones can be fixed for the whole felling cycle or rotate from time to time and may or may not overlap with the network of areas reserved from logging.

68. The use of electric shocks, bombs and poison in fishing is destructive to many components of the aquatic ecosystem and thus kills many more animals than are actually collected. These non-specific fishing techniques should be stopped and sanctions imposed on employees involved (**mandatory**).

69. Negotiate and establish exclusive hunting rights for the original inhabitants of certain areas. This could limit the impact of commercial hunting by outsiders. Such controls can be based on traditional claims (*adat* in Kalimantan) and councils but with written documents in which rights and responsibilities are clearly defined (**recommended**).

Note that this recommendation appears sensitive in the Vietnamese context where the government considers that the law should be

the same for all and that such rights could be considered as privileges based on ethnicity and therefore not permitted.

70. Logging companies' and contractors' vehicles should be barred from carrying wildlife, thereby ensuring that they cannot be used for the wild meat or pet trade. Sanctions should be imposed on offending drivers (**mandatory**).

71. Staff and relatives should be instructed regarding the importance and use of wildlife resources in the concession. Staff should not feel free to collect whatever they wish from the forest and should be strictly regulated in terms of all wildlife collection (**strongly recommended**).

Bennett (2002) and Lee (2000) argue that a reduction in hunting pressure on tropical wildlife is more likely if people have alternative sources of protein. They suggest that companies could be required to subsidise and import meat and/or to encourage small-scale localised farming (chickens, pigs or fish). They could assist in the development of farming programmes, although the cultural acceptance of domestic sources of protein as opposed to wildlife remains an obstacle in many locations. Access to and subsidy of technological improvements in storing meat (freezing and refrigeration) can also help decrease waste but also potentially increases the risk of storage of wild meat for commercial purposes. However, the threat to wild species potentially posed by domestic livestock, particularly through disease and cross-breeding, should be noted. Special care must be taken not to release domesticated pigs or 'Bali cattle' (domesticated Banteng), which may interbreed with the remaining wild populations of Bearded Pig *Sus barbatus* or Banteng *Bos javanicus*.

72. Logging companies should ensure adequate protein supplies for all staff and workers using the most appropriate solutions (import, farming…), thereby removing the need for them to hunt (**strongly recommended**).

Fire

In Indonesia, recent major fires, such as those in 1997–98 that devastated large areas of forest in East Kalimantan (Siegert *et al*. 2001), show the considerable damage that fires can cause to forests and wildlife, especially when coupled with poor logging practices (Nasi *et al*. 2002). Smoke also has a severe impact on people and the environment. This is especially true in the drier parts of Borneo where drought and fires have the ability to destroy large areas of selectively logged forest (Leighton and Wirawan 1986; Woods 1989) as well as in peat swamp forest areas (Page *et al*. 2002). In Vietnam, people seem much more sensitive to the issue of forest fires and most employees of state bodies (including forest enterprises or research organisations) are required to undertake fire fighting training. Arson is also rare because it is very severely punished.

It is nevertheless important that a fire management strategy is in place and that the human and financial resources are available to implement this immediately. At a monitoring level, satellite-based early warning systems detecting active fires (hot spots) and dryness indices provide valuable information for forest managers (Hoffmann *et al*. 1999). A number of these systems are semi-operational in Indonesia (Dennis 1999). In theory, such systems provide fire managers with the necessary information to carry out hazard reduction and removal, establishment of fire breaks to protect valuable resources, and up-to-date fire situation information during an active fire emergency. However there are still major challenges to building institutional infrastructure for fire management, in both the public and private sector, and there is also the problem of lack of instantaneous communication with remote sites (Dennis *et al*. 2005).

73. There is a need for trained fire fighters to be on call at the forest management unit or district level, and for at least one trained manager who monitors fires and coordinates fire fighting and prevention activities during periods of threat in each concession (**strongly recommended**).

74. Establishing working relationships with local communities who traditionally use fire for agricultural activities or for attracting wildlife near logging concessions would further help reduce the risk of unwanted fires in the vicinity of forest areas (**strongly recommended**).

Van Nieuwstadt *et al*. (2001, 2002) showed that the current practice of salvage harvesting in dipterocarp forests needs to be revised. In Indonesia, concession holders cannot normally re-cut harvested forest areas without waiting the statutory period (35 years according to

the TPTI system). However, fire removes this restriction, and allows further felling at little cost.

75. Perverse incentives that encourage arson must be removed and regulations about salvage logging after fires should be carefully designed to avoid both such perverse incentives and the waste of residual timber (**mandatory**).

Exotic and invasive species

The uncontrolled spread of exotic invasive species is a problem affecting all forest ecosystems, with profound potential impacts on biodiversity, ecosystem processes and services, and even global climate. The problem is already severe in some forested areas, and just starting in others as increases in trade, tourism and other factors accelerate the rates both of introduction and of successful establishment of new species. Prevention of alien species problems is possible, particularly if pathways of introduction are understood and effective preventative measures and rapid-detection surveillance systems are initiated. If invasions are detected early enough, eradication may be an option. Failing that, there exist long-term management approaches, in particular classic biological control, which may mitigate the impacts of invasive alien species. Beyond technology, community participation, effective policy development and international cooperation all have roles to play in protecting forests from damage by invasive alien species. Though exotic invasion after logging does not appear to be a major problem in Vietnam, since usual felling intensity is relatively low and native species regenerate, the Global Invasive Species Database (http://www.issg.org/database/welcome/) records 25 invasive species in natural forests in Vietnam. The same database records 44 invasive species for Indonesian forests.

76. Logging concessionaires should monitor the spread of exotic species in their area and actively remove them before they become a problem for wildlife and forest regeneration. Species and genera known to have caused problems elsewhere should be actively guarded against (**strongly recommended**).

77. An institution (national agency, NGO, cooperative…) should publish and update lists of invasive exotic species, how to recognise them, and how to combat them (**strongly recommended**).
Rejmanek (1999), for example, provided such a scheme for screening high-risk woody exotics. Frequent consultation of the Global Invasive Species Program Website (http://www.gisp.org/) will also provide useful information.

78. Reforestation programmes should avoid exotic species as far as is practicable – if exotics must be used, species must be selected with care and the results should be monitored (**strongly recommended**).
See also recommendation 62.

Measures are needed to ensure minimal transfer of soil and other potentially infected material between sites. A general recommendation is to seek region-wide control regarding the import and movements of live soil, plants and animals – and associated hygiene regulations. Many useful templates for such regulations exist, with Australia providing very detailed prescriptions.

79. All vehicles brought in from outside the concession area need to be washed down to remove weed seed and cuttings of exotic species (**recommended**).

Implementation of these recommendations requires increased awareness of the issues at the community, local government and concession levels.

80. Producing well targeted extension materials about the risks of spreading harmful organisms may make a significant contribution (**strongly recommended**).

Domestic animals

As already noted in the section on hunting, domestic animals such as cattle, dogs and cats can be major threats to native wildlife, either directly (e.g. May and Norton 1996; Clarke and Pacin 2002) or indirectly as sources of disease. Knapen (1997) reported a rinderpest epidemic that killed a large proportion of the cattle population of Southeast Borneo between 1871 and 1872 before spreading to the Bearded Pig population, which it affected in areas as far afield as the Upper Kahayan and Kapuas Rivers in Central Kalimantan. In 1878, rinderpest struck once more, again hitting the cattle population first and later killing pigs in large numbers. Another epidemic was reported

by Nieuwenhuis (1907, Vol. 1, p. 196), who mentioned that during his journey through central Borneo in 1894 pigs were rare because both the wild and domestic pig populations had been killed off by an epidemic in central Borneo in 1888 and 1889. The spread of rabies and distemper from domestic dogs to wildlife as well as of various avian diseases spread by domestic fowl is an additional threat to native species (e.g. Butler *et al*. 2004).

81. Prohibit free-ranging pets and livestock in forest areas. In order to minimize risk of disease transmission to and from native species, domestic cattle, goats, pigs and chickens should confined, preferably penned, in specific areas and not be allowed to run free (**recommended**).

Traffic

Stringent regulations for road use will reduce the number of accidents and injuries and would also limit illegal hunting and timber extraction. These regulations could include closure of roads to non-essential traffic at night, checkpoints to monitor wildlife and the timber trade, prohibition of foot traffic on roads, and prohibition of transport of hunting weapons, traps, snares, etc. on forest roads.

82. Manned booths with security guards should be established at the main entry points to the concession area (**mandatory**).
If vehicles are seen that have entered without a permit from the appropriate authority: (1) drivers should be requested to leave immediately, (2) staff who manned the booth should be reprimanded, and (3) the management authority should be notified (Muziol *et al*. 2000).

83. Traffic needs to be regulated and speed limits should be imposed, not only to reduce road kills of wildlife but also accidents (**recommended**). See also recommendations 56, 57 and 70.

Forest roads are public in Vietnam so official traffic rules need to be followed. In Indonesia the roads are private and thus have (or may not have) their own rules and regulations.

Pollution

Although not necessarily very high on the conservation agenda, pollution problems created by the existence of an industrial logging operation in an area should not be neglected and are generally taken into consideration in most certification schemes. It is necessary to state first that the forest management in such a case is accountable only for its own operation and cannot be accountable for pollution occurring upstream (such as the use of mercury in gold panning).

Refuse from camp and workshop areas should be removed, and all solid waste should be placed in a refuse pit and buried (Elias *et al*. 2001). This is important, as local people often scavenge for improperly disposed refuse (especially car batteries) exposing themselves to serious health risks. Rubbish should never be thrown into watercourses.

84. All refuse, including rubbish, solid waste, oils and chemicals, if no longer suitable for re-use, should be disposed in an environmentally friendly manner at off-site locations (**strongly recommended**).

85. Used oils, batteries and other potentially harmful but recyclable chemicals should be recycled in the company's facilities or, if such do not exist, transported out of the forest to existing facilities (**strongly recommended**).

86. The use of herbicides must be restricted to silvicultural treatments under strictly controlled conditions so as to avoid contamination of the environment (**mandatory**).

87. The use of toxic chemicals in the vicinity of water courses is strictly prohibited (**mandatory**).

88. Wood preservatives should be utilized with appropriate techniques to protect the health of the worker and the environment (**mandatory**).

Logging and conservation for local people

Logging operations should seek common ground with local people as a basis for developing conservation activities outside strictly protected areas. Some of these ideas have already been noted elsewhere (e.g. protecting salt-licks, clean water and valued wildlife resources; see Sheil 2003a, b for East Kalimantan). The following recommendations are worth noting. They appear much more relevant for Indonesia, where indigenous people live in forest concessions, than in Vietnam, with its system of gazetted State Forests, but some recommendations might apply to areas where ethnic minorities live.

89. Consultation with communities who access the concession is required to both guide and inform management (**mandatory**).

90. It is necessary to identify and clearly protect sites with local heritage values or other local significance (grave sites, old villages, sacred locations, etc.) from logging (**strongly recommended**).

91. Ensure that the legal and practical mechanisms are in place for local communities to be involved in decision making about and management of natural resources in their area (**strongly recommended**).
This must be done so that the necessary checks and balances are in place to prevent overexploitation. Co-management or collaborative management partnerships between local communities and technical/ scientific advisors (government or non-government) may ensure this.

92. Areas with a high abundance of important products (even if legal rights are unclear) such as bamboo, rattan, eagle-tree or *gaharu* (*Aquilaria* spp.), birdnest caves, etc. should be identified with the help of local people and protected (**strongly recommended**).

93. Species of great importance to local people should be granted special status under government regulations and not be harvested except by locals for their own use (**mandatory**).

94. The cultural needs of local communities need to be assessed and incorporated into management plans (**strongly recommended**).
For example, in East Kalimantan Dayak tribes have a cultural need for hornbill feathers (Sheil *et al.* 2003c).

Implementation and vigilance

Monitoring

Regarding monitoring, Sheil *et al*. (2004) suggested an initial emphasis on conventions, laws and locally negotiated rules. The purpose of monitoring programmes should then be to check that these regulations are accepted and are implemented. A basis for local verifiers could include:

1. What are the current major threats in the vicinity? What are the most likely future threats? Are these reflected in pre-emptive monitoring?
2. What proportion of the responsible parties knows the agreed rules and responsibilities?
3. How many times have rules been enforced, over time? What has happened as a result?
4. What are the estimated amounts of illegal hunting produce found by spot checks in local areas (number or weight of animals found per day)?
5. What is the percentage of forest workers who have affordable alternative sources of protein?
6. What are the numbers of tools, trophies, or other items associated with illegal hunting activities found in inappropriate locations per head of population?

Qualitative assessments (i.e. spot checks) will probably often suffice to identify whether or not there is a serious problem with commercialised hunting. The verifiers and milestones would relate to specific knowledge of the rules and agreements, evidence of capacity and efforts to enforce them, and a search for evidence regarding implementation. There may be good reasons for monitoring selected wildlife populations directly, as sometimes proposed (e.g. Stork *et al*. 1997), but this needs to be the result of careful deliberation. Indirect monitoring may be more efficient.

Monitoring of management interventions is recommended, as is the monitoring of changes in indices of wildlife abundance, when this can guide management – perhaps with outside assistance to ensure expert guidance and evaluation. The specific criteria for this could be stated in a local management plan and a CoP (i.e. what will be done and how). We believe that this two-pronged approach would provide a solid foundation for improving logging practices and making them more compatible with wildlife conservation (Sheil *et al*. 2004).

95. Monitoring procedures following the above philosophy should be put in place, implemented and have their results fed into forest management activities (**strongly recommended**).

96. All concession staff and actors working within the concession should recognise and understand all company regulations concerning their activities. All top and middle-range managers

should know and understand existing local and national regulations (**mandatory**).

97. The activities of staff involved in logging should be constantly supervised at different levels. This should include production supervisors, block inspectors, and felling and skidding foremen (**strongly recommended**).

98. Contractual clauses should be used to specify that violation of regulations may result in penalties and dismissal (**strongly recommended**).

99. To minimize corruption and maximize efficiency, law enforcers should not be paid directly by the logging concessions (**strongly recommended**).
To provide funding for monitoring by the national administration, private companies could, for example, be required to post a bond, paid to the appropriate government ministry, for an amount indexed to the area of forest to be exploited that year (Wilkie *et al.* 2001).

This point is relevant for Indonesia but not for Vietnam, where forest enterprises are state-run, in contrast to Indonesia where they are private. In Vietnam the inspectors who supervise logging are paid by directly by the government, not by the concessions.

100. Means of enforcement should be built into company regulations and backed by official guidelines (**strongly recommended**).
There should be a combination of self-policing with checks by appropriate authorities; ideally these would include trained and authorized biologists. Other stakeholders (community representatives, NGOs, etc.) should be given opportunities to be involved in verification.

101. Forestry certification audits must be carried out by independent third-party accredited organisations as a means of assessing practices and gauging success (**strongly recommended**).

Awareness and training

Current poor harvesting and infrastructure-building practices are mainly the result of lack of knowledge, supervision and incentives of both logging company employees and the government officials supposed to monitor them. We note also that a lack of clarity has allowed many rules and laws to be ignored, misunderstood and even abused. It is necessary to build awareness and understanding of RIL and its links to sustainable forest management and biodiversity conservation among all personnel involved in harvesting and creating roads or trails in the forest, especially key individuals such as chainsaw operators, tree inventory and marking teams, harvesting and roading supervisors, log extraction and roading crews, machine operators, and log scalers. Note that such training would be highly beneficial for forestry officials and other civil servants who are supposed to monitor logging company practices; however this is beyond the control of forest managers.

102. Regular and well structured training of company staff should be carried out in the following topics: chainsaw operation, directional felling and vine cutting; planning, construction and rehabilitation of roads, water crossings, landings and skid trails; supervision (**mandatory**).

103. Staff, especially field supervisors, should also be trained in biodiversity-related issues (**strongly recommended**).
Such training should address: protected status of species and other legal aspects of hunting and trade (including awareness and knowledge of law enforcement authorities and mechanisms), procedures to apply when protected species are in the direct vicinity of a felling site, biodiversity concepts, tree and animal identification, etc.

104. The production of simple but precise educational and public information materials that can be disseminated through official channels, schools, traders, etc. should be considered to raise awareness about biodiversity concerns among staff and their relatives (**strongly recommended**).

References

Anonymous. 2005. Vietnam Environment Monitor 2005. Biodiversity. World Bank, World Bank in Vietnam, Ministry of Natural Resources and Environment Vietnam and Embassy of Sweden, World Bank Office, Hanoi, Vietnam.

Asia-Pacific Forestry Commission. 2006. Taking Stock: Assessing the Progress in Developing and Implementing Codes of Practice for Forest Harvesting in ASEAN Member Countries. Association of South East Asian Nations and FAO, Bangkok, p. 50.

Asner, G.P., Broadbent, E.N., Oliveira, P.J.C., Keller, M., Knapp, D.E. and Silva, J.N.M. 2006. Condition and fate of logged forests in the Brazilian Amazon. Proceedings of the National Academy of Sciences of the USA 103: 12947–12950.

Bennett, E.L. 2000. Forest Certification: Where Is the Voice of the Biologist? Conservation Biology 14: Editorial.

Bennett, E.L. 2002. Is there a link between wild meat and food security? Conservation Biology 16: 590-592.

Bennett, E.L. 2004. Seeing the Wildlife and the Trees: Improving Timber Certification to Conserve Tropical Forest Wildlife. World Bank and Wildlife Conservation Society, Washington, D.C.

Bennett, E.L. and Robinson, J.G. 2000. Hunting of wildlife in tropical forests. Implications for biodiversity and forest peoples. World Bank, Washington, D.C.

Bernard, H. 2004. Effects of selective logging on microhabitat-use patterns of non-volant small mammals in a Bornean tropical lowland mixed-dipterocarp forest. Nature and Human Activities 8: 1-11.

Bierregaard, R.O.J., Lovejoy, T.E., Kapos, V., dos Santos, A. and Hutchings, R.W. 1992. The biological dynamics of tropical rainforest fragments. Bioscience 42: 859-866.

Bierregaard, R.O.J. and Stouffer, P.C. 1997. Understorey birds and dynamic habitat mosaics in Amazonian rainforests. Tropical forest remnants: ecology, management, and conservation of fragmented communities. University of Chicago Press, Chicago, p. 138-155.

Brearley, F.Q., Press, M.C. and Scholes, J.D. 2003. Nutrients obtained from leaf litter can improve the growth of dipterocarp seedlings. New Phytologist 160: 101-110.

Bruenig, E.F. 1957. Waldbau in Sarawak. Allgemeine Forst- und Jagdzeitung 128: 156-165.

