IUCN
The World Conservation Union

Best Practice Guidelines for Reducing the Impact of Commercial Logging on Great Apes in Western Equatorial Africa

David Morgan and Crickette Sanz
Series Editor: E.A. Williamson

Occasional Paper of the IUCN Species Survival Commission No. 34

SSC
Species Survival Commission

IUCN—The World Conservation Union

Founded in 1948, the World Conservation Union brings together States, government agencies and a diverse range of non-governmental organizations in a unique world partnership: over 1,000 members in all, spread across some 140 countries. As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. The World Conservation Union builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

IUCN Species Programme

The IUCN Species Programme supports the activities of the IUCN Species Survival Commission and individual Specialist Groups, as well as implementing global species conservation initiatives. It is an integral part of the IUCN Secretariat and is managed from IUCN's international headquarters in Gland, Switzerland. The Species Programme includes a number of technical units covering Wildlife Trade, the Red List, Freshwater Biodiversity Assessments (all located in Cambridge, UK), and the Global Biodiversity Assessment Initiative (located in Washington DC, USA).

IUCN Species Survival Commission

The Species Survival Commission (SSC) is the largest of IUCN's six volunteer commissions with a global membership of 8,000 experts. SSC advises IUCN and its members on the wide range of technical and scientific aspects of species conservation and is dedicated to securing a future for biodiversity. SSC has significant input into the international agreements dealing with biodiversity conservation.
Web: www.iucn.org/themes/ssc

IUCN SSC Primate Specialist Group

The Primate Specialist Group (PSG) is concerned with the conservation of more than 630 species and subspecies of prosimians, monkeys, and apes. Its particular tasks include carrying out conservation status assessments, the compilation of action plans, making recommendations on taxonomic issues, and publishing information on primates to inform IUCN policy as a whole. The PSG facilitates the exchange of critical information among primatologists and the professional conservation community. The PSG Chairman is Russell A. Mittermeier, the Deputy Chair is Anthony B. Rylands; and the Coordinator for the Section on Great Apes is Liz Williamson.
Web: www.primate-sg.org/

Best Practice Guidelines for Reducing the Impact of Commercial Logging on Great Apes in Western Equatorial Africa

David Morgan and Crickette Sanz

Occasional Paper of the IUCN Species Survival Commission No. 34

IUCN
The World Conservation Union

Published by: The World Conservation Union (IUCN), Gland, Switzerland in collaboration with the Center for Applied Biodiversity Science at Conservation International.

Citation: Morgan, D. and Sanz, C. (2007). *Best Practice Guidelines for Reducing the Impact of Commercial Logging on Great Apes in Western Equatorial Africa.* Gland, Switzerland: IUCN SSC Primate Specialist Group (PSG). 32 pp.

ISBN: 978-2-8317-0991-8

Cover photo: ©Thomas Breuer, MPI-EVA/WCS

Layout by: Center for Applied Biodiversity Science at Conservation International

Available from: [e-mail] j.lucena@conservation.org; [web] http://www.primate-sg.org/

Table of Contents

Section 1:
Executive Summary

A significant number of remaining chimpanzee and gorilla populations in Western Equatorial Africa reside in active timber concessions, many of which are within areas identified as being exceptional for the conservation of these apes. Habitat alteration and human disturbance can result in changes to the dietary regimes, behaviour, susceptibility to disease, abundance and distribution of great apes, which may affect their short- and long-term prospects for survival. The conservation outlook of these endangered apes will improve significantly if forestry companies are prepared to make a few changes to management policies in logging concessions. These guidelines outline specific recommendations for reducing the impact of commercial logging on wild apes, many of which can be implemented within the framework of sustainable, reduced-impact logging at little or no additional cost (Table 1). We believe that advantages will also accrue for logging companies which rapidly implement these measures, allowing them to be recognised as "ape-friendly" timber producers.