Bruijnzeel, L.A. & Critchley, W.R.S. 1994. Environmental impacts of logging moist tropical forests. IHP Humid Tropics Programme Series No. 7. UNESCO, Paris.

Butler, J.R.A., du Toit, J.T. and Bingham, J. 2004. Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: threats of competition and disease to large wild carnivores. Biological Conservation 115: 369-378.

Chunkao, K. 1978. The effects of logging on soil erosion. *In*: Suparto, R.S., Soerianegara, I., Hamzah, Z., Haeruman, H.J., Hadi, S., Manan, S., Basjarudin, H. and Sukotjo, W. (eds.) Proceedings of the Symposium on the Long-term Effects of Logging in Southeast Asia, 656-72. BIOTROP, Bogor, Indonesia.

Clarke, A.L. and Pacin, T. 2002. Domestic cat 'colonies' in natural areas: A growing exotic species threat. Natural Areas Journal 22: 154-159.

Clevenger, A.P., Chruszcz, B. and Gunson, K. 2001. Drainage culverts as habitat linkages and factors affecting passage by mammals. Journal of Applied Ecology 38: 1340-1349.

Counsell, S. and Loraas, K.T. 2002. Trading in Credibility: The myth and reality of the Forest Stewardship Council. Rainforest Foundation, London, UK.

Curran, L.M., Trigg, S.N., McDonald, A.K., Astiani, D., Hardiono, Y.M., Siregar, P., Caniago, I. and Kasischke, E. 2004. Lowland forest loss in protected areas of Indonesian Borneo. Science 303: 1000-1003.

Dawkins, H.C. 1958. The management of natural tropical high forest with special reference to Uganda. Institute Paper No. 34. Oxford Forestry Institute, Oxford, UK. 155p.

DeBonis, J.N. 1986. Harvesting tropical forests in Ecuador. Journal of Forestry 84 (4): 43-46.

DFID. 1999. Indonesia. Towards sustainable forest management. Final report of the senior management advisory team and the provincial level forest management project. Vol. 2. DFID and Ministry of Forestry of Indonesia, Jakarta.

Dennis, R.A. 1999. A review of fire projects in Indonesia 1982–1998. Center for International Forestry Research (CIFOR), Bogor, Indonesia, p. 112.

Dennis, R.A., Mayer, J., Applegate, G., Chokkalingam, U., Colfer, C.J.P., Kurniawan, I., Lachowski, H., Maus, P., Permana, R., Ruchiat, Y. *et al*. 2005. Fire, people and pixels: linking social science and remote sensing to understand underlying causes and impacts of fires in Indonesia. Human Ecology 33: 465-504.

Dennis, R., Meijaard, E., Nasi, R. and Gustafsson, L. 2007. Biodiversity conservation in SE Asian timber concessions: An overview of the implementation of guidelines and recommendations. Unpublished.

Down to Earth. 2001. Certification in Indonesia: A Briefing. International Campaign for Ecological Justice in Indonesia, London, UK.

Dunn, R.R. 2004. Managing the tropical landscape: a comparison of the effects of logging and forest conversion to agriculture on ants, birds, and lepidoptera. Forest Ecology and Management 191: 215-225.

Dykstra, D.P. and Heinrich, R. 1992. Sustaining tropical forests through environmentally sound timber harvesting practices. Unasylva 169: 9-15.

Dykstra, D. and Heinrich, R. 1996. FAO model code of forest harvesting practices. FAO, Rome.

Elias, Applegate, G., Kartawinata, K., Machfudh and Klassen, A. 2001. Reduced impact logging guidelines for Indonesia. Center for International Forestry Research (CIFOR), Bogor, Indonesia.

Estève, J. 1983. La destruction du couvert forestier consécutive à l'exploitation forestière de bois d'oeuvre en forêt dense tropicale humide africaine ou américaine. Bois et Forêts des Tropiques 201: 77-84.

Ewel, J. & Conde, L.F. 1980. Potential ecological impact of increased intensity of tropical forest utilization. Biotrop Special Publication No. 11. Biotrop, Bogor, Indonesia.

FAO (Food and Agriculture Organization of the United Nations). 1993a. The challenge of sustainable forest management: What future for the world's forests? FAO, Rome.

FAO (Food and Agriculture Organization of the United Nations). 1993b. Forest resources assessment 1990: Tropical countries. Forestry Paper No. 112. FAO, Rome.

FAO (Food and Agriculture Organization of the United

Nations). 1999. Code of Practice for Forest Harvesting in Asia-Pacific. RAP Publication No. 1999/12. FAO, Regional Office for Asia and the Pacific, Bangkok, Thailand.

FAO (Food and Agriculture Organization of the United Nations). 2005. Global Forest Resources Assessment 2005. Progress towards sustainable forest management. Forestry Paper No. 147. FAO, Rome.

Fiji Ministry of Forests. 1990. Fiji National Code of Logging Practice. Ministry of Forests, Suva, Fiji. (Plus a 7-page booklet on chainsaw use and safety).

Fimbel, R.A., Grajal, A. and Robinson, J.G. 2001. Logging and wildlife in the tropics. *In*: Fimbel, R.A., Grajal, A. and Robinson, J.G., (eds.) The cutting edge: conserving wildlife in logged tropical forest, 667-695. Columbia University Press, New York.

Forest Liaison Bureau (FLB). (2002). Revising the silviculture system? Forests Initiatives Newsletter 10: 4-5.

Fox, J.E.D. 1968. Logging damage and the influence of climber cutting prior to logging in the lowland dipterocarp forest of Sabah. Malaysian Forester 31(4): 326-347.

Fredericksen, T.S. and Putz, F.E. 2003. Silvicultural intensification for tropical forest conservation. Biodiversity and Conservation 12: 1445-1453.

FSC. 1994, revised 2000. FSC Principles and Criteria. Forest Stewardship Council, Oaxaca, Mexico. http://www.fscoax.org/principal.htm.

Goosem, M. 1997. Internal fragmentation: Effects of roads, highways, and powerline clearings on movements and mortality of rainforest vertebrates. *In*: Laurance, W.F and Bierregaard, O.J. (eds.) Tropical forest remnants: ecology, management, and conservation of fragmented communities, 245-255. University of Chicago Press, Chicago.

Goosem, S. and Tucker, N.I.J. 1995. Repairing the rainforest. Theory and practice of rainforest re-establishment in North Queensland's wet tropics. Wet Tropics Management Authority, Cairns, Australia.

Government of Vietnam. 2007. Vietnam Forestry Development Strategy 2006–2020. (Promulgated and enclosed with Decision No. 16/2007/QD-TTg, dated 5 February 2007, by the Prime Minister). Government of Vietnam, Hanoi.

Gray, J.A. and Hadi, S. 1989. Forest concessions in Indonesia: Institutional aspects. (Ministry of Forestry, Government of Indonesia, Food and Agriculture Organization of the United Nations, UTF/INS/065/INS: Forestry Studies, Field Document No: VI-1). FAO, Jakarta.

Hendrison, J. 1989. Damage-controlled logging in managed tropical rain forests in Suriname. Ecology and Management of Tropical Rain Forests in Suriname (series). Wageningen Agricultural University, Wageningen, The Netherlands.

Hoffmann, A.A., Hinrichs, A. and Siegert, F. 1999. Fire damage in East Kalimantan in 1997/1998 related to land use and vegetation classes: Satellite radar inventory results and proposal for further actions. IFFM-SFMP Report No.1a. MOFEC, GTZ and KfW, Samarinda, East Kalimantan, Indonesia.

ITTO (International Tropical Timber Organization). 1990. ITTO guidelines for the sustainable management of natural tropical forests. Technical Series No. 5. ITTO, Yokohama, Japan.

ITTO (International Tropical Timber Organization). 1993. ITTO Guidelines for the conservation of biological diversity in Tropical Production Forests. ITTO, Yokohama, Japan.

ITTO (International Tropical Timber Organization). 2005. Revised ITTO criteria and indicators for the sustainable management of tropical forests including reporting format. Policy Development Series No. 15. ITTO, Yokohama, Japan.

ITTO (International Tropical Timber Organization). 2006. Status of Tropical Forest Management 2005: Asia and the Pacific. ITTO, Yokohama, Japan.

IUCN. 2006. Guidelines for the Conservation and Sustainable Use of Biodiversity in Tropical Timber Production Forests. IUCN – The World Conservation Union, Gland, Switzerland.

Jennings, S., Nussbaum, R., Judd, N. and Evans, T. 2003. The High Conservation Value Forest Toolkit. http://www.proforest.net/publications/allpubs2

Johns, J.S., Barreto, P. and Uhl, C. 1996. Logging damage during planned and unplanned logging operations in the eastern Amazon. Forest Ecology and Management 89: 59-77.

Jonkers, W.B.J. 1987. Vegetation structure, logging damage and silviculture in a tropical rain forest in Suriname. Ecology and Management of Tropical Rain Forest in Suriname No. 3. Wageningen Agricultural University, Wageningen, The Netherlands.

Klassen, A. 2005. Planning considerations for reduced impact logging. Prepared for ITTO Project PD 110/01 Rev. 4 (I). Tropical Forest Foundation, Jakarta, Indonesia.

Knapen, H. 1997. Epidemics, droughts, and other uncertainties on Southeast Borneo during the eighteenth and nineteenth centuries. *In*: Boomgaard, P., Colombijn, F. and Henley, D. (eds.) Paper Landscapes. Explorations in the environmental history of Indonesia, 121-152. KITLV Press, Leiden, The Netherlands.

Lambert, F.R. 1991. The conservation of fig-eating birds in Malaysia. Biological Conservation 58: 31-40.

Lambert, F.R. and Collar, N.J. 2002. The future for Sundaic lowland forest birds: long-term effects of commercial logging and fragmentation. Forktail 18: 127-146.

Laurance, W.F. 1990. Comparative responses of five arboreal marsupials to tropical forest fragmentation. Journal of Mammalogy 71: 641-653.

Laurance, W.F. 1991. Ecological correlates of extinction proneness in Australian tropical rain forest mammals. Conservation Biology 5: 79-89.

Lee, R.L. 2000. Impact of subsistence hunting in North Sulawesi, Indonesia, and conservation options. *In*: Robinson, J.G. and Bennett, E.L. (eds.) Hunting for sustainability in tropical forests, 455-472. Columbia University Press, New York.

Leighton, M. and Leighton, D.R. 1983. Vertebrate responses to fruiting seasonality within a Bornean rain forest. *In*: Sutton, S.L., Whitmore, T.C. and Chadwick, A.C. (eds.) Tropical rain forest: Ecology

and management, 181-196. Blackwell Scientific Publications, Oxford.

Leighton, M. and Wirawan, N. 1986. Catastrophic drought and fire in Borneo tropical rain forest associated with the 1982-1983 El Nino southern oscillation event. *In*: Prance, G.T. (ed.) Tropical rain forest and world atmosphere, 75-101. Westview Press, Boulder, Colorado.

Lindenmayer, D.B., Frankling J.F. and Fischer, J. 2006. General management principles and a checklist of strategies to guide forest biodiversity conservation. Biological Conservation 131: 433-445.

Lovejoy, T.E., Bierregaard, O.J., Rylands, A.B., Malcolm, J.R., Quintela, C.E., Harper, L.H., Brown, K.S., Powell, A.H., Powell, G.V.N., Scubart, H.O.R. and Hays, M.B. 1986. Edge and other effects of isolation on Amazon forest fragments. *In*: Soulé, M.E. (ed.) Conservation biology; the science of scarcity and diversity, 257-285. Sinauer Associates, Inc., Sunderland, MA.

Malcolm, J.R. and Ray, J.C. 2000. Influence of timber extraction routes on Central African mammal communities, forest structure, and tree diversity. Conservation Biology 14: 1623-1638.

Marn, H.M. and Jonkers, W. 1982. Logging damage in tropical high forest. *In*: Srivastava, P.B.L. *et al*. (eds.) Tropical forests – source of energy through optimisation & diversification. Proceedings of an international conference. Penerbit Universiti Pertanian, Serdang, Selangor, Malaysia, 11-15 November 1980, p. 27-38.

Mason, D.J. and Putz, F.E. 2001. Reducing the impacts of tropical forestry on wildlife. *In*: Fimbel, R.F., Grajal, A. and Robinson, J.G. (eds.) The cutting edge: Conserving wildlife in logged tropical forest, 473-509. Columbia University Press, New York.

Mason, D.J. and Thiollay, J. 2001. The effects of logging on tropical forest ungulates *In*: Fimbel, R.F., Grajal, A. and Robinson, J.G. (eds.) The cutting edge: Conserving wildlife in logged tropical forest, 167-191. Columbia University Press, New York.

Marcot, B.G., Gullison, R.E. and Barborak, J.R. 2001. The effects of logging on tropical forest ungulates. *In*: Fimbel, R.F., Grajal, A. and Robinson, J.G. (eds.) The cutting edge: Conserving wildlife in logged tropical forest, 523-558. Columbia University Press, New York.

May, S.A. and Norton, T.W. 1996. Influence of fragmentation and disturbance on the potential impact of federal predators on native fauna in Australian forest ecosystems. Wildlife Research 23: 387-400.

Meijaard, E. and Sheil, D. 2007a. The persistence and conservation of Borneo mammals in lowland rain forests managed for timber: observations, overviews and opportunities. Ecological Research. DOI 10.1007/s11284-007-0342-7.

Meijaard, E. and Sheil, D. 2007b. A logged forest in Borneo is better than none at all. Nature 446: 974.

Meijaard, E. and Sheil, D. 2007c. Is wildlife research useful for wildlife conservation in the tropics? A review for Borneo with global implications. Biodiversity & Conservation. DOI 10.1007/s10531-007-9161-y.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A. *et al*. 2005. Life after Logging. Reconciling wildlife conservation and production forestry in Indonesian Borneo. Center for International Forestry Research (CIFOR) and UNESCO, Jakarta.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M. J., Rachmatika, I., Wong, A. *et al*. 2006a. Hutan pasca pemanenan. Melindungi satwa liar dalam kegiatan hutan produksi di Kalimantan. CIFOR, WCS and UNESCO, Bogor, Indonesia.

Meijaard, E., Stanley, S.A., Pollard, E.H.B., Gouyon, A. and Paoli, G.. 2006b. Practitioners' guide to managing High Conservation Value Forest in Indonesia. A case study from East Kalimantan. The Nature Conservancy, Samarinda, East Kalimantan, Indonesia.

Ministry of Forestry of Indonesia. 2000. Principles and Practices of Forest Harvesting in Indonesia. Ministry of Forestry, Republic of Indonesia, Jakarta.

Muziol, C., Yuan, C.T. and Keong, G.B. 2000. Reconciling logging and the conservation of biodiversity: Recommendations for a large timber concession in Terengganu, Peninsular Malaysia. *In*: Bista, M.S., Joshi, R.B., Amatya, S.M., Parajuli, A.V., Adhikari, M.K., Saiju, H.K., Thakur, R., Suzuki, K. and Ishii, K. (eds.) Proceedings of the 8th International Workshop of Bio-Refor, Kathmandu, Nepal, November 28 – December 2, 1999, 270-277. BIO-REFOR, Nepal.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., de Fonseca, G.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Nasi, R., Dennis, R., Meijaard, E., Applegate, G. and Moore, P. 2002. Forest fires and biological diversity. Unasylva 53: 36-41.

Nasi, R. and Forni, E. 2003. La gestion durable des forêts. Le Flamboyant 56: 39-40.

Nicholson, D.I. 1958. An analysis of logging damage in tropical rain forest, North Borneo. Malaysian Forester 21: 235-245.

Nicholson, D.I. 1979. The effects of logging and treatment on the mixed dipterocarp forests of South-East Asia. Report FO:MISC/79/8. Food and Agriculture Organization of the United Nations, Rome.

Nieuwenhuis, A.W. 1907. Quer durch Borneo. Ergebnisse seiner Reisen in den Jahren 1894, 1896-97 und *1898-1900*. E.J. Brill, Leiden, The Netherlands.

Nykvist, N.H., Grip, H., Liam Sim, B., Malmer, A. and Khiong Wong, F. 1994. Nutrient losses in forest plantations in Sabah, Malaysia. Ambio 23: 210-215

O'Brien, T.G., Kinnaird, M.F., Direnfeld, E.S., Conklin-Brittain, N.L., Wrangham, R.W. and Silver, S.C. 1998. What's so special about figs? Nature 392: 668.

Page, S.E., Siegert, F., Rieley, J.O., Boehm, H.-D.V., Jaya, A. and Limin, S. 2002. The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature 420: 61-65.

Pinard, M.A., Barker, M.G. and Tay, J. 2000. Soil disturbance and post-logging forest recovery on

bulldozer paths in Sabah, Malaysia. Forest Ecology and Management 130: 213-225.

Poonswad, P., Sukkasem, C., Phataramat, S., Hayeemuida, S., Plongmai, K., Chuailua, P., Preeda Thiensongrusame and Jirawatkavi, N. 2004. Comparison of cavity modification and community involvement as strategies for hornbill conservation in Thailand. Biological Conservation 122: 385–393.

Poore, D. and Sayer, J. 1990. The management of tropical moist forest lands: Ecological guidelines, Second Edition. IUCN Tropical Forest Programme, Publication No. 2. IUCN, Gland, Switzerland.

Poore, D., Burgess, P., Palmer, J., Rietbergen, S. and Synott, T. 1989. No timber without trees: Sustainability in the tropical forest. Earthscan Publications Ltd., London.

Primack, R. and Corlett, R. 2005. Tropical Rain Forests. An Ecological and Biogeographical Comparison. Blackwell Publishing, Malden, MA, USA.

Pringle, C.M. and Benstead J.P. 2001. The effects of logging on tropical river ecosystems. *In*: Fimbel, R.F., Grajal, A. and Robinson, J.G. (eds.) The cutting edge: Conserving wildlife in logged tropical forest, 305-325. Columbia University Press, New York.

Proforest/SmartWood. 2003. Identifying, Managing and Monitoring High Conservation Value Forests in Indonesia: A Toolkit for Forest Managers and other Stakeholders. SmartWood Asia Pacific Program, Jakarta, Indonesia.

Putz, F.E. and Pinard, M.A. 1993. Reduced-impact logging as a carbon-offset method. Conservation Biology 7(4): 755-757.

Putz, F.E., Blate, G.M, Redford, K.H., Fimbel, R. and Robinson, J. 2001. Tropical forest management and conservation of biodiversity: an overview. Conservation Biology 15: 7-20.

Queensland Forest Service. Undated. Guidelines for the selective logging of rainforest areas in North Queensland state forests and timber reserves. Queensland Forest Service, Brisbane, Queensland, Australia.

Redhead, J.F. 1960. An analysis of logging damage in lowland rain forest, Western Nigeria. Nigerian Forest Information Bulletin (new series) 10: 5-16.

Rejmanek, M. 1999. Invasive plant species and invasible ecosystems. *In*: Sandlund, O.T. (ed.) Invasive species and biodiversity management, 79-102. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Schulte-Herbrüggen, B. and Davies, G. 2006. Wildlife Conservation and Tropical Timber Certification. ZSL Conservation Report No. 6. Zoological Society of London, London.

Sheil, D., Liswanti, N., Basuki, I., Wan, M., van Heist, M., Samsoedin, I., Kartawinata, K., Rukmiyati and Agung, M. 2003a. Prioritas lokal dan keanekaragaman hayati dalam lansekap hutan: apa yang penting menurut masyarakat? Jurnal Hutan Indonesia (Indonesia Forest Journal) *Edisi Agustus* (August) – 4-p pull-out special.

Sheil, D., Liswanti, M. van Heist, Basuki, I., Syaefuddin, Samsoedin, I., Rukmiyati and Agung, M. 2003b. Local priorities and biodiversity in tropical forest landscapes: asking people what matters. Tropical Forest Update 13: http://www.itto.or.jp/newsletter/Newsletter.html.

Sheil, D., Puri, R.K., Basuki, I., van Heist, M., Wan, M., Liswanti, N., Rukmiyati, M., Sardjono, M.A., Samsoedin, I., Sidiyasa, K. *et al*. 2003c. Exploring biological diversity, environment and local people's perspectives in forest landscapes. CIFOR with ITTO, Bogor, Indonesia.

Sheil, D., Nasi, R. and Johnson, B. 2004. Ecological criteria and indicators for tropical forest-landscapes: Challenges in the search for progress. Ecology and Society 9: article 7. http://www.ecologyandsociety.org/vol9/iss1/art7

Siegert, F., Ruecker, G., Hinrichs, A and Hoffmann, A.A. 2001. Increased damage from fires in logged forests during droughts caused by El Nino. Nature 414: 437-440.

Sist, P. and Brown, N. 2004. Silvicultural intensification for tropical forest conservation: a response to Fredericksen and Putz. Biodiversity and Conservation 13: 2381-2385.

Sist, P., Dykstra, D. and Fimbel, R. 1998. Reduced-Impact Logging Guidelines for Lowland and Hill Dipterocarp Forests in Indonesia. CIFOR Occasional Paper No. 1. CIFOR, Bogor, Indonesia.

Sist, P., Picard, N. and Bertault, J-G. 2002. Why minimum diameter cutting alone cannot fit with RIL objectives. *In*: Proceedings of the International Conference on the Application of Reduced Impact Logging to Advance Sustainable Forest Management: constraints, challenges and opportunities, 26 February – 1 March 2001, Sarawak, Malaysia.

Sist, P.R., Fimbel, R., Sheil. D, Nasi, R. and Chevallier, M.H. 2003. Towards sustainable management of mixed dipterocap forest of South East Asia: Moving beyond minimum diameter cutting limits. Environmental Conservation 30: 364-374.

Sodhi, N.S. and Brook, B.W. 2006. Southeast Asian Biodiversity in Crisis. Cambridge University Press, Cambridge.

Sterling, E.J., Hurley, M.M. and Minh, L.D. 2006. Vietnam: a natural history. Yale University Press, New Haven and London.

Stork, N.E., Boyle, T.J.E, Dale, V., Eeley, H., Finegan, B., Lawes, M., Manokaran, N., Prabhu, R. and Soberon, J. 1997. Criteria and indicators of assessing the sustainability of forest management: conservation of biodiversity. CIFOR Working Paper Number 17. http://www.cifor.cgiar.org/docs/_ref/publications/workingpapers.htm. CIFOR, Bogor, Indonesia.

Stouffer, P.C. and Bierregaard, R.O.J. 1995. Use of Amazonian forest fragments by understory insectivorous birds. Ecology 76: 2429-2445.

Styring, A.R. and Hussin, M.H. 2004. Effects of logging on woodpeckers in Malaysian rainforest: the relationship between resource availability and woodpecker abundance. Journal of Tropical Ecology 20: 495-504.

SUFORD. 2006. Review of ProForest HCVF methodology and its application in Lao PDR with the view of further simplification, p. 39. Sustainable Forestry

and Rural Development Project. Co-operation between Governments of Lao PDR, Finland and World Bank, Vientiane, Lao PDR.

Tan C. L. & Drake J. H. 2001. Evidence of tree gouging and exudate eating in Pygmy slow lorises (*Nycticebus pygmaeus*). Folia Primatologica 72: 37-39.

Tropical Forest Foundation. 2006. Management Considerations for Successful Implementation of Reduced Impact Logging. TFF, ITTO, MOF and APHI, Jakarta, Indonesia.

Van Nieuwstadt, M.G.L., Sheil, D. and Kartawinata, K. 2001. The ecological consequences of logging in the burned forests of East Kalimantan, Indonesia. Conservation Biology 15: 1183-1186.

Van Nieuwstadt, M.G.L., Kartawinata, K. and Sheil, D. 2002. Konsekuensi ekologis pembalakan dalam kawasan hutan yang terbakar di Kalimantan Timur. Jurnal Hutan Indonesia (Indonesian Forest Journal), August 2002: 1-4.

Ward, J.P. & Kanowski, P.J. 1985. Implementing control of harvesting operations in north Queensland rainforests. *In*: Shepherd, K.R. and Richter, H.V. (eds.) Managing the tropical forest. Proceedings of a workshop held at Gympie, Australia, 11 July – 12 August 1983, 165-186. Development Studies Centre, Australian National University, Canberra.

Wilkie, D.S., Sidle, J.G, Boundzanga, G.C., Auzel, P. and Blake, S. 2001. Defaunation, not deforestation: Commercial logging and market hunting in Northern Congo. *In*: Fimbel, R.F., Grajal, A. and Robinson, J.G. (eds.) The cutting edge: Conserving wildlife in logged tropical forest, 375-399. Columbia University Press, New York.

Woods, P. 1989. Effects of logging, drought, and fire on structure and composition of tropical forests in Sabah, Malaysia. Biotropica 21: 290-298.

Wyatt-Smith, J. and Foenander, E.C. 1962. Damage to regeneration as a result of logging. Malaysian Forester 25: 40–44.

Appendix 1

Some conservation biology concepts and theories relevant to South East Asian rainforest

Forests, flora and fauna

Biodiversity hotspots

The biodiversity of tropical rainforests is very rich: it is estimated that originally, before the heavy impact of humans, they covered 6–7% of the global land area and supported 50% of all plant and animal species (Primack and Corlett 2005). Tropical rainforests occur on all three equatorial continents – Asia, South America and Africa – and they form one of the most distinct biomes (vegetation units) of the earth. Tropical rainforests are found in areas with very high rainfall and temperature distributed more or less evenly over the year, and they are tall, evergreen and evenly dense. The South East Asian rainforest is found from Burma in the west to New Guinea in the east and from the Philippines in the north to Indonesia in the south. This region is exceptional in hosting 4 out of a total of 25 global hotspots, i.e. areas with very high proportions of endemic species (species which are confined to one area) and very high rates of habitat loss. These four hotspots – Indo-Burma, Sundaland, Wallacea and the Philippines – together cover the whole area of South East Asia (Myers *et al*. 2000) (Figure 1.1).

The importance of production forests to biodiversity

Protected areas versus production forests

The traditional method for preserving biodiversity has been to set aside areas for conservation. According to UN Food and Agriculture Organization (FAO) statistics, about 11% of the world's forest area is in protected areas as classified by the World Conservation Union (IUCN). In South and South East Asia, this proportion is 20% (FAO 2005). Thus, even if the area of protected forest were to increase in the future, it would still represent a fairly small proportion of all the forestland in these two regions. For biodiversity to be conserved, the production forests will always be very important, and it will be necessary to

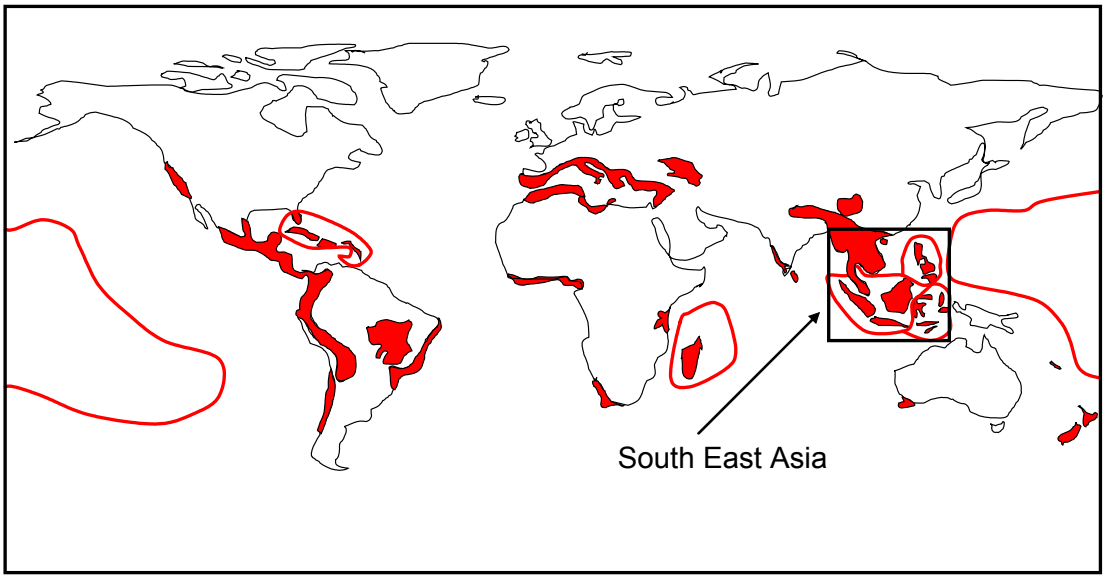

Figure 1.1. Four of the world's 25 hotspots, i.e. areas with exceptionally high biodiversity that are suffering from heavy human impact, are found in South East Asia (Modified from Myers *et al*. 2000)

consider biodiversity very carefully in logging and management activities. Further, it seems clear that protected areas, e.g. in Borneo, are being illegally logged and degraded and thus are losing their biodiversity value (Curran *et al*. 2004).

Most forests in tropical countries, and in other parts of the world, will be actively managed in the future, hence a large proportion of the populations of forest species will inevitably depend on the composition and dynamics of such managed forests. The production forests that act as habitat for species also have an important role to play in supporting and connecting protected areas. The presence of high quality production forests may greatly enhance the probability of reproduction, dispersal and survival of a number of species otherwise at risk of extinction.

Unprotected forests – the matrix

Today there is an increasing focus on the importance of unprotected areas (or the 'matrix', a term used in conservation biology), and on the interaction between reserve and off-reserve areas. It is widely acknowledged that a forest area cannot be viewed in isolation but that there is a need to consider the whole forest landscape with its different forest types, stages of maturity, and degrees and types of management (Figure 1.2).

Production forests are not only of importance to the long-term survival of different species but also play a critical role in providing various ecosystem goods and services for humans such as wood, clean water, pollinators, carbon storage and non-timber forest products such as fruits and construction material.

Four different roles for the matrix

The matrix for forested landscapes plays different roles in biodiversity conservation (Lindenmayer and Franklin 2002):

a) Supporting populations

The matrix hosts numerous species, many of them in large populations. The quality of the managed forests determines the species composition. The further from the original, unmanaged state, the less the probability of survival for species dependent on the characteristics of natural forests. Large populations are advantageous for long-term survival since they decrease the risk of extinction in single catastrophic events and usually also ensure high levels of genetic variation. Protected areas, especially if they are small, may have large fluctuations in species populations as a result of random events. Inflow of individuals, and with them genes, from the matrix may help to counteract local extinctions and to increase the viability of populations.

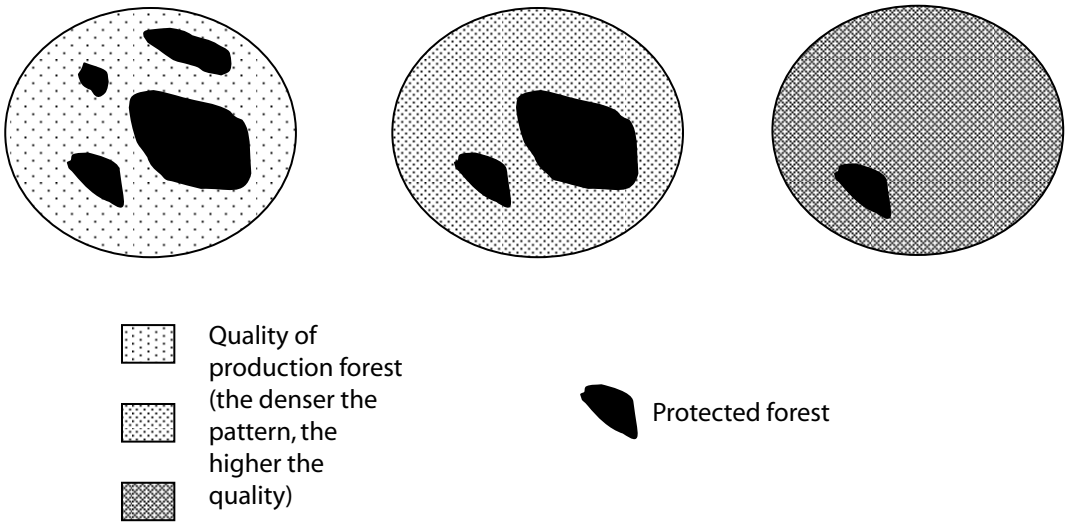

Figure 1.2. In the forest landscape there is an interaction between the quality of the matrix and the size of the protected forest. In order to maintain a high level of biodiversity, the quality of the matrix needs to be high when the protected area is small. With large areas of protected forests, the need to consider biodiversity in production forests decreases

b. Regulating movement
The movement of individuals between existing subpopulations and also to new sites is of fundamental importance to the long-term persistence of species in forest landscapes. Moist and wet tropical forest landscapes are usually not subjected to large catastrophic disturbances as are the fire-prone landscapes of drier areas. Thus, many tropical rainforest species have adapted to large, contiguous tracts of forest and may have difficulty in adjusting their movement patterns when forests are cleared or partially felled. The composition of the matrix might enhance or seriously hinder the movement and dispersal of species. Large cleared areas might totally preclude movement for some species, but if corridors which connect forest patches are retained, this could suffice for the dispersal of many of the species.

c. Buffering sensitive areas and reserves
When forests are cleared, the environmental conditions change not only in the area felled but also on the edges of the surrounding forests. The degree of change depends on the type and intensity of felling, and on the shape and size of the logged-over area. The effects are climatic, e.g. there are changes in radiation, temperature and air humidity. However, interactions between organisms are also affected, e.g. predation is known to increase in edge zones. If biodiversity concerns are taken into account during logging, the contrasts between logged areas and reserves and other sensitive areas might be reduced. The effectiveness of small set-aside areas might be increased if logging is less intense in their edge zones.

d. Maintaining the integrity of aquatic systems
Water bodies are very important components in forest landscapes and occur in widely different sizes, from large lakes and rivers to small pools and wallows. Watersheds are drained through intricate networks of watercourses of different sizes. When forest landscapes are logged, the form and function of these networks may be severely altered. Habitats with and near water are of special importance to many plant and animal species since they offer a more moist and humid environment than do the surrounding forests. Animals gather close to water, and live in water and in the riparian zone. Felling, skidding and road construction can seriously impact aquatic systems.

Critical factors for the preservation of biodiversity

Environmental conditions

The biodiversity of tropical rainforests represents a gigantic range of life forms. Each species has specific, unique requirements that need to be fulfilled if it is to persist and have a viable population in the long term. These requirements operate on different scales, e.g. immediately around a tree, in a stand of some hectares in which forestry operations are conducted, or over a much larger area, e.g. in the large landscapes of forest concessions, covering hundreds or even thousands of square kilometres. At these large levels, forest planning is a key issue.

The environmental conditions that need to be fulfilled in order for species to exist can be divided into different categories: site of occupancy/nesting, food/nutrients, water, shelter, reproduction and dispersal (Table 1.1).

Dispersal can be taken as an example of a process that is of fundamental importance to the abundance and distribution of species. As an example, plant dispersal has two phases, 1) the movement of propagules (seeds, spores) from a source to a new site, 2) the establishment and early development at the new site (Figure 1.3).

Dispersal mode and capacity vary enormously between the different organisms. Some, such as plants with large quantities of frequently

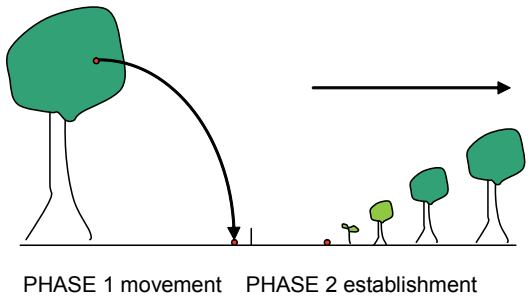

Figure 1.3. The two-step process of dispersal for a plant, illustrated with the spread of a tree species by seed from one site to another

Table 1.1. Conditions that are required for the long-term persistence of plant and animal species, with examples

Condition	Examples for plants	Examples for animals
Occupancy/nesting site	Tree stems – orchids (epiphytes) Leaves – bryophytes and lichens (epiphylls) Riversides – hydrophilic (water-loving) plants	Tree crowns – monkeys Large trees – hornbills Hollow trees – owls
Food/nutrients	Uptake from soil. Mycorrhiza (symbiosis with fungus in which the plant provides the fungus with carbohydrates and the fungus provides the plant with nutrients. Parasitism. Saprophytism (dead material)	Vegetation for herbivores, prey for carnivores, carcasses for scavengers
Water	Groundwater for ground-living herbs, rainfall for epiphytes.	Lakes, watersheds, pools, wallows
Shelter	Presence of dense and dark tree canopy for shade-demanding plants	Protection from predators, e.g. dense vegetation, large tree crowns, hollow trees
Reproduction	Production of viable seeds/ spores that are able to establish and grow, and in due course reproduce	Production of healthy off-spring that will survive and in due course reproduce
Dispersal	Wind, water, animals that carry seeds or spores (passively or actively)	Environments that allow movement to new sites. For many rainforest animals this often implies the presence of large tracts of unspoilt forest

produced wind-borne seeds, may disperse very widely. Others, such as arboreal animals that never leave tree-crowns, are restricted to existing forest patches. It has been claimed that species that have evolved over a long time under stable environmental conditions can be expected to have lower dispersal capacity than species that have evolved in changing, dynamic landscapes (Fahrig 1990).