Section 2:
Introduction

Western Equatorial Africa (WEA includes Cameroon, Central African Republic, Gabon, Equatorial Guinea and the Republic of Congo) encompasses the complete geographical range of two sub-species of African apes, the western lowland gorilla (*Gorilla gorilla gorilla*) and the central chimpanzee (*Pan troglodytes troglodytes*).[1] The region has long been considered a stronghold for the conservation of chimpanzees and gorillas because of the abundance of apes and remoteness of many large forest blocks. This perspective is changing with the increasing threat of poaching, disease, and habitat loss or degradation. For example, ape populations in Gabon were halved in less than 20 years by a combination of bushmeat hunting and Ebola haemorrhagic fever (Walsh *et al.* 2003). Both gorillas and chimpanzees reside in tropical forests containing valuable timber trees, and harvesting of timber plays an important role in the economy of ape habitat countries.

A young central Africa chimpanzee **(Pan troglodytes troglodytes).** ***Photo ©Crickette Sanz, MPI-EVA.***

[1] There may also be remnant ape populations in Cabinda (Angola) and southwest Democratic Republic of Congo (Tutin *et al.* 2005).

Table 1. Summary of the potential impacts of mechanized logging and associated activities on wild ape populations, and ape-friendly recommendations to mitigate these impacts. For each activity, recommendations are listed in decreasing order of their potential benefit to great apes. An estimated cost of implementation is also provided. Refer to document text under Section headings for more information.

Logging Activities	Potential Impact of Logging Activity on Apes	Degree of Impact and Ape Recovery	Ape-friendly Recommendations	Benefit to Apes[1]	Estimated Cost[2]
STRATEGIC PLANNING: - Hiring/ Coordination	Preferential hiring from local populations can remove incentives for secondary immigration, which increases human pressures on apes. It is necessary to define the roles and responsibilities of all parties involved in wildlife issues to ensure effectiveness of activities.	Moderate to Severe Impact, Long-term Recovery	• Preferential Hire from Local Populations, Section 4.1a • Collaborate with Conservation Scientists, Section 4.1b • Designate a Point-Person for Wildlife Issues, Section 4.1c • Establish and Schedule Independent Reviews, Section 4.1d	*** *** ** **	- - $$ $
- Ape Surveys	Without surveys of ape populations in logging concessions, it is impossible to assess high conservation value forests for these endangered species or develop effective strategies to protect them.	Moderate Impact, Long-term Recovery	• Establish Ape Population Monitoring Programme, Section 4.2a • Conduct Standardized Ape Surveys, Section 4.2b • Obtain Baseline Ape Abundance Estimates, Section 4.2c • Contribute Information to A.P.E.S. Database, Section 4.2d	*** ** ** **	$$$ $$ $$ -
- Conservation Zones	Conflicts between humans and wild apes are more likely to occur in production forests than conservation zones.	Moderate Impact, Long-term Recovery	• Designate Wildlife Conservation Zones, Section 4.3a • Establish Buffer Zones around Protected Areas, Section 4.3b	*** **	$$$ $$$
- Road Planning	Establishment of road networks results in destruction of ape habitats and increased access to remote areas.	Severe Impact, Long-term Recovery	• Plan Roads Away from Protected Areas, Section 4.4a • Adopt Reduced Road Widths, Section 4.4b • Place Road Networks in Certain Habitats, Section 4.4c • Minimize Secondary Roads, Section 4.4d • Reuse Old Roads rather than Build New Roads, Section 4.4e	*** *** ** ** **	$$$ $$ $$$ $$ $$
- Harvesting Protocol	Without consideration of apes, planning can result in logging regimes that disrupt the feeding ecology and socio-spatial organization of apes.	Moderate Impact, Long-term Recovery	• Identify Important Ape Food Trees for Protection, Section 4.5a • Design Compartment Size and Sequence, Section 4.5b • Work Inward from Barriers or Boundaries, Section 4.5c	*** ** **	$ $$ $$
- Training & Education	Lack of conservation awareness can result in negative pressures on apes and lack of information on emerging health issues can put both apes and company employees at risk.	Moderate Impact, Short-term Recovery	• Detect/Report Ebola Outbreaks in Concessions, Section 4.6a • Initiate Educational Programme for Employees, Section 4.6b • Implement an Employee Health Programme, Section 4.6c	*** ** **	**$** **$$** **$$**
EMPLOYEE CODE OF CONDUCT: - Inventory Teams - Felling Teams - Extraction Teams - Vehicle Drivers	Several teams work in forestry concessions throughout the logging process which can result in disturbance, displacement, or decline of local ape populations (see Section 6). Further, it has been documented that forestry teams may be involved in or facilitate the hunting of gorillas and chimpanzees.	Severe Impact, Long-term Recovery	• Ban Hunting, Section 4.7a • Prohibit Facilitation of Hunting, Section 4.7b • Subsidize Ecoguard Patrols, Section 4.7c • Implement Road Check Points for Bushmeat, Section 4.7d • Implement Snare Patrols and Removal, Section 4.7e • Establish Professional Accountability, Section 4.7f • Implement a Standardized Reporting System, Section 4.7g • Reduce Size of Forestry Teams, Section 4.7h • Provide Food for Forestry Teams, Section 4.7i • Enforce Sanitation Measures in Forest Camps, Section 4.7j	*** *** *** *** *** *** ** ** ** *	$ $ $$$ $$$ $$ $ $$ $$ $$ $
HARVESTING: - Felling - Extraction	Depending on techniques used in timber felling and extraction, harvesting can result in varying degrees of impact on ape food resources and habitats.	Moderate to Severe Impact, Long-term Recovery	• Avoid Damaging Trees Important in Ape Diets, Section 4.8a • Limit Forest Canopy Loss, Section 4.8b • Implement Directional Felling, Section 4.8c • Minimize Impacts of Log Extraction, Section 4.8d • Avoid Damage to Chimpanzee Tool Sites, Section 4.8e	*** *** ** ** *	$$$ $$ $$ $$ $