Species may be limited in their movement to and establishment at new sites in two ways. They may be dispersal-limited, which means that they are hindered by producing only few seeds/individuals or that their capacity to move is restricted. They may also be substrate/habitat-limited, which means that they cannot establish themselves in new environments because of a lack of suitable substrate or habitat, even though they can disperse easily. An example is the hornbill, which has no problem in moving to new sites but which cannot establish itself if there is a lack of fruit and nest trees. For conservation purposes it is very important to differentiate between these two cases. If a species is rare and dispersal-limited, it is important to save the actual sites where it occurs, which means that forest management must be undertaken very carefully or avoided altogether, i.e. areas are set aside. If a species is substrate/habitat-limited but has good dispersal capacity, the preservation of key factors might be incorporated into forest management, such as leaving nest trees and food resources.

Landscape properties

Almost all species are not only dependent on the conditions in their immediate surroundings but also are impacted by events and conditions in a larger context. This is most evident for mobile species, such as most animals, but is also important for plants. Pollination and dispersal are often mediated by animals, and their populations are often regulated by processes that take place on a large scale. A major assumption in conservation models at landscape level is that species are promoted if their sites (patches) are connected. The landscape can be viewed as a mosaic with

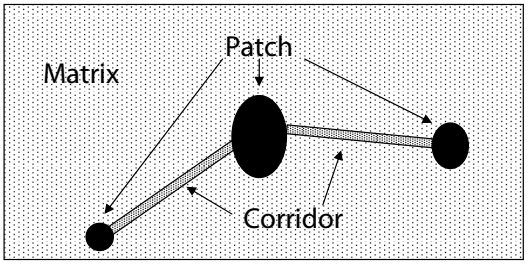

Figure 1.4. Landscapes can be divided into components of patches, corridors and matrix (Forman 1995)

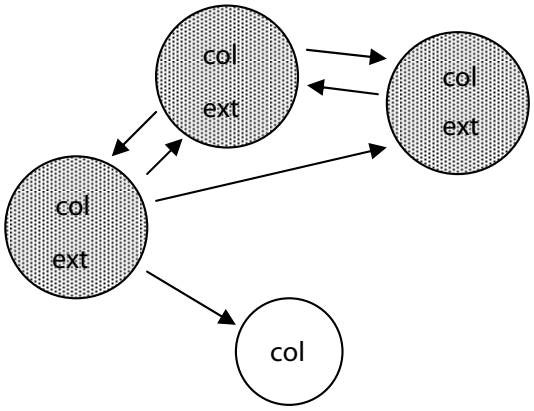

Figure 1.5. In a metapopulation there are extinctions (ext) and colonizations (col) in subpopulations (patches) and dispersal between them (arrows). Some patches are occupied (grey) and some are empty (white) due to local extinctions

three components, i) patches with more-or-less homogenous conditions that are suitable for a species, ii) corridors that are linear patches of the same type, and iii) matrix, i.e. areas that are not suitable or are suboptimal for the species (Figure 1.4). In forest conservation biology, the matrix is often equivalent to the production forests, the patches to the set-aside areas and the corridors to connecting links between the protected areas.

Metapopulation dynamics is an important concept, mainly in conservation biology science and also in practical biodiversity conservation (Hanski 1999). A metapopulation is a 'population of populations', i.e. in a local population there are many subpopulations (patches), with some contact between them. There is constant change in a metapopulation, with dispersal between and extinction within subpopulations (Figure 1.5). Metapopulation models study only one species at a time, and they are often used to assess the extinction risk of a species in a landscape.

Conservation applications of the metapopulation theory imply that biodiversity planning needs to be performed at such large scales that there are several subpopulations of a species within a target area. Information on the dispersal capacity, extinction risks and colonization abilities in patches needs to be taken into account.

Fragmentation and the importance of habitat size

Fragmentation means that large contiguous areas of habitat are transformed into a smaller number of patches (Figure 1.6). Fragmentation causes a reduction in the total amount of habitat, an increase in number of habitat patches, a decrease in the sizes of habitat patches and an increase in the isolation of patches. The generally held view among conservation biologists today is that isolation between patches is negative for many species but that reduction in habitat poses an even more severe threat (Fahrig 2003), however in

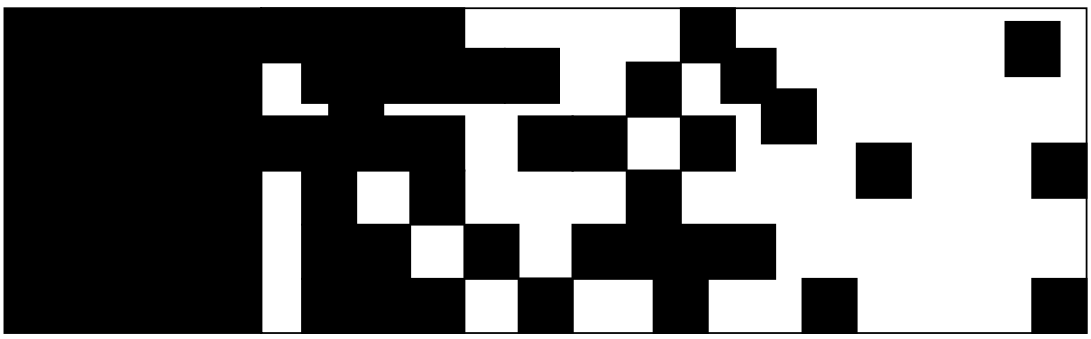

Figure 1.6. Fragmentation is the transformation of continuous habitat into a smaller number of patches, i.e. the development from left to right

order to maintain the rainforest vertebrate fauna, for example, it is also very important to retain a contiguous forest (Meijaard *et al*. 2005).

Fragmentation is often discussed in relation to extinction threshold, i.e. a threshold level of the habitat below which a population cannot sustain itself. It has been suggested that the threshold has been reached when only 20–30% of a habitat remains in the landscape (Flather and Bevers 2002). As a general rule, species number increases with area in a non-linear manner. This species-area curve is one of the most important and consistent relationships in ecology (Figure 1.7).

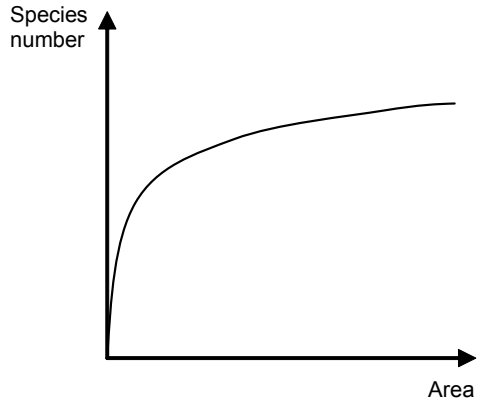

Figure 1.7. One of the most fundamental principles in ecology is that species number increases with area in a non-linear manner

From the species–area rule it follows that if an area is reduced in size there will be a more-or-less predictable decrease in the number of species it can hold. Some species react very slowly to habitat change, however, and may not become extinct until many years after fragmentation begins. This time delay is called an 'extinction debt' (Tillman *et al*. 1994), i.e. the number of species that are expected eventually to become extinct as result of irreversible past changes in the habitat. The extinction debt is considered to be especially large in communities where many species are rare, and for such species the time delay can be very long (Hanski and Ovaskainen 2002). Care should be taken when using the concept of extinction debt in an uncritical manner since it most probably depends largely on the overall quality of the landscape, not least the state of the matrix surrounding the fragmented area.

References

Curran, L.M., Trigg, S.N., McDonald, A.K., Astiani, D., Hardiono, Y.M., Siregar, P., Caniago, I. and Kasischke, E. 2004. Lowland forest loss in protected areas of Indonesian Borneo. Science 303: 1000-1003.

Fahrig, L. 1990. Interactive effects of disturbance and dispersal on individual selection and population stability. Comments on Theoretical Biology 1: 275-299.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34: 487-515.

FAO (Food and Agriculture Organization of the United Nations). 2005. Global Forest Resources Assessment 2005. Progress towards sustainable forest management. FAO Forestry Paper No. 147. FAO, Rome.

Flather, C.H. and Bevers, M. 2002. Patchy reaction-diffusion and population abundance: the relative importance of habitat amount and arrangement. American Naturalist 159: 40-56.

Forman, R.T. 1995. Land mosaics: The ecology of landscapes and regions. Cambridge University Press, New York and Cambridge.

Hanski, I. 1999. Metapopulation ecology. Oxford University Press, Oxford.

Hanski, I. and Ovaskainen, O. 2002. Extinction debt at extinction threshold. Conservation Biology 16: 666-673.

Lindenmayer, D.B. and Franklin, J.F. 2002. Conserving forest biodiversity. A comprehensive multiscaled approach. Island Press, Washington, D.C.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., *et al*. 2005. Life after Logging. Reconciling wildlife conservation and production forestry in Indonesian Borneo. Center for International Forestry Research (CIFOR) and UNESCO, Jakarta.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., de Fonseca, G.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Primack, R. and Corlett, R. 2005. Tropical Rain Forests. An Ecological and Biogeographical Comparison. Blackwell Publishing, Malden, MA, USA.

Tillman, D., May, R.M., Lehman, C.L. and Nowak, M.A., 1994. Habitat destruction and the extinction debt. Nature 371: 65-66.

Appendix 2

National guidelines for sustainable forest management and biodiversity considerations in South East Asia

Introduction

In Appendix 2, forest management in the following countries is discussed briefly: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste and Vietnam. This is followed by a discussion of efforts being made towards sustainable forest management (SFM) and the extent to which environmental and biodiversity guidelines are covered within the SFM approach. Guidelines relevant to SFM in general and biodiversity in particular as well as information relating to certification in each country are detailed in Table 2.1.

Many of the countries in South East Asia do not yet have drafts or even official guidelines for biodiversity to be given consideration in logging concessions. Only in Cambodia, Indonesia, Lao PDR, Malaysia and Vietnam has there been any concrete action relating to biodiversity in logging concessions, and this ranges from the actual production of guidelines, in the case of Cambodia and Malaysia, to the Forest Stewardship Council (FSC) certification of production forests, in Indonesia and Lao PDR. Table 2.2 scores biodiversity management guidelines from Cambodia, reduced-impact logging (RIL) guidelines from Indonesia, and biodiversity monitoring guidelines from Lao PDR against recommendations made in *Life after Logging* (Meijaard *et al*. 2005, 2007a, b, c; Sheil and Meijaard 2005). However, all the countries named in the first paragraph above are discussed because advances in forest management or SFM are possible signs of an opportunity for biodiversity to be given consideration in production forest management.

The history of forest management and the current status of SFM vary considerably across the countries. Several countries, namely Indonesia, Malaysia and Myanmar, have a long tradition of forest policy development, and management of forest resources spans decades. The National Forest Policy of Malaysia was adopted by the National Forestry Council in 1977. The forest policy in Indonesia was derived from Article 33 of the Indonesian Constitution of 1945 and Forestry Act No. 5 in 1967, which was replaced by Forestry Act No. 41 in 1999. Myanmar has an even longer history of forest policy, starting with the Burma Forest Act in 1902, which was repealed in 1992 by the State Law and Order Restoration Council. In Cambodia, Lao PDR and Vietnam, forest policies have been formulated more recently and the new state of Timor-Leste is just beginning the process of developing its forest policy.

Table 2.1. SFM initiatives on a country-by-country basis

SFM Initiative / Country	National Guidelines	National Certification Scheme	International Certification Scheme[1]	Specific Guidelines for Biodiversity
Brunei Darussalam	1. National Forest Policy. 2. Brunei Selection Felling System. 3. Five Star Approach to Excellence. 4. Basic Guidelines for Logging in Mixed Dipterocarp Forest (undated).	None	None	No specific guidelines
Cambodia	1. Cambodian Code of Practice for Forest Harvesting, July 1999. 2. Cambodian Forest Law (Revised 2000 Sub-Decree on Forest Concession Management). 3. Guidelines for SFM (2000) containing Guidelines for Forest Concession Management Planning Systems; Construction Guidelines for Forest Engineering Works; Guidelines for Special Area Management; Biodiversity Conservation Guidelines for Managed Forests; Guidelines for Socio-Economic Surveys of Communities Surrounding Forest Concession Areas; Guidelines for Environmental and Social Impact Assessment (ESIA). 4. Forest Concession Management Planning Manual for SFM 2001. 5. Sustainable Forest Management Plans (SFMP). 6. Field Guide to RIL in Cambodia, 1999.	None	None	Biodiversity Conservation Guidelines for Managed Forests, 2000 (MAFF, WCS input)
Indonesia	1. TPTI Selective Felling and Planting System, 1989. 2. RIL Guidelines for Indonesia, 2003, various technical manuals by TFF/MOF/ITTO. 3. EIA (AMDAL) required. 4. Principles and Practices of Timber Harvesting in Indonesia, 2000. 5. Criteria and Indicators of Natural Production Forest Utilisation, 2002	Indonesian Ecolabelling Institute – LEI	FSC Natural Forest (4) Planted Forest (1)	1. Life after Logging (Meijaard *et al.)* 2005, and Indonesian version (Meijaard *et al.* 2006a). 2. Practitioners guide to managing High Conservation Value Forest in Indonesia (Meijaard *et al*. 2006b).
Lao PDR	1. National Code of Timber Harvesting Practices in Lao, 2005. 2. Prime Minister Decree No. 59 dated 22/5/2002 re: Sustainable Management of Production Forest Areas.	None	FSC Natural Forest (2)	1. Guidelines and Procedures for Biodiversity Monitoring in Production Forest Areas 2006 (SUFORD) 2. HCVF Toolkit for LAO PDR (only draft SUFORD)

SFM Initiative / Country	National Guidelines	National Certification Scheme	International Certification Scheme[1]	Specific Guidelines for Biodiversity
Malaysia	1. Selective Management System (SMS). 2. Model Forests. 3. Code of Practice for Harvesting of Natural Inland Forest, Peninsular Malaysia, 1997. 4. Code of Forest Harvesting of Mangrove Forest, Peninsular Malaysia, 1997. 5. Guidelines for RIL in Peninsular Malaysia, 2003. 6. RIL Guidelines, Sabah Forestry, 1999. 7. Guidelines/Procedures on Reduced and Low Impact Harvesting Systems, Sarawak, 1999. 8. The Manual of Silviculture for the Permanent Forest Estate of Sarawak, 1999. 9. RIL Operation Guide Book Specifically for Crawler Tractor Use, Sabah, 2001. 10. Environmental Impact Assessment (EIA) Guidelines for Logging and Forest Clearance Activities, Sabah, 2002. 12. Procedures for Identifying and Demarcating Sensitive Areas for the Protection of Soil and Water, Sarawak, 1999. 13. Guidelines for Forest Road Layout and Construction, Sarawak, 1999. 14. Wildlife Conservation Enactment, Sabah, 1997. 15. Biodiversity Enactment, Sabah, 2000.	Malaysian Timber Certification Council (MTCC)	FSC Natural Forest (1) Mix Planted/ Natural Forest (1) Planted Forest (1)	1. Sarawak Wildlife Plan 1996.
Myanmar	1 Myanmar Selection System (MSS) dates back to 1856. 2. National Code of Timber Harvesting Practices in Myanmar, 2000. 3. Myanmar C&I (undated).	Timber Certification Committee set up but no details	None	None found
Philippines	CoP not yet published. Philippines Selective Logging System.	None	None	None found
Singapore	Not applicable.	Not applicable	Not applicable	Not applicable
Thailand	None found.	None	FSC Planted Forest (2)	
Timor - Leste	In process of developing forest policy.	None	None	None
Vietnam	1. Drafting CoP. 2. RIL Guidelines for Vietnam 2003. 3. Vietnam C&I.	None	FSC Planted Forest (1)	1. HCVF Toolkit 2. Biodiversity Guidelines (SLU, CIFOR, FSIV, Sida)

[1] List from FSC website, accessed October 2006 http://www.fsc.org/keepout/en/content_areas/92/1/files/ABU_REP_70_2006_10_05_FSC_certified_forests.pdf

Table 2.2. Forest management guidelines for biodiversity conservation by country scored against *Life after Logging* guidelines (Meijaard *et al.* 2005)

Biodiversity recommendations for production forest managers	**Cambodia** Biodiversity Conservation Guidelines	**Indonesia** Codes of Practice/RIL	**Lao PDR** Guidelines for Biodiversity Monitoring[1]
Planning before logging			
Ecological survey and impact assessment	***	*	NA
Conservation planning	***	*	NA
Operational planning	***	**	NA
Maintaining landscape connectivity and watershed protection	***	**	NA
Specific biodiversity surveys	***	NM	**
Minimizing damage during logging and related operations			
Roads and infrastructure	***	**	NA
Protecting reserved areas	***	**	NA
Minimizing damage in production areas	***	**	NA
Maintaining habitat complexity and diversity	***	**	NA
Keeping keystone resources	***	*	**
Post-logging operations	***	*	NA
Minimizing indirect impacts and threats			
Hunting and extraction	**	*	***
Fire	NM	**	NM
Exotic and invasive species	*	NM	NM
Domestic animals	NM	NM	NA
Traffic	*	NM	NA
Pollution	*	*	NA
Logging and conservation for local people	***	***	NA
Develop forest practices that honour local rights	***	***	NA
Implementation and vigilance	***		
Monitoring	***	**	***
Legal aspects, and implementation and control	***		**
Awareness and training	**	***	***
Species-specific suggestions			
Provide management recommendation on a species-by-species basis	*	NM	NA
Recommendations for government planning			
The need for a wildlife master plan	***	NM	NA
Land tenure agreement	*	*	NA
Fragmentation	***	NM	NA
Hunting and fishing	***	NM	NA
Law enforcement	***	NM	***
Effective implementation	**	NM	NA

Explanation of key: *** - well covered; ** - adequately covered; * - briefly mentioned; NM – not mentioned; NA – not applicable.

[1.] These guidelines relate only to biodiversity monitoring.

Brunei Darussalam

Not ITTO Member. Not Asia Pacific Forestry Commission member. Not signatory to Convention on Biological Diversity.

Background

Brunei Darussalam is a relatively small country, covering only 576 000 ha, but 78% of its land area is covered in tropical rainforest, ranging from mangrove, freshwater swamp and peatswamp forests to tropical heath, mixed dipterocarp and montane forests. The remaining areas are plantation and secondary forests. There is very little threat to the forests and biodiversity of Brunei. The country enjoys a high standard of living through its significant oil reserves and, with a relatively low population density, pressure on forest resources is very low. The export of timber is banned, and very limited logging activities harvest only to meet local needs. The country has a significant protected areas network with around 20% of the total land area under some form of protection. The National Forest Policy emphasizes environmental conservation and protection, taking into account the need to conserve and maintain the nation's biodiversity heritage. This policy also addresses the need to protect water catchments and to prevent erosion and flooding.

Forest Management

Forest management in Brunei is largely carried out or closely monitored by the Department of Forestry. The department places considerable emphasis on its planning systems. All forests in Brunei are managed in accordance with formal, nationally approved management plans. Around 65% of Brunei's forests are designated as production forests and are managed according to appropriate management plans, which incorporate stringent harvesting regulations. Other forest areas are managed for a variety of conservation, protection and recreational purposes.

Four principal silvicultural systems have been utilized in Brunei during the past century. Since 1986, a modification of the Selective Management System (SMS) practiced in Malaysia has replaced the Malayan Uniform System. This system, known as the Brunei Selection Felling System, involves pre- and post-logging assessment of the timber stand. Trees to be cut and harvested and remaining trees that constitute the next timber crop are marked. Woody climbers are removed if they pose competition or if they are likely to hamper logging operations. The size of commercial species harvested is governed by a set of diameter limits. At the same time, undesirable trees are cut in order to liberate the selected residual crop trees from competition. About 10 years after logging, silvicultural treatments are applied until the end of the felling cycle. The application of enrichment planting in understocked areas and openings created during logging operations is an important component of the system.

Private sector harvesting of commercial and obligatory timber is permitted by the Government of Brunei under the supervision of the Forestry Department. Harvesting is based on a quota system, which is subject to periodic review. At present, logging is limited to 100 000 m^3 per annum, and is strictly confined to meeting local needs for wood products. Consequently, the bulk of Brunei's consumption of wood products is met by imports. Harvesting in Brunei's forests is carried out almost exclusively under the Brunei Selection Felling System.

Sustainable Forest Management

The absence of real pressure on Brunei's forests, and the strong role government plays in their management, means few special initiatives have been required to promote sustainable forest management by the private sector. Pursuit of the vision of Five Star Excellence in tropical forestry has propelled the Forestry Department to identify several priority areas for action, including the need for a survey of forest reserves in order to develop additional protective legislation and to improve silvicultural efforts in natural forests. A particularly important objective is the implementation of full forest and wildlife inventories.

Biodiversity and Sustainable Forest Management

Apart from general statements about sustainable forest management and conservation of biological diversity, no specific guidelines were encountered which addressed the issue of biodiversity considerations within logging areas. It is assumed that logging

standards are fairly high and that operating procedures in Malaysia have been taken as a precedent.

Information Sources

The majority of this information was collected from the country profile information on the UN Food and Agriculture Organization (FAO) Forestry website (FAO 2006a). Unlike many other countries in this review, there was little Internet information on sustainable forest management in Brunei beyond general information available on the FAO Forestry website. As Brunei is not a member of the International Tropical Timber Organization (ITTO) or the Asia Pacific Forestry Commission (APFC) these usually good sources of information were not available. No individuals were contacted in relation to forestry in Brunei.

Cambodia

ITTO Member. Member of Asia Pacific Forestry Commission. Has acceded to the Convention on Biological Diversity.

Background

The extent of forest is estimated by FAO at 9.33 million ha (FAO 2005) whereas the Forestry Administration (FA) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) estimates 11.1 million ha (ITTO 2006). Cambodia's lowland tropical moist forest covers the northeastern part of the country bordering Laos and Thailand, and is dominated by Dipterocarpaceae. Medium-altitude closed forest is found in the hilly country around the Gulf of Thailand and east of the Mekong River. Closed deciduous forests and open forests are mixed and found in the northwestern part of the country. Deforestation and illegal logging are a serious problem and are having a major impact on efforts towards sustainable forest management (SFM) (ITTO 2006).

Cambodia is not a global biodiversity 'hotspot' and for most biological groups it is not rich in species, has fairly low rates of endemism and is relatively low in geographic diversity (DFW 2002). However, Cambodia is exceptionally important for some specific components of faunal biodiversity that have become extinct or greatly reduced in other countries of the region. A few examples of animals in this category include Eld's Deer *Cervus eldi*, Banteng *Bos javanicus* (Figure 2.1), Jungle Cat *Felis chaus*, Bengal Florican *Houbaropsis bengalensis*, Eastern Sarus Crane *Grus antigone*, Giant Ibis *Thaumatibis gigantea*, Greater Adjutant *Leptoptilos dubius* and Siamese Crocodile *Crocodylus siamensis* (DFW 2002).

Figure 2.1. Male Banteng *Bos javanicus* at water hole. Photo: courtesy WCS Cambodia

Forest Management

Prior to the early 1990s, the forests of Cambodia were managed in a relatively conservative manner, felling was mainly carried out manually using axes and extraction by buffalo or elephant. Subsequent political developments caused this system to disappear; in the mid 1990s, the Government of Cambodia awarded 30–40 timber concessions totalling an area of 7 million ha to a range of Cambodian and foreign-owned companies (Global Witness 2005), and timber harvesting became mechanized.

There have been many international efforts to assist Cambodia to improve forest management (Hinrichs & Mckenzie 2004). Since 1998, the Forest Authority, and its predecessor, the Directorate of Forestry and Wildlife, have developed a broad set of regulations and guidelines to control and safeguard forest management practice in concession areas, with funds and technical support from FAO, Asian Development Bank (ADB), the World Bank and several bilateral donors (see Table 2.1 for a list of guidelines available). The World Bank funded a Forest Concession Management and Control Pilot Project (FCMCPP) to help resolve controversial issues in concession management and public consultation; this report received some criticism (Global Witness 2005).

In 2000 the government conducted a review of all forest concessionaires to determine whether they were acting in compliance with their contracts and with Cambodian law (Kollert *et al*. 2000). The review recommended that new contracts and management plans should be drawn up, and that, in the interim, a moratorium on harvesting should be imposed. As a result of this review, 22 forest concessions covering an area of 3 million ha were terminated (Kollert *et al*. 2000).

Sustainable Forest Management

Cambodia has no shortage of recent guidelines relating to SFM, as seen in Table 2.1, and has the largest selection of guidelines pertaining

to SFM of any country assessed in this study. The set of guidelines for SFM were created with assistance from the World Bank's FCMCPP. These guidelines may be perceived as more of a burden than a blessing as they are more likely to lead to confusion than to clarification for any forest manager seeking guidance. Amongst these guidelines is the only set of national guidelines that relate specifically to biodiversity conservation within production forests in South East Asia.

Another instrument directed at achieving SFM is the Cambodian Code of Practice for Forest Harvesting, which was made official policy on 26 July 1999. A Model Forest Concession Agreement was also developed in collaboration with the World Bank and ADB technical assistance, as a framework for dialogue between the Forestry Administration, concessionaires and other stakeholders (DFW *et al*. 2001). However, very little has come of this.

The Biodiversity Conservation Guidelines

The Biodiversity Conservation Guidelines (BCGs) were initially prepared in 1998, by a short-term World Bank mission to the FCMCPP, and were incorporated without modification into the *Guidelines for Sustainable Forest Management* published in 2001 (Hinrichs & Mckenzie 2004). In addition, in June 2002 the Wildlife Conservation Society (WCS), in conjunction with the FA, World Bank and Samling Ltd., held a workshop on Biodiversity Conservation in Concession Forests in Cambodia, which has helped some concessionaires. Guidance on biodiversity conservation is also provided in other forest management guidelines such as Forest Function Zonation, and also in Guidelines for Special Area Management, which forms part of the SFM Guidelines. Finally, biodiversity assessment and impact mitigation are also key components of the Environmental and Social Impact Assessment (ESIA).

The BCGs provide a logical conceptual orientation for the concession planner, reviewing the relevance of biodiversity to forestry concessions, the general principles of forest biodiversity management, key characteristics of Cambodian biodiversity, and the legal framework for its protection. The guidelines are presented in a nested hierarchical format (regional, concession, compartment and coupe), discuss the different levels of biodiversity management, and identify key tasks at each level, which again reduces confusion for the prospective forest manager (see Table 2.3, below).

As can be seen in Table 2.2, these guidelines are very comprehensive and amply cover most of the recommendations suggested by Meijaard *et al*. (2005) in *Life after Logging*. Starting at the regional scale, the guidelines stress the importance of viewing the forest management unit (FMU) as part of the wider landscape and its constituent parts. They also introduce the concept of the Biodiversity Conservation Network to create: 'a continuously-connected Biodiversity Conservation Network (BCN) within the natural forest estate and individual FMUs providing ecological linkages through the landscape' (DFW 2002). However, there are no specific recommendations for how this may be done, although it is obvious that this is a multi-stakeholder type of task that would require significant cooperation and coordination between government departments, local communities and other FMUs. A single FMU manager would need considerable will and guidance to attempt to carry out this recommendation.

The level of conservation planning guidance within the FMU is fairly detailed, especially for aspects such as keystone species, as seen in the following text: 'A major focus of biodiversity conservation at the stand level will be the protection and retention of specific 'keystone' ecological species and features. This will be achieved through identifying features such as pollinating species (such as insects, bats, primates, birds, etc); seed-dispersing species (such as bats, birds, civets, mongooses, primates, elephants, pigs etc); cavity-excavating species (such as woodpeckers, parakeets, bears etc); 'wallowing' species (such as wild cattle, pig, elephant, large deer, etc) that create waterholes used by many other animals; and predators that regulate herbivore populations (such as cats, wild dog, raptors, other carnivores, etc); topographic features; mineral licks; riparian communities and wetlands; small springs, moist depressions and wallow; rock outcrops; and ridge tops.'

The foundation of successful biodiversity conservation within an FMU is undoubtedly the quality of ecological surveys and planning that

are carried out prior to logging. These surveys identify important habitats and species for protection, and provide a baseline for future monitoring of the impact of concession management on fauna and flora. However, the BCGs do not provide any detailed guidelines on how this should be achieved. This is a specialist task and requires considerable training and knowledge. Concessionaires are directed to use the IUCN/The Nature Conservancy (TNC) rapid appraisal methods, but no source is given in order to enable them to locate this information. It would be more helpful to suggest that if the concessionaires do not have qualified staff, which is most likely, they seek guidance from conservation organizations, such as WCS in Cambodia, that have previously formed partnerships with concessions in Sarawak and Cambodia with the objective of carrying out biological surveys (see below).

The issue of hunting is particularly well covered in the guidelines. WCS Cambodia Program provided detailed input to an earlier version of the guidelines, which were clearly deficient in this area. Hunting is mentioned at the FMU, compartment and coupe level (see Table 2.1). There is an absolute ban on hunting, purchasing or transporting of all wildlife by company employees and their families, and the concessionaire is obliged to ensure that a good alternative source of protein is supplied to company employees. Company vehicles are to be routinely checked to ensure that they are not transporting wildlife, and the company should check that local communities are hunting non-protected species sustainably. Roads no longer in use should be closed so they cannot be used by hunters. A detailed assessment should be made of the hunting trends in the area, working with local communities, concession staff and local authorities, and focusing on who is hunting what species, where, at what levels and for what purpose or market; local markets are to be checked for wildlife trade. In addition to these recommendations, the guidelines call for regular patrolling and law enforcement. Again, these guidelines cover most issues connected with hunting but actual guidance on implementation is lacking for some aspects, such as monitoring. Regarding law enforcement, cooperation and coordination with the Department of Forestry and Wildlife/police is critical. However, again, there is an opportunity for collaboration with conservation NGOs.

Special Case Study: Pioneering Wildlife Conservation in Managed Forests in Cambodia

Between 2000 and 2002, the WCS Cambodia Program, SL International (Samling), and the Department of Forestry and Wildlife (DFW) had a collaborative programme for biodiversity conservation, focusing on wildlife, on the Samling Forestry Concession, focusing in Keo Seima District, in Mondulkiri Province (Poole 2002). WCS previously had a successful collaboration with Samling in Sarawak.

WCS identified hunting of wildlife as the major threat to biodiversity conservation within the Samling concession area for a number of key reasons (Poole 2002). First, hunting by outsiders had major implications for the food security of local ethnic communities whose main source of protein was from Red Muntjac *Muntiacus muntjak* and Wild Pig *Sus barbatus*. Second, it was found that populations of key pollinators and dispersers, such as fruit bats, hornbills and primates, which are essential in order to ensure forest regeneration and long-term SFM, were reduced as a result of hunting pressure. In addition, it was found that illegal hunting went hand-in-hand with other illegal practices such as collecting large amounts of NTFPs. Finally, field surveys by WCS confirmed that the concession was important for globally threatened bird and mammal species.

Unfortunately, Samling was one of the concessions 'frozen' in 2002, but up until that point WCS, Samling International, DFW, and MAFF had made the following concrete progress:

- WCS and Samling had entered into a formal agreement on collaboration and the input of wildlife and habitat data and conservation recommendations into the Environmental and Social Impact Assessment component of Samling's Forest Management Plan submitted to the government in September 2001; and
- Samling had issued an order to all camp employees, contractors and security staff, banning all hunting and trade in wildlife or their parts. Non-residents and outsiders were also to be actively discouraged from hunting or trading. An exception was made for local communities, who could hunt for domestic consumption only. Any one

contravening this order would be dealt with severely by the company's disciplinary board. Fresh domestic meat is supplied to all camps.

Follow-up recommendations were as follows:

i) conduct a socio-economic survey of wildlife hunting and consumption patterns,
ii) WCS, the Cambodian Timber Industry Association (CTIA), and DFW should hold an internal workshop to promote wildlife conservation in Cambodian concession management; and
iii) evaluate and monitor populations of Focal Key Species (Poole 2002).

Forest Certification and Criteria and Indicators

Forest certification and labelling schemes have not yet been introduced in Cambodia. Cambodia has prepared a report on Criteria and Indicators (C&I) for sustainable forest management of natural tropical forests with the support of ITTO; however this needs to be followed up as a number of the C&I have not been fulfilled (ITTO 2006).

Current Situation

Officially all concessions are 'frozen' as a result of a long-running dispute over royalty rates, and no one is quite sure of the current status of the guidelines (Joe Walston (WCS) personal communication). WCS worked with Samling until 2002, when the concession was 'frozen', therefore little is happening with the implementation of SFM and there is no progress with regard to the biodiversity guidelines.

Information Sources

Of all countries within the scope of this study, most of the material relevant to biodiversity management within logging concessions was found for Cambodia. A good selection of material was found on the Internet, however the majority of the material was generously provided by Joe Walston of WCS.

Table 2.3. Summary of Biodiversity Conservation Guidelines for Cambodia (DFW 2002)

2.1. Biodiversity Considerations at the PROVINCIAL LEVEL	
Issues	• Incremental, unplanned loss of natural forest land, often the result of unsanctioned and illegal forest conversion activities, e.g. for agriculture, timber exploitation and settlement. • Loss of biodiversity through the conversion of habitats of regional importance (i.e. wetlands, old-growth forests, etc.). • Loss of connectivity between protected areas, and general habitat fragmentation.
Management Measures	• Rationalize land allocation by linking it to real assessments of land capability. • Slow the process of land, forest and water degradation. • Improve the prosperity and security of local communities. • Conserve important plant and animal biodiversity.
Monitoring	• Environmental Condition Monitoring (national and regional scale (1:100 000 – 1:250 000), regularly updated (every 5 years), land use/land cover/ land administration maps). • Compliance Monitoring (a regime of regular inspections and surveillance by government staff to curtail illegal land and resource use activities).
2.2 Biodiversity Conservation at the SUB-REGIONAL OR FOREST MANAGEMENT UNIT LEVEL	
Issues	• The need to balance sustainable forest commodity production with the maintenance of ecological services, biodiversity and forest landscape stability. • Planning will have to look at both internal and regional levels in its compartment designations and management prescriptions. • Almost invariably the FMU will contain land and biodiversity resources of significant cultural, subsistence and economic value to local communities.
Management Measures	• Designate major ecological, watershed, traditional-use and stream protection compartments and their interconnection in a biodiversity conservation network (BCN). • Maintain a near-natural range of age classes, forest stand composition and structure, and spatial distribution of important plant communities within the production forest compartments. • Protect wildlife to maintain a full, natural composition of species at ecologically-functioning levels.
Components of Management Plan (15 yrs) to achieve Management Measures Monitoring	• Establishment of an Ecological Baseline. • Forest Zoning: Delineation of Compartments and a BCN. • Selection of Rotation Age and a Silvicultural System. • Calculation of the Annual Allowable Cut (AAC). • Environmental Condition Monitoring (measure forest change, biodiversity surveys). • Compliance Monitoring (harvest compliance, community relations, intensity of NTFP harvest, check illegal harvesting and hunting).

2.3. Biodiversity Conservation at the COMPARTMENT LEVEL	
Issues	• Environmental degradation (particular of aquatic ecosystems) due to poor road building and stream-crossing practices. • Habitat fragmentation due to excessive road clearing widths and road densities. • Increased hunting of wildlife and exploitation of plant resources as a result of increased forest access. • Loss of forest structure and composition and introduction of exotic species due to inappropriate silvicultural practices.
Management Measures	• The concession must establish and enforce a total ban on the hunting, capture, consumption, transportation and trade of wildlife by its subcontractors and all its employees. • Roads and skid trails should be permanently closed as soon as possible after logging (with the exception of those providing essential access for local communities) by erecting vehicle barriers and removing bridges and culverts. • Recognizing the importance of wildlife as a protein source for local indigenous peoples, government and FMU staff should cooperate with local communities in the development of sustainable, community-based wildlife management programmes. • Hunting of wildlife and the harvest of traditional non-wood forest products by outside commercial interests should be prohibited and strictly enforced by regular foot and road patrols.
Monitoring	• Environmental Condition Monitoring (pre- and post-harvesting forest stand and vegetation surveys; monitor the status of wildlife and plant species). • Compliance Monitoring (access development and silvicultural plans checked; control any hunting by employees; check local markets for bush meat, illegally harvested forest products).
2.4. Biodiversity conservation at the FOREST COUPE AND BLOCK LEVELS	
Issues	• Limiting soil and site disturbance. • Ensuring that annual coupe boundaries respect higher-level forest management unit zoning. • Ensuring that the size of openings is consistent with silvicultural and ecological objectives. • Protecting and retaining stand-level biodiversity values, especially identified 'ecological keystones'.
Management Measures	• Prepare annual harvesting plans in accordance with compartment-level objectives and codes of best forest practice prescriptions that emphasize 'reduced-impact logging' techniques. • Plan for post-harvesting site rehabilitation. • Consider biodiversity at the coupe and block levels to focus on maintaining stand structure and vegetation species composition, and identify and protect 'keystone' ecological features (plant species and plant materials; animal species and the conditions necessary for their survival; and topographic features [mineral licks, springs, wallows etc.]).
Monitoring	• Compliance Monitoring (approved harvesting plans and permits are being followed; check for signs of hunting and other illegal activities).