[1] * = some short and/or long term benefits, ** = moderate short and/or long term benefit to apes, *** = high short and/or long term benefits to ape populations.

[2] - = no cost, $ = minimal cost, $$ = medium cost, $$$ = high cost.

More than 50% of the range of chimpanzees and gorillas in WEA is allocated to logging concessions (Figure 1), which is more than double the area of their range encompassed by protected areas (17%). Therefore, the expansion of mechanized logging throughout the forests of equatorial Africa can be seen either as the most widespread and long-term threat to wild gorilla and chimpanzee populations; or as an opportunity to extend protection measures beyond national parks and increase the chances of survival of great apes in the region.

Although further survey and monitoring efforts are needed to estimate the number of apes in many forest blocks, experts have identified certain areas that are of exceptional importance for the long-term conservation of chimpanzees and gorillas in WEA (Tutin *et al.* 2005). The selection criteria for these priority areas included estimated size of ape populations based on past surveys, size of the continuous ape habitat, and importance of the area in terms of biodiversity. Existing national parks were found to be paramount in safeguarding ape populations due to their remoteness and comparatively undisturbed state. Many of the exceptional priority regions for ape conservation include both protected areas and the adjacent forestry management units that significantly increase the size of the continuous blocks of habitat and in some cases provide critical ecological links between protected areas.

Indeed, 36% of the total area of the exceptional priority ape conservation areas is within logging concessions (Table 2). Maintenance of forest connectivity between protected areas and logging concessions is important to facilitating the persistence of apes on a larger spatial scale. Research has shown that apes residing in protected areas surrounded by buffer zones of controlled extractive use are less susceptible to population declines and local extinction (Butynski 2003). Implementation of strategies to reduce the direct and indirect impacts of logging on apes in these areas will significantly enhance both the short- and long-term conservation prospects of chimpanzees and gorillas.