Indonesia

ITTO member. Asia Pacific Forestry Commission member. Has ratified Convention on Biological Diversity.

Background

Forest cover estimates vary from 105 million ha (FAO 2005) to 93 million ha as estimated by the Indonesian Ministry of Forestry using 2005 satellite imagery (Ministry of Forestry of Indonesia 2006). About 88% of forest cover is classified as tropical moist forest (ITTO 2006). There has been a rapid loss of forest cover in the last 40 years; the average annual loss between 1990 and 2000 was an estimated 1.3 million ha (1.2%) (FAO 2005).

All of Indonesia's natural forests are owned and administered by the state and are designated as forestland (whether or not forest remains). The total area of forestland according to latest reports is 133.6 million ha and this is divided into conservation forest (20 million ha), protection forest (31.6 million ha) and production forest (59.2 million ha) (Ministry of Forestry of Indonesia 2006). The remaining area is designated as conversion forest (22 million ha), and special function (7000 ha) (Ministry of Forestry of Indonesia 2006). However, in reality the decline in the forest industry since the mid 1990s has seen the total area under forest concessions declining from a high of over 60 million ha to +/-25 million ha, with a corresponding decline in the number of concession licences from +/-570 to a current number of around 250, of which fewer than 100 are considered to be active (Klassen 2006).

The lowland dipterocarp forests of Indonesia are where most logging takes place, and these forests area globally renowned for their high species richness and endemism. Indonesia is one of the most species-rich areas in the world (e.g., Myers *et al*. 2000), with its terrestrial biodiversity being considered the second highest of any country in the world (Stone 1997). This species richness is primarily the result of the region's dynamic geological past (Holloway and Hall 1998), and relatively stable environmental conditions, which resulted in many speciation opportunities (e.g. Whitmore 1987). Indonesia is also the only place on earth where three biogeographic realms – Indo-Malaya, Oceania, and Australia – meet: resulting in a mixture of species with very different evolutionary backgrounds.

In biogeographic terms, the Indonesian island arc is traditionally referred to as the Malay Archipelago (Wallace 1876). It is a highly fragmented region consisting of >18 000 islands varying in size from a few hectares to some of the largest islands in the world. This fragmentation has led to complex patterns of species diversity, much of which remains to be discovered.

Forest Management

In Indonesia, forest harvesting is based on a well-established concession system whereby private concessions are granted to private or state companies. Under the concession management system, each concessionaire is required to prepare an Annual Management Plan that covers production, marketing, equipment usage, road network development and maintenance, and silvicultural activities on the logged areas, as well as community development. The concessionaire is also required to submit a 5-year management plan, as well as an overall plan that covers the duration of the concession tenure, and a comprehensive Environmental Impact Assessment Report for the entire concession area. Management plans must show progress in post-logging silvicultural activities to ensure the sustainability of the forest for the next harvesting rotation. Particular attention is paid to the number of commercial species standing in post-harvest inventories. Failure to file adequate plans is punishable by limiting the following year's production targets of the violating concessionaire.

The dominant TPTI (selective felling system) has been applied to management of the natural forests since 1969. This system requires concession holders to manage on a 35-year felling cycle (mangroves, by contrast, are managed on a 45-year cycle). No tree less than 50 cm in diameter may be felled for timber. At least 25 commercially valuable trees with diameters between 20 cm and 30 cm must remain per hectare after logging, and enrichment planting is specifically required after harvesting. Seedling stock may come from either nurseries or from dense natural regeneration elsewhere in the forest. Each concession is divided into 35 blocks, and only

one block may be harvested per year. The Ministry of Forestry sets an allowable annual cut that is based on the felling cycle and the area under concession. A minimum of 700 ha within each concession area is required to be protected as a conservation area.

Sustainable Forest Management

Indonesia demonstrates its commitment to establishing SFM through its membership of many international organizations and its adherence to all relevant major international conventions. The Ministry of Forestry has developed laws and regulations on SFM. For instance in, April 1993, the Minister of Forestry issued a decree (No. 252/Kpts-II/1993) on the Criteria and Indicators for the Sustainable Management of Natural Production Forests for application at the national level. This was followed by the decree (No. 208/Kpts/IV-Set/1993) of the Director General for Forest Utilization concerning Technical Guidance on Criteria and Indicators for management at the concession level.

Indonesia has operated as task manager for the FAO Asia Pacific Forestry Commission in developing the Asia Pacific Code of Practice for Forest Harvesting and has organized related training tours and workshops. A national code has also been prepared and a guidebook, *Principles and Practices of Forest Harvesting in Indonesia*, was published in 2000 (Ministry of Forestry of Indonesia 2000). RIL continues to be promoted and has involved the establishment of RIL demonstration sites and the publication of a technical procedures manual and training material (Elias *et al*. 2001) and five manuals by the Tropical Forest Foundation in Jakarta (Tropical Forest Foundation 2006). Since 1996, around 100 forest concessionaires have been trained in RIL techniques.

Biodiversity Considerations

No specific biodiversity guidelines have been produced for Indonesia, despite its large forest area and high biodiversity as well as long history of conservation NGO involvement in the country. However, as of December 2006, 739 216 ha of natural forest have been certified by FSC, two in East Kalimantan, one in Central Kalimantan and one in Riau.

A number of conservation NGOs are working collaboratively with logging concessions, such as The Nature Conservancy (TNC) in East Kalimantan. Activities by TNC have included (High Conservation Value Forest) HCVF assessments for logging concessions (Meijaard *et al*. 2006b), developing techniques for biological surveys within logging concessions, training company staff in identification of birds and mammals, and hunting surveys.

Since 1993, CIFOR has been conducting long-term research in a 48 000-ha logging concession managed by a state-owned company, in Malinau, East Kalimantan. Wildlife monitoring studies began in the late 1990s with baseline biological studies carried out in collaboration with WCS Indonesia. More recent surveys have included camera-trapping. Based on CIFOR's experience in Malinau and work carried out by other researchers in Borneo, the publication *Life after Logging* was produced (Meijaard *et al*. 2005). This book synthesizes a vast amount of research in the area of wildlife and logging and provides a guide to biodiversity considerations in logging concessions, including species-specific guidelines. An Indonesian-language version of the book has recently been published, which makes its recommendations available to a much wider audience of practitioners (Meijaard *et al*. 2006a).

Information Sources

Internet sources such as the Indonesian Ministry of Forestry, FAO and ITTO websites provided useful background information on SFM. Grahame Applegate generously provided Codes of Practice documents for Indonesia and other related information on RIL.

Figure 2.2. Aerial view of FSC-certified production forest, East Kalimantan. Photo: Ed Pollard

Lao People's Democratic Republic

Not ITTO member. Asia Pacific Forestry Commission member. Has acceded to Convention on Biological Diversity.

Background

Lao PDR retains a relatively high proportion of forests – about 16 million ha, which is almost 70% of its area (FAO 2006b), but there are conflicting figures for forest cover and it has been reported that as little as 41.5% remains forested (ICEM 2003), half of which is degraded forest (World Bank 2001). The dominant evergreen forest types are dry or semi-evergreen forests and hill evergreen forests. The dominant deciduous forest types are mixed deciduous. The mountainous terrain is a barrier to commercial logging, with only 24% of the land below 5% slope and a good 70% over 20% (ICEM 2003). Two and a half million hectares are designated as production forests, however these are not mapped, criteria for their designation have not been published, and logging is not confined to these areas. Forests with potential for commercial production might actually total more than 5.6 million ha. Deforestation is occurring at a rate of 0.6–0.8% per year (World Bank 2001).

Lao PDR, Cambodia and Vietnam comprise the Indo-Malayan biodiversity hotspot. Species new to science are still being discovered here, such as the mammal shown in Figure 2.3, below, a specimen of which was discovered by WCS in 2005 in a village market.

Figure 2.3. *Kha-nyou* (*Laonastes aenigmamus*) – a new species. Modified from Robert Timmins, WCS

Forest Management

The government's principal forestry agency is the Department of Forestry, housed within the Ministry of Agriculture and Forestry. The state owns all land, including forestland, though land-use and management rights are devolved to communities. Basic forestry policy and guidelines were formulated only in 1989.

All production forests, both natural forests and forest plantations, are required in principle, but not always in reality, to be managed according to forest management plans derived from the results of research carried out in the country and the region. There are no management plan guidelines and no requirements to prepare them prior to allocation of harvesting quotas. There are basic operational management plans for harvesting, and logging quotas for each province are worked out based on assumptions that in some cases have yet to be adequately validated. Annual quotas are not set systematically and do not necessarily reflect forest management objectives.

In 1991 concerns over unsustainable logging practices and corruption led to a Presidential Decree banning logging. The full ban was, however, relatively short-lived. The country stopped issuing concessions for forest harvesting in 1994, but logging is still permitted in areas designated to become hydroelectric reservoirs, irrigation reservoirs, transmission pylons, electricity lines and other infrastructural and rural development projects. Commercial forest harvesting in Lao PDR is carried out almost exclusively by state-owned enterprises such as the Bolisat Phattana Khet Phoudoi (BPKP), a company founded and owned by the Ministry of Defence, or by joint ventures associated with these companies.

Between 1996 and 2000 a project funded by the World Bank and the Government of Finland set up a series of Village Forestry Associations (VFAs) in Savannahkhet and Khammouane Provinces. The project, part of the Forest Management and Conservation Programme (FOMACOP), aimed to develop a model of 'village forestry', through which villagers would log the forests and receive a share of the income from the timber. The villagers organize themselves into VFAs, conduct participatory planning with other villages, demarcate boundaries, prepare village land-use plans, conduct forest inventories, prepare forest management plans, enter into an agreement with the government to manage the forests, and prepare annual operation plans approved by the relevant government authorities.

Sustainable Forest Management

A positive step towards SFM was taken in 2002 with Decree 59/PM/2002 on the Sustainable Management of Production Forest Areas. *Guidelines on the Control of Timber Production* were published in May 2006 (Jonsson 2006), and this, in theory, should go a long way to improving a situation in which there were no standards or guidelines for roading, landing locations, felling or extraction. There are few incentives for either efficient harvesting operations or supervisory or monitoring procedures to ensure compliance with regulations and specifications. A *National Code of Timber Harvesting Practice* was drafted in mid 1997 and published in 2005 (Asia-Pacific Forestry Commission 2006).

The World Bank reported in 2001 that Lao forestry is poorly equipped for the challenge of providing sustainable resource management and that the industry is in 'disarray' (TRP 2000; World Bank 2001). Currently, there is major overcapacity in the log-processing sector, and owners are actively seeking new timber resources (World Bank 2001). While the government is aware of this trend and is moving to address the situation, the level of exploitation and the dynamics of the forest production sector are not sustainable at the present time.

In an attempt to help the government resolve this dire situation the Sustainable Forestry and Rural Development (SUFORD) Project (which superseded FOMACOMP) is trying to institute nation-wide systematic forest management in natural production forests in order to alleviate rural poverty, protect biodiversity and enhance the contribution of forestry to the development of national and local economies in a sustainable manner. The project recognizes the importance of multiple-use forestry which combines production aspects at the same time as protecting the forests' environmental functions and biological diversity. The existing diversity of flora and fauna has to be maintained as part of the forest management principles and therefore forms a biodiversity consideration in inventory and planning, forest operations and harvesting. There are two FSC-certified forests in Lao, totalling an area of 44 985 ha: one is a communal forest, the other is private. This is a positive development for SFM in Lao PDR with respect to helping the government improve forest management practices in some areas. However, there has been some recent criticism of these certifications with regard to Chain of Custody.

Biodiversity Considerations

A proposal for official guidelines on how to monitor biodiversity values relevant for managing production forest areas in Lao PDR was prepared in 2006 (SUFORD 2006). These guidelines (see Table 2.2) were precipitated by a review of HCVF assessments which were carried out in two production forest areas (PFAs) (SUFORD 2006). The authors felt that the HCVF Toolkit for Lao PDR was unnecessarily complicated and difficult to interpret; they therefore proposed a set of guidelines: Guidelines and Procedures for Biodiversity Monitoring in Production Forest Areas. These guidelines remain in a draft state and the authors are sceptical that they will ever been taken up by the government.

The objectives state, 'Biodiversity monitoring in PFAs are to provide relevant input for planning and implementation of Sustainable Forest Management that include integration of biodiversity aspects.' The scope states, 'Biodiversity monitoring in PFAs is carried out and repeated yearly to gather, analyze and present data on biodiversity trends, ensuring that biodiversity is not negatively impacted by the direct interventions (harvesting) or by indirect interventions (hunting/increased agricultural encroachment) as result of management decisions taken on any level (from village to central level).'

The guidelines recommend that annual biodiversity surveys are carried out in the PFAs by staff from the Division of Forest Resource Conservation from the Department of Forestry. There are detailed requirements about who should be in the team, the equipment required, and the need for forward budget planning to allocate funds for the activity.

The SUFORD team has also carried out baseline biodiversity surveys in six PFAs (Poulsen *et al*. 2005, 2006). These surveys were carried out as preparation for HCVF assessments.

Information Sources

Dr. Michael Poulsen was very helpful in providing relevant documents on his biodiversity surveys carried out for the SUFORD project. He also answered general questions on issues pertaining to SFM in Lao PDR. Otherwise information was gleaned from the Internet, FAO and ITTO websites.

Malaysia

ITTO member. Asia Pacific Forestry Commission member. Has ratified Convention on Biological Diversity.

Background

Malaysia is a federation of 13 states, 11 in the Malay Peninsula (West Malaysia) and 2 on Borneo (Sabah and Sarawak). Lowland evergreen tropical rainforest, dominated by Diptercarpaceae, is the principal forest formation on dry land at low altitudes in Peninsular Malaysia, Sabah and Sarawak. The forest extent in 2005 was almost 21 million ha, covering almost 64% of the land area (FAO 2006b). Deforestation rates were 0.4% between 1990 and 2000, and rose to 0.7% between 2000 and 2005 (FAO 2006b).

Forest Management

Peninsular Malaysia has a long history of careful forest management, and conservation of its extremely rich biological reserves is well developed (Collins *et al*. 1991). Peninsular Malaysia has had a Forest Department for over 100 years. The Forest Departments of the peninsula and the East Malaysian states of Sabah and Sarawak are independent. Major logging at high intensity started in the 1950s using the monocyclic Malayan Uniform System (MUS), which has now been replaced by the Selection Management System (SMS), which includes polycyclic logging.

The National Forest Policy clearly differentiates between a Permanent Forest Estate (PFE), to be maintained and managed as forest in perpetuity, and State Land Forest, areas outside the PFE often termed Conversion Forests. In the past, State Land Forests were designated for eventual clearing to meet demands for additional land for agricultural, urban or other non-forest purposes. More recently, efforts are being made to incorporate these into the PFE. All forest land in Malaysia is state-owned.
The National Forest Policy specifies that productivity in the PFE be optimized through sound regeneration and rehabilitation programmes compatible with environmental requirements, and that the conservation and protection of the forests' biological diversity, water, soil, and sustainable productivity potential should also be provided for.

Since the 1950s, the development and implementation of forest management working plans has been mandatory. Each forest concession area or FMU, whether inside or outside the PFE and including protected areas, must have a Forest Management Plan that includes prescriptions for RIL, rehabilitation, wildlife management, forest biodiversity conservation, and environmental mitigation; results of Pre-felling and Post-felling Forest Inventories; records of enrichment planting; and records of planting of rattan and forest fruit trees.

SMS operates on a 25–30 year felling cycle with an expected net out put of 30–40 m^3 per hectare. The minimum felling diameter at breast height (dbh) prescribed for dipterocarp species is 50 cm. The felling limit for non-dipterocarp species should not be less than 45 cm dbh, while the residual stocks should incorporate at least 32 sound commercial trees per hectare with a diameter class of 30–45 cm. Similar systems are practised in Sabah and Sarawak. The modified MUS and SMS promote RIL, with an emphasis on reducing residual damage to future crop trees. Environmental impact assessments are required for logging areas greater than 500 ha.

Sustainable Forest Management

Efforts are also taken by the Forestry Departments to enhance *in situ* conservation of biological diversity during forest harvesting within the production forests of the PFE. Environmental protection and forest conservation measures such as subscribing to approved forest harvesting guidelines and forest road specifications, as well as leaving behind buffer zones to protect the water resources and minimize soil erosion, are also indicative of conservation efforts (ITTO 2006).

In Sabah, the State Government has implemented a system of Sustainable Forest Management Licence Agreements (SFMLAs) as a means of SFM. Private sector organizations sign SFMLAs to manage forests in accordance with SFM principles for 100 years. SFMLA holders are expected to prepare long-term management plans, employ ecologically friendly harvesting techniques, and undertake enrichment planting, forest rehabilitation and silviculture. SFMLA holders are not permitted to extract timber from their concession until

they have complied with all the conditions of the licence. To date, however, most licence holders have not been able to meet the stringent guidelines or to fulfil the licence conditions.

Harvesting in Malaysia is largely mechanized with roads and skid trails built. Yarding is generally done using tractors and skidders, although cable yarding systems are used in locations where roading options are limited. Malaysia is, however, implementing a large number of innovative projects designed to develop better techniques for RIL. These include, for example, the testing of helicopter logging in Sarawak (under an ITTO-funded Sarawak Model Forest Management Area project implemented by the Sarawak Forestry Department in partnership with Sarawak Timber Association). This project is developing a variety of measures to encourage efforts towards SFM, including airborne video recording and mapping, computer-aided road building and design, and comparative studies of RIL logging, helicopter logging and conventional logging (ITTO 2006).