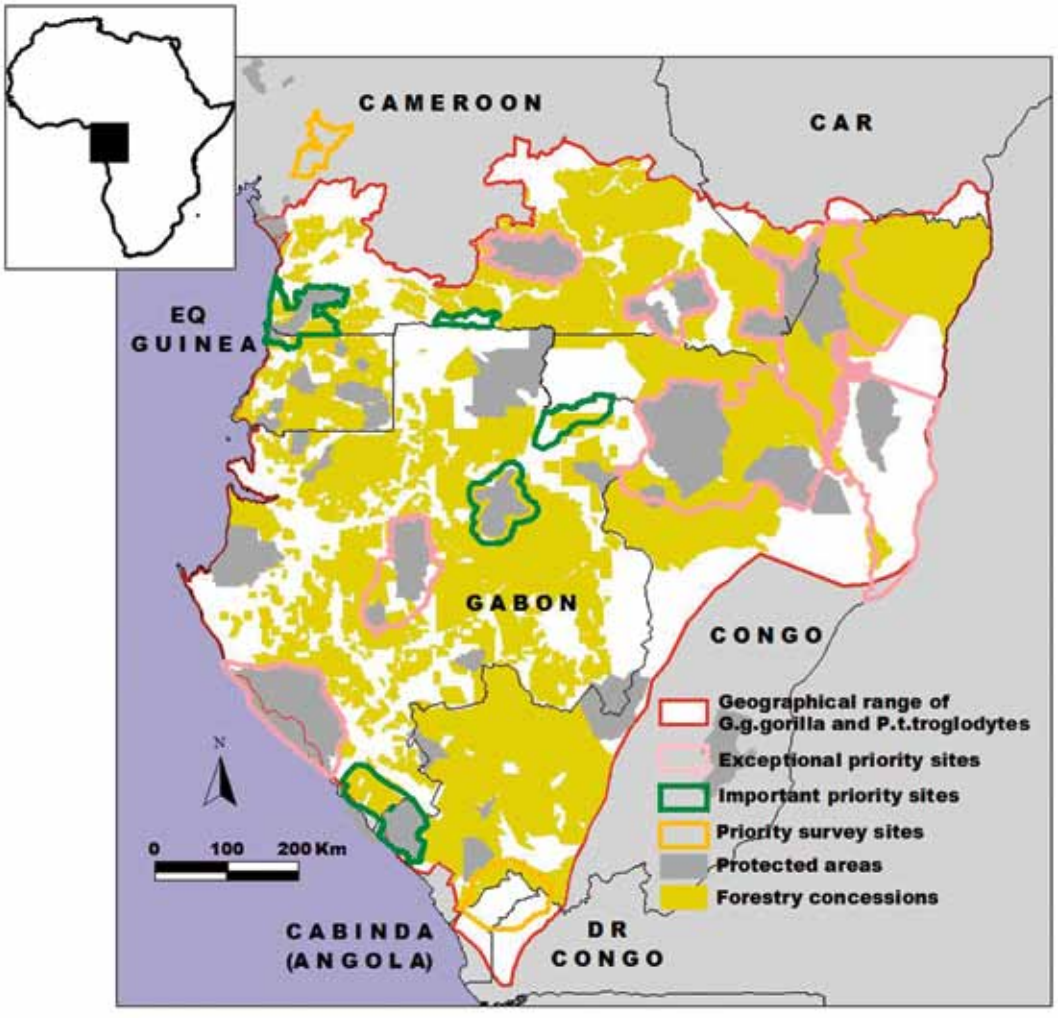

***Figure 1.** Logging concessions and priority great ape populations in Western Equatorial Africa.*[2,3]

Exceptional Priority Sites: Areas with the large ape populations (>2000 apes) combined with a large size (>8,000km²) and ranked as having the highest important for conservation and sustainable forest management at the Libreville biodiversity vision workshop.

Important Priority Sites: Areas with large or medium sized populations (>1,000 apes), which are also large (>4,000km²) and ranked as having high importance for biodiversity conservation.

Priority Survey Sites: Areas that are believed to be very important for ape conservation, but for which no population estimate exists, making surveys an urgent priority.

[2] Priority populations