Forest management practices in Malaysia are presently in the process of a paradigm shift from sustained timber yield management to sustainable forest ecosystem management. Malaysia is relatively advanced in this respect compared to other Asian countries (ITTO 2006). The country has prepared national-level C&I for SFM, developed a domestic forest management certification system (MTCC), and has a relatively robust forest regulatory and monitoring system. MTCC certificates for natural production forests are held for 4 730 774 ha; only 55 949 ha are outside Peninsular Malaysia, and in Sarawak they are held by the Samling Corporation. The Sabah Forestry Department holds an FSC certificate for its 55 683-ha Deramakot forest reserve. Nonetheless, the country recognizes that, in the future, the majority of harvesting will be carried out in regenerated logged-over forests. Hence, more intensive and prudent forest management practices will have to be applied to assessing the current growing stock of logged forests and to ensuring their productivity and sustainability (ITTO 2006).

Biodiversity

In 1997, the Sarawak Government adopted A Master Plan for Wildlife in Sarawak as official government policy. The Master Plan was co-written by staff from WCS and the Sarawak Forestry Department. Its two core themes were control of unsustainable hunting, and conserving wildlife in different land categories. The implementation of this plan has included legislative changes incorporating a total legal ban on sales of wildlife taken from the wild, regulations to control hunting in logging concessions, and controlling modern hunting technologies. Implementation involved state-wide conservation education and enforcement programmes, formal training for government staff, the creation of important new protected areas, and reductions in sales of shotgun cartridges. The results have been an increase in protected areas, and a decline in wildlife trade (Bennett 2004). Factors contributing to successful implementation of the Master Plan include: long-term field research and in-depth local knowledge; its being requested, supported throughout, and formally approved by the most senior government decision makers; its being user-friendly and specific, including having timetables for action by specific agencies; and the rural population's understanding the need for, and its support for, the conservation measures proposed.

WCS, Samling Group and the Sarawak Forest Department

Since 2001 WCS has been working in the Upper Baram area with the Sarawak Forest Department and Samling Corporation on a project designed to implement the Master Plan for Wildlife in Sarawak – in particular, the legal restrictions on the trade in wildlife – and to work with local communities to reduce hunting pressure on wildlife in the logging concession. This has involved conservation education for local communities and logging company staff, enforcement operations in the logging camps, and regular wildlife surveys and hunting interviews to assess wildlife populations and hunting patterns. The Samling concession is certified under the MTCC scheme as RIL techniques have been utilized in the concession. The logging company contributes to the cost of the biodiversity surveys.

Deramakot, Sabah

The Sabah Forestry Department started to implement SFM in 1989, in collaboration with the German Agency for Technical Co-operation (GTZ). The Deramakot Forest Reserve (approximately 55 000 ha of logged-over forest)

in central eastern Sabah has been designated an SFM Model Forest. SFM in Deramakot Forest Reserve has also been certified by the FSC as a well managed forest. Deramakot is managed in accordance with the principles of sustained yield and multiple-use forest management. RIL and Skyline logging techniques have been researched and implemented there. At present, two major research programmes are investigating the impact of forest harvesting and forest disturbance in Deramakot. The programme on forest harvesting focuses on the effect of different diameter felling limits and different degrees of slope on the flora and fauna. This programme is funded by the Federal Government of Malaysia. The second programme is being conducted in collaboration with a consortium led by the Centre for Ecological Research, Kyoto University, to investigate forest disturbance and recovery. Biodiversity studies are conducted within both programmes and thus such information will provide a more comprehensive picture of RIL and biodiversity. See Sabah Forestry Department website (http://www.forest.sabah.gov.my) and the Deramakot SFM Model Forest website (http://www.deramakot.sabah.gov.my) for more information.

Information Sources

Further information needs to be sought on the existence of guidelines for biodiversity planning and monitoring in production forest areas in both Sarawak (Samling/WCS) and Sabah (Deramakot Model Forest/Sabah Forestry).

Myanmar

ITTO member. Asia Pacific Forestry Commission member. Has not ratified Convention on Biological Diversity

Background

Myanmar holds more than half of mainland South East Asia's closed forests. Most of Myanmar's undisturbed closed-canopy forests are located in the mountains that ring the country. Peripheral to the Central Dry Zone are extensive mixed deciduous forests that are of great economic importance as the source of teakwood. The teak forests are surrounded by a fringe of moist evergreen forests and evergreen mountain forests. Myanmar holds 70% of the world's remaining teak forests. The exploitation of the teak forests dates back to 1856 (WRI 1998) (see Figure 2.4). The total land area of Myanmar is 65 755 000 ha, of which 49% is recorded as forested (FAO 2006b). Deforestation rates for the past five years stand at 1.4% per annum (FAO 2006b).

Forest Management

Forest management is the remit of two main governmental institutions: the Forestry Department, which undertakes conservation and management of forests, and the Myanma Timber Enterprise (MTE) which undertakes extraction and utilization of the forests. Timber extraction follows the Myanma Selection System (MSS). There is a National Code of Forest Harvesting Practice (2000) which is in the process of being implemented (see Table 2.1).

MTE employs a combination of animal and mechanical power for timber extraction work (U Khin Zaw 2003). Animal skidding has proven to be the most economical and environmentally friendly method of extraction as it avoids the need to construct costly and easily eroded roads in forest or up steep, hilly terrain. Moreover animal skidding prevents the possible destruction of valuable unfelled trees. Stumping (felling and logging) and skidding are undertaken mainly by elephants, and in some flat areas water buffaloes are used. MTE uses about 3000 elephants for its work, and 650 pairs of water buffalo are used for dragging. When mechanical power is used for logging, elephants assist by dragging logs from stump to wider drag paths or clearings just outside the extraction area. Further hauling or skidding is done by wheel loaders onto timber hauling trucks.

The Forest Policy of 1995 lays out the basic following conditions for the protection of forests and biodiversity: production should be sustainable; it should satisfy basic needs; there should be institutional strengthening and improvements in efficiency; forestry should be participatory; and public awareness should be raised. Conservation objectives emphasized include the protection of soils, water catchments, ecosystems, biodiversity, genetic resources, scenic reserves and national heritage sites. The policy plans for a participatory approach to forest management with an emphasis on people's participation in forestry, wildlife and nature conservation activities, as well as in establishing plantations and increasing incomes through the use of community and agroforestry systems (U Khin Zaw 2003).

Sustainable Forest Management

Although there are major challenges facing the implementation of SFM, such as the limitation on resources and funding, recent developments in terms of SFM include the following (ITTO 2006):

- Identification of C&I for SFM based on the ITTO initiative.
- Formulation and documentation of national forest programmes.
- Updating and reformulation of forest management plans covering the whole country.
- Establishment of model forests using a partnership approach.
- Formulation of National Code of Practice for Forest Harvesting in Myanmar (U Khin Zaw 2003). The Code was completed in 2000 and is now being disseminated to national staff for implementation.

In 1998, Myanmar set up a Timber Certification Committee with a mandate to develop a national timber certification process. Myanmar has also established a National Code of Forest Harvesting Practices. The country has established two model forests, Oktwin and Pauk Khaung Model Forests, in the Bago Yoma region. The Forest Department has co-

operated with the Japanese International Forestry Promotion and Cooperation Centre and the Japan Overseas Forestry Consultants Association in managing these forests. Myanmar is also participating in a regional Implementation of Model Forest Approach for SFM project. In the late 1990s, 62 forest management plans, covering forests of the entire country, were developed (ITTO 2006).

However, there are many reports that the forest management system in Myanmar is far from sustainable (Global Witness 2003). As stated by Global Witness, 'Burma is the epitome of unrealized potential, a country rich in natural resources and social capital, yet poor.' In 1999–2000, the volume of Burma's official recorded timber exports totalled 806 000 m^3, whilst during the same period importing countries recorded approximately 1.72 million m^3, which suggests illegal exports of 914 000 m^3 (Global Witness 2003). Logging has led to environmental destruction, particularly in Kachin State where Chinese logging companies have clear cut vast swathes of virgin forest (Global Witness 2003). The Global Witness report contains a very thorough description of the theory and reality of logging in Myanmar (Global Witness 2003). As the country is effectively 'closed' there are no markets for sustainably produced timber, which means that existing markets are interested only in low-cost timber which in turn means that producers tend to maximize short-term profits at the expense of long-term investment in SFM.

Biodiversity

No examples of biodiversity guidelines were found. BirdLife International is working in Myanmar on the identification of Important Bird Areas (IBAs), but was not contacted with regard to this report.

Information Sources

As the country is effectively closed it has been quite difficult to collect credible information. Will Duckworth, WCS, kindly provided some comments on the situation. Follow-up with BirdLife International would be prudent.

The Philippines

ITTO Member. Asia Pacific Forestry Commission member. Has ratified Convention on Biological Diversity.

Background

Since the 1970s, the rapid depletion of timber stocks has triggered a shift in emphasis from timber harvesting and utilization, to protection, development and rehabilitation of forest lands (ITTO 2006). In the Philippines, Department Administrative Order No. 24 (1991) prohibited logging in old growth forests and on slopes with gradients greater than 50%. Logging is still permissible, however, in some second-growth natural forests.

Forest Management

Forest management in the Philippines emphasizes multiple uses of forest lands (ITTO 2006). Management recognizes that forests serve production, conservation and protection purposes. The specific forest management goals encapsulated in the Master Plan for Forestry Development reflect an emphasis on conservation and social equity. The Master Plan outlines general goals of conserving forest ecosystems and genetic resources, while at the same time meeting people's needs for forestry products in a sustainable manner, and promoting the country's overall goals of social justice based on principles of equity. Forest management is also required to encompass proper land management practices to ensure protection of land against degradation, including desertification, soil erosion, floods and other ecological calamities. Upland watersheds are required to be managed to facilitate the production of food, clean water, energy and other basic needs. Forests are also expected to contribute to employment objectives and growth in national and local economies.

Forest management planning is envisaged to be strongly consultative, with NGOs, private sector organizations, communities and other beneficiaries involved in participatory planning with national, regional and provincial planning groups, and the Community, Environment and Natural Resources Forestry Planning Group.

In the past, access to forest resources has mostly been through licence agreements or permits operated mainly in large-scale operations involving thousands of hectares of forest land (ITTO 2006). Since 1993, specific forest management planning by private sector concessionaires has been carried out under Industrial Forest Management Agreements (legislated under Department Administrative Order No. 60, 1993). The various forms of community-based forest management (CBFM) also require the preparation of management plans. Forests under the Integrated Social Forestry Programme (ISFP) are managed under a Certificate of Stewardship Contract. Production-sharing contracts for plantation forests managed under Forest Land Management Agreements (FLMAs) provide for leasehold agreements, with specified reforestation targets. As of October 1996, all people-oriented forestry programmes were integrated and unified under the CBFM programme. By mid 1999 almost 4 million ha were covered by CBFM tenurial instruments.

Silvicultural interventions in the Philippines are predominantly carried out utilizing three distinct management systems (ITTO 2006). The Philippines Selective Logging System is a polycyclic system, under which extensive natural management is applied to residual dipterocarp forest. The system specifies that trees with a dbh greater than 60 cm be harvested, while 20–25 undamaged trees per hectare with dbh in the range 36–60 cm remain to provide the next crop. The system is expected to operate in felling cycles of around 40 years, though in practice the cycle is generally 30 years – or sometimes less. Loggers are required to implement Timber Stand Improvement (TSI) measures after harvest, although TSI measures are regularly omitted from logging operations. TSI is the post-logging phase of the system and generally comprises refining and liberation. Refining involves climber cutting and girdling of over-mature and defective trees. Liberation eliminates competing vegetation.

An intensive natural management system, similar to the Malayan Uniform System, is also applied to dipterocarp forests. This system operates on a 60–80 year rotation and involves removing the overstorey in a series of two or three harvesting operations over a period of 10 years. The canopy is gradually opened up,

and finally cleared, to induce regeneration. Silvicultural treatments are applied 10 years after the final harvest, followed by two thinning operations at 20-year intervals.

Department Administrative Order No. 24 (1991) prohibits logging in the old growth forests and on slopes with gradients greater than 50%. An FAO study on the efficacy of imposing logging bans concludes that the Philippines is continuing to struggle to implement logging bans on harvesting in natural forests. In spite of the ban, the achievement of effective protection and conservation remains elusive. The lack of effective institutions and policies to deal with both reduced timber supplies and enforcement of harvesting restrictions together with substantial social and economic impacts has made the realization of natural forest conservation difficult. The Philippines has become a major net importer of timber since imposing restrictions on harvesting in natural forests, leading to concerns over the harvesting practices and sustainability of harvests in the other countries supplying imported timber.

Sustainable Forest Management

The Philippines Government has adopted CBFM as the national strategy to ensure the sustainable development of the country's forestland resources (ITTO 2006). The system emphasizes the importance of a holistic and systematic approach to forest land management. Under Executive Order No. 263, the management of CBFM areas must be consistent with overall strategies for district and regional development. Government policy envisages community-based approaches to ensure sustainable, effective and efficient management of forest lands by empowered local communities with strong, viable community organizations working in close coordination with the Department of Environment and Natural Resources and other organizations. A Community-Based Forest Management Office (CBFMO) has been created within the regular structure of the Forest Management Bureau to oversee the implementation of various people-oriented forestry programmes.

Biodiversity

No specific biodiversity guidelines were encountered, although a more thorough search of literature related to CBFM needs to be carried out to assess the inclusion of biodiversity and other environmental considerations.

Information Sources

All the information presented was collected from the ITTO and FAO websites.

Singapore

Not ITTO member. Not Asia Pacific Forestry Commission member. Has not ratified Convention on Biological Diversity.

Until 1819, when the British established a settlement, Singapore was covered with tropical rainforest. Subsequent intensive agricultural schemes, coupled with logging and fuelwood collection, led to significant deforestation and forest degradation. By 1884, only 7% of the island was forested. To provide for watershed protection and wood production needs, in the late 1880s forest reserves were established and reservoirs and their catchments were afforded legal protection.

In 2000, about 3.3% of Singapore's land area was classified as forest. Bukit Timah Nature Reserve and the Singapore Botanical Gardens' Jungle are Singapore's lone remnant rainforest fragments from the island's once-rich forest. Both of these fragments have been the focus of intense study on the effect of fragmentation on forest patches. Both forests have been isolated for a long period, about 130 years, but species composition is significantly different in the two patches. Bukit Timah Nature Reserve covers about 50 ha and retains some primary forest characteristics, while the smaller Botanical Gardens' Jungle covers only 4 ha and retains relatively little of its original diversity and forest structure. No commercial logging takes place in Singapore, and for the purposes of this review SFM is not applicable.

Thailand

ITTO Member. Asia Pacific Forestry Commission member. Has acceded to Convention on Biological Diversity.

Background

The Kingdom of Thailand covers a land area of 51 million ha and has a population of 62.4 million people. The forest extent is about 14.5 million ha, or 28.4 % of the total land area (FAO 2006b). The forest formations are evergreen forests with three subtypes – tropical rainforests, semi-evergreen forests and hill evergreen forests (43% of the forest area), pine forests, mangrove and coastal forests (2%), mixed deciduous forest (22%), and dry dipterocarp forest (31%) (ITTO 2006). Much of the remaining forest is within the protected area network.

Throughout the 1980s there was accelerated depletion of natural resources, which is all the more surprising considering that in the latter half of the nineteenth century Thailand was the first South East Asian country to start managing its forests for a sustained yield (Collins *et al*. 1991). Precipitated by a landslide in late 1988 which killed 359 people, two Royal Decrees were passed in 1989 to make provision for a nationwide ban on commercial timber production from natural forests. Timber harvesting has been reduced drastically since the implementation of these bans and is now only legally undertaken in plantations and mangroves. Thailand was the first country in the world to ban all logging.

Forest Management

Forest management, under the Royal Forest Department, has changed significantly over time from single-use management focused on timber extraction towards more progressive multiple-use management with simultaneous consideration of soil and water issues, plantation development, forest rehabilitation and community interests. Plantation projects have broadened to include non-teak species, fuelwood, mangrove species and community forests.

Sustainable Forest Management

Thailand is currently in the process of establishing a continuous monitoring system to support information for C&I. Thailand also participates in the process to establish model forests, and a separate project proposal to establish a model forest for sustainable management has been prepared with support from ITTO (ITTO 2006). Despite the logging ban, deforestation and degradation through encroachment, and illegal logging, remain serious problems, even within protected forests.

Biodiversity Guidelines

No specific biodiversity guidelines were found; further investigation is required.

Timor-Leste

Not ITTO member. Asia Pacific Forestry Commission member. Party to Convention on Biological Diversity 2007 but has not yet ratified.

Background

Timor-Leste covers an area of almost 1.5 million ha and has a population of 925 000. It is a rugged, hilly country with over half (53%) of the land area classified as forest and woodland (FAO 2006b), bearing in mind that that woodland occupies a much larger area than dense forest. Human impacts, including repeated burning and land clearing for cultivation, hunting and grazing have resulted in the loss of most of the original forests. The vegetation now consists largely of secondary forest and woodland, savannah and grasslands. Deforestation rates are high, with 16% of the forested area being completely cleared between 1972 and 1999 (Erikstad *et al*. 2001 in (Bouma and Kobryn 2004). Massive deforestation took place during successive occupations of the territory, and sandalwood trees were especially targeted for their valuable oil. Erosion is now a serious problem, as is the spread of a wide range of introduced weeds.

Forest Management

With the establishment of the interim United Nations Transitional Administration in East Timor (UNTAET) in 1999 following the withdrawal of the Government of Indonesia, early operations were concerned with establishing a legal basis for facilitating the provision of emergency assistance and rehabilitation to traumatized Timorese communities. Two initial measures were adopted to establish an interim basis for strategic directions in natural environmental management. The first of these initiatives (Regulation 17/2000) decreed a ban on commercial logging of extant timber stocks and larger-scale commercial exploitation of other resources such as fisheries and non-timber forest products, especially sandalwood. The second initiative (Regulation 19/2000) related to the question of land tenure within East Timor.

In order to aid Timor-Leste on its long road to forest management recovery, FAO has been working with the government on developing a comprehensive forest policy for the country, with an additional emphasis on community forestry (Gilmour 2005). The final version of the forest policy statement was tabled for debate in parliament in early 2006. The policy statement was produced through a participatory approach, based on feedback from village communities and other stakeholders (S. Appanah, National Forest Programme Adviser (Asia Pacific), FAO Regional Office for Asia Pacific, personal communication). The following is an excerpt from the aforementioned policy: 'The forest policy objective is effective protection of the ecological integrity and biological composition of no less than 70% of the area of forests by 2020. Protection of forests will facilitate sustainable forest management, preserve and maintain their ecological, social and economic values especially for sustainable livelihoods and the economic development of communities, the reduction of poverty, and for the benefit of the nation'.

The forest policy is based on 11 strategies, and protection of the environment and biodiversity feature prominently. Fire, grazing, invasive species and fuelwood collection have all been identified as serious issues which need to be addressed in order to protect biodiversity and improve forest management. The cornerstone on which management will be established is participatory CBFM whereby boundaries will be determined and legally recognized under Land Law 01-2003 and forthcoming new forest legislation as a basis for defining forest ownership and forest management responsibilities. A detailed weed and pest management strategy will also be drawn up by 2008.

Biodiversity Guidelines

No specific guidelines on biodiversity conservation within production forestry or community forestry areas yet exist, but the forest policy objective and strategies are certainly cognizant of biodiversity considerations. BirdLife International has been working with the Government of Timor-Leste (Ministry for Agriculture, Forestry and Fisheries, MAFF) for several years on a programme of biological surveys, resulting in the identification of the country's Important Bird Areas (IBAs).

Figure 2.4. The Threatened Yellow-crested Cockatoo Cacatua sulphurea. Photo: Rosemary Low

With other partners BirdLife will focus on the area of highest biodiversity value in Timor-Leste, to build partnerships and collaboratively identify conservation priorities and objectives. It will establish a foundation for community-based conservation via a national protected areas network. The Critically Endangered Yellow-crested Cockatoo *Cacatua sulphurea* (see Figure 2.4) is one of the important species found in Timor-Leste.

Information Sources

Staff from the FAO Regional Office in Bangkok (Patrick Durst and S. Appanah) were very helpful in providing the latest information on the status of the forest policy. Don Gilmour kindly provided his insight and documentation on the community-forestry initiative. The remaining information was found on the Internet.

Vietnam

Not ITTO member. Asia Pacific Forestry Commission member. Has acceded to Convention on Biological Diversity.

Background

In Vietnam, where natural forests have been cleared or degraded during decades of high-impact timber extraction and shifting cultivation, the government has enacted decisions to limit production for a period of 15–20 years to assist forest restoration and rejuvenation. A timber exploitation ban was placed on special-use forests and reserved forests (most natural forests) in 1992, and also encompassed limits on other logging. Commercial logging has been prohibited in the remaining natural forests of Northern Vietnam, southeast of the South Mekong delta, and in the Red River delta. An annual allowable cut of 300 000 m^3 has been applied since 2000. The logging area in Vietnam is now only 12 000 ha.

Vietnam contains a great wealth of biological diversity in its forests. Endemism is high in many groups. An estimated 50% of the entire national flora is endemic (Thai van Trung 1970, on WCMC website: http://www.unep-wcmc.org/). Even groups with relatively low levels of endemism, such as mammals and birds, have some important endemic species. The main mountain blocks such as the Lang Bien plateau, central mountains and mountains of Hoang Lien Son are those which carry the highest levels of endemism in conifers, other plants and birds. In addition, Vietnam contains globally important populations of some of Asia's rarest animals, such as Kouprey *Bos sauveli*, Javan Rhinoceros *Rhinoceros sondaicus*, Asian Elephant *Elephas maximus*, Tiger *Panthera tigris*, Eld's Deer, Douc Langur *Pygathrix nemaeus* (see Figure 2.5) and Crested Argus *Rheinardia ocellata*.

Forest Management

The forestry sector in Vietnam is organized in state-owned public enterprises to which a State Forest is assigned. Until 1981, the country forest sector was made of 413 State Forest Enterprises (SFEs), which are managed at different levels. Since 10/1993 the management of the forestry sector has been reorganized and now operates under the promulgated regulations of Decree No. 388/HDBT involving 599 SFEs self-controlling their economic activities.

- The Ministry of Forestry directly manages 128 forest business units (69 SFEs, 20 forest product processing factories, 12 forest product business companies, 6 seed companies and 17 forest service enterprises).
- Provincial People's Committees directly manage 471 forest business units (343 SFEs, 81 forest product processing enterprises, 32 forest product companies, 1 seed company and 14 forest service enterprises).

A revised law on Forest Protection and Development was adopted by the National Assembly in 2004 and came into force in April 2005. Considerable work is ongoing to prepare the Decree on Implementation of the Law, the formulation of a National Forestry Strategy (2005–2020) and a 5-year plan (2006–2010) for the forestry sector (for additional information see http://www.vietnamforestry.org.vn/index.asp).

Forests have been classified into three categories: production forests, (watershed) protection forests and special use forests, which covers forests managed for biological diversity conservation and protected for other purposes. Most recent data indicate that 4.6 million ha are classified as production forests, 5.7 million ha as protection forests, and 1.8 million ha as special-use forests (UNFF 2005).

Figure 2.5. Douc Langur *Pygathrix nemaeus*. Photo: Benjamin Lee

Forest management plans have been given relatively low emphasis in Vietnam. Strong restrictions on harvesting in natural forests mean that the focus of silvicultural efforts in Vietnam are on rehabilitating natural forests and establishing plantations. Protection forests, managed for the conservation of water and soil, and to counter the erosive impacts of water and wind, form the largest category of natural forests. The key trend in forest management is an effort to expand and develop forestry while at the same time stabilizing and improving standards of living for local people. The majority of Vietnam's forestry incentive programmes are related to plantation establishment.

Although the country's forest cover is said to have been increasing over the past few years, forest quality continues to decline as a result of forest degradation, further impacting water discharge patterns and biological diversity. The underlying and proximate causes of forest loss and degradation are rural poverty, shortage of arable land, limited institutional capacities, inadequate tenure regulations, unsustainable land use, excessive logging and natural calamities. These causes combine to exert heavy pressure on the remaining natural forest areas.

Sustainable Forest Management

In order to prevent further deforestation and degradation of forests, the Government of Vietnam has announced a series of policies relating to management, protection and development of the forest resources and promoting sustainable participatory management of forests. Such policies include the Forest Protection and Development Law (1991 and 2004), the Land Law (1993 and 2003), Policy on Closing Natural Forests, and the Forest Land Allocation (FLA) programmes, which have been conducted since the Land Law revision of 1993.

Major national programmes for afforestation, reforestation and improved forest management have included Programmes 327, 556, and 661. In 1993, the government started Programme 327, Regreening Open Land and Barren Hills, for the period 1993–2000, with the objective of afforesting barren land and open treeless hills throughout Vietnam. In 1995, a revised programme, named Programme 556, was adopted. In 1998, the National Assembly agreed to adopt the ambitious 5 Million Hectare Reforestation Programme (5MHRP) for the period 1998–2010. The 5MHRP is implemented by Government Decision 661 (and thus often referred to as Programme 661).

As of 2003, the 5MHRP has achieved approximately 2 million out of the planned 5 million ha of improved forest management or rehabilitation. The majority of the achievements have been in the area of protection and special-use forests, whereas performance for the production forests is lagging behind the targets. Consequently, the Ministry of Agriculture and Rural Development (MARD) is now undertaking a study to look at how the implementation of the 5MHRP can be improved (UNFF 2005).

In 2004, four bilateral Forest Sector Support Project partners and MARD agreed to establish a multi-donor Trust Fund for Forests (TFF). This new fund is intended to provide financing to promote pro-poor sustainable forest management and a transition towards a sector-wide approach to management of the forest sector. Vietnam has developed the Vietnam Criteria and Indicators (C&I) for sustainable forest management. These national C&I have been submitted to the international FSC for approval. These C&I were prepared by the national working group on SFM, through a wide consultation process that involved workshops and meetings with participation of all related stakeholders, such as SFEs, private companies, household and community representatives, and related government agencies. To date, some preliminary pilot assessments have been conducted in Kon Tum and Nghe An Provinces. Since the MARD considers the use of such national C&I to be a voluntary action of the private sector, to promote their products in international markets, it is considered unnecessary to have the Vietnam C&I approved officially by government.

Biodiversity Guidelines

A project involving the Swedish University of Agricultural Sciences (SLU), the Center for International Forestry Research (CIFOR) and the Forest Science Institute of Vietnam (FSIV), financed by the Swedish International Development Agency (SIDA), has provided biodiversity-oriented guidelines for tropical forestry in Vietnam (this report).

Information Sources

The main information source was the Internet, in addition to the UNFF Country Report for Viet Nam (UNFF 2005).

References

Asia-Pacific Forestry Commission. 2006. Taking Stock: Assessing Progress in Developing and Implementing Codes of Practice for Forest Harvesting in ASEAN Member Countries, p. 50. Association of South East Asian Nations and FAO, Bangkok.

Bennett, E.L. 2000. Forest Certification: Where Is The Voice of the Biologist? Conservation Biology 14: Editorial.

Bennett, E.L. 2004. Seeing the Wildlife and the Trees: Improving Timber Certification to Conserve Tropical Forest Wildlife, p. 45. Wildlife Conservation Society and The World Bank, New York.

Bouma, G.A. and Kobryn, H.T. 2004. Change in Vegetation Cover in East Timor 1989–1999. Natural Resources Forum 28: 1-12.

Collins, N.M., Sayer, J.A. and Whitmore, T.C. (eds.) 1991. The Conservation Atlas of Tropical. Forests: Asia and the Pacific. Macmillan Press, London.

Counsell, S. and Loraas, K.T. 2002. Trading in Credibility: The myth and reality of the Forest Stewardship Council. Rainforest Foundation, London.

Dennis, R.A., Mayer, J., Applegate, G., Chokkalingam, U., Colfer, C.J.P., Kurniawan, I., Lachowski, H., Maus, P., Permana, R., Ruchiat, Y. *et al*. 2005. Fire, people and pixels: linking social science and remote sensing to understand underlying causes and impacts of fires in Indonesia. Human Ecology 33: 465-504.

DFW. 2002. The Cambodian Forestry Code of Practice. Biodiversity Conservation Guidelines for the Managed Forest. Draft for Discussion Purposes, p. 22. The Directorate of Forestry and Wildlife, Royal Government of Cambodia, Phnom Penh.

DFW, MAFF, RGC and CTIA. 2001. Model Agreement for Forest Timber Concession Management, p. 41. Department of Forestry and Wildlife, Ministry of Agriculture Forestry and Fisheries, Royal Government of Cambodia and Cambodian Timber Industry Association, Phnom Penh.

Down to Earth. 2001. Certification in Indonesia: A Briefing. International Campaign for Ecological Justice in Indonesia, London.

Elias, G., Applegate, K., Kartawinata, Machfudh and Klassen, A. 2001. Reduced impact logging guidelines for Indonesia. Center for International Forestry Research (CIFOR), Bogor, Indonesia.

FAO (Food and Agriculture Organization of the United Nations). 2005. State of the World's Forests 2005. FAO, Rome,.

FAO (Food and Agriculture Organization of the United Nations). 2006a. Country Profiles – Forest Management. FAO, Rome.

FAO (Food and Agriculture Organization of the United Nations). 2006b. Global Forest Resources Assessment 2005: Progress towards sustainable forest management, p. 320. FAO Forestry Paper. FAO, Rome.

Gilmour, D. 2005. A policy framework for community forestry in Timor-Leste: Discussion of issues and options, p. 38. FAO Regional Office for Asia and the Pacific, Bangkok.

Global Witness. 2003. A Conflict of Interests: The Uncertain Future of Burma's Forests. Briefing document. Global Witness, London.

Global Witness. 2005. Submission to the World Bank Inspection Panel: World Bank Forest Concession Management and Control Pilot Project in Cambodia, p. 91. Prepared for the NGO Forum on Cambodia. Global Witness, London.

Hinrichs, A. and Mckenzie, C. 2004. Results of the Independent Review of Strategic Forest Management Plans prepared by Concession Companies Operating in Cambodia. p. 140. GFA Terra Systems GmbH, Hamburg, Germany.

Holloway, J.D. and Hall, R. 1998. SE Asian geology and biogeography: an introduction. *In*: Hall, R. and Holloway, J.D. (eds.) Biogeography and geological evolution of SE Asia, 1-23. Backhuys Publishers, Leiden.

ICEM (International Centre for Environment Management). 2003. Lao PDR National Report on Protected Areas and Development. Review of Protected Areas and Development in the Lower Mekong River Region, p. 101. Indooroopilly, Queensland, Australia.

ITTO (International Tropical Timber Organization). 1993. ITTO Guidelines for the Conservation of biological diversity in Tropical Production Forests. ITTO, Yokohama, Japan.

ITTO (International Tropical Timber Organization). 2005. Revised ITTO criteria and indicators for the sustainable management of tropical forests including reporting format. Policy Development Series No. 15. ITTO, Yokohama, Japan.

ITTO (International Tropical Timber Organization). 2006. SFM Tropics: Status of Tropical Forest Management 2005. Technical Series No. 24. ITTO, Yokohama, Japan

IUCN. 2006. Guidelines for the Conservation and Sustainable Use of Biodiversity in Tropical Timber Production Forests. IUCN – The World Conservation Union, Gland, Switzerland.

Jonsson, T. 2006. Control of Timber Production. Sustainable Forestry and Rural Development Project – Lao PDR. Co-operation between the Governments of Lao PDR, Finland and the World Bank, Vientiane, Lao PDR.

Klassen, A. 2006. Forest Concession Policy in Indonesia: Incentive or Disincentive for Sustainable Forest Management, p. 12. Reduced Impact Logging and Certification Newsletter of the Tropical Forest Foundation.

Kollert, W., Dillon, T. and McNaughton, A. 2000. Cambodian Forest Concession Review. Evaluation of the Draft Report and Recommendations for Follow-up Action. Final Report of the Expert Panel, p. 14. Asian Development Bank (ADB), Phnom Penh.

Meijaard, E. and Sheil, D. 2007a. A logged forest in Borneo is better than none at all. Nature 446: 974.

Meijaard, E. and Sheil, D. 2007b. Is wildlife research useful for wildlife conservation in the tropics? A review for Borneo with global implications. Biodiversity & Conservation. DOI 10.1007/s10531-007-9161-y.

Meijaard, E. and Sheil, D. 2007c. The persistence and conservation of Borneo mammals in lowland

rain forests managed for timber: observations, overviews and opportunities. Ecological Research. DOI 10.1007/s11284-007-0342-7.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., *et al*. 2005. Life after Logging. Reconciling wildlife conservation and production forestry in Indonesian Borneo. Center for International Forestry Research (CIFOR) and UNESCO, Jakarta.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M. J., Rachmatika, I., Wong, A. *et al*. 2006a. *Hutan pasca pemanenan. Melindungi satwa liar dalam kegiatan hutan produksi di Kalimantan*. CIFOR, WCS and UNESCO, Bogor, Indonesia.

Meijaard, E., Stanley, S.A., Pollard, E.H.B., Gouyon, A. and Paoli, G. 2006b. Practitioners' guide to managing High Conservation Value Forest in Indonesia: A case study from East Kalimantan. The Nature Conservancy, Samarinda, Indonesia. [Edited for errors.]

Ministry of Forestry of Indonesia. 2000. Principles and Practices of Forest Harvesting in Indonesia. Ministry of Forestry of the Republic of Indonesia, Jakarta.

Ministry of Forestry of Indonesia. 2006. Forestry Statistics 2005. Ministry of Forestry of the Republic of Indonesia, Jakarta.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Nasi, R., Dennis, R., Meijaard, E., Applegate, G. and Moore, P. 2002. Forest fires and biological diversity. Unasylva 53: 36-41.

Page, S.E., Siegert, F., Rieley, J.O., Boehm, H.-D.V., Jaya, A. and Limin, S. 2002. The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature 420: 61-65.

Poole, C. 2002. Pioneering Wildlife Conservation in Managed Forests in Cambodia, p. 7. Wildlife Conservation Society, Phnom Penh.

Poulsen, M.K., Phanthavong, B., Sisomphane, C.N. and Phutaamath, B. 2006. Review of Biodiversity in Production Forest Areas in Support of HCVF Identification, p. 26. Sustainable Forestry and Rural Development Project – Lao PDR. Cooperation between Governments of Lao PDR and Finland and World Bank, Vientiane, Lao PDR.

Poulsen, M.K., Phanthavong, B., Sisomphane, C.N. and Phutaamath, B. 2005. Biodiversity Surveys of Production Forest Areas, p. 28. SUFORD Technical Report. Sustainable Forestry and Rural Development Project – Lao PDR. Co-operation between Governments of Lao PDR and Finland and World Bank, Vientiane, Lao PDR.

Sheil, D. and Meijaard, E. 2005. Seeking life after logging: Reconciling wildlife conservation and production forestry in Indonesian Borneo. Tropical Forest Update 15: 12-15.

Sist, P., Dykstra, D. and Fimbel, R. 1998. Reduced-impact logging guidelines for lowland and hill Dipterocarp forests in Indonesia. Occasional Paper No. 1. Center for International Forestry Research (CIFOR), Bogor, Indonesia.

Stone, D. 1997. Biodiversity of Indonesia: *Tanah Air*. Archipelago Press, Singapore.

SUFORD. 2006. Review of ProForest HCVF methodology and its application in Lao PDR with the view of further simplification, p. 39. Sustainable Forestry and Rural Development Project – Lao PDR. Co-operation between Governments of Lao PDR and Finland and World Bank, Vientiane, Lao PDR.

Tropical Forest Foundation 2006. Management Considerations for Successful Implementation of Reduced Impact Logging. TFF, ITTO, MOF, APHI, Jakarta, Indonesia.

TRP (Tropical Rainforest Programme). 2000. Aspects of Forestry Management in the Lao PDR. TRP, Amsterdam, The Netherlands.

U Khin Zaw. 2003. Current state of the development and implementation of the National Code of Harvesting Practices in Myanmar. Country paper presented at the International Expert Meeting on the Development and Implementation of National Codes of Practice for Forest Harvesting – Issues and Options, Chiba, Japan, 17–20 November 2003.

UNFF (United Nations Forum on Forests). 2005. Viet Nam Country Report. National Report to the Fifth Session of the United Nations Forum on Forests, p.21. www.un.org/esa/forests/pdf/national reports/unff5/vietnam.pdf

Wallace, A.R. 1876. The Geographical Distribution of Animals; with a study of the relationships of living and extinct faunas as elucidating the past changes of the Earth's surface. Vols. 1 and 2 (reprinted, 1962). Hafner Publishing Company, New York and London.

Whitmore, T.C. 1987. Biogeographical evolution of the Malay Archipelago. Clarendon Press, Oxford.

World Bank. 2001. LAO PDR Production Forestry Policy: Status and Issues for Dialogue. Vol. 1: Main Report, p. 52. Co-operation between World Bank, Sida and Ministry of Foreign Affairs Government of Finland, Washington, D.C.

WRI (World Resources Institute). 1998. Logging Burma's Frontier Forests: Resources and the Regime, p. 48. WRI, Washington, D.C.

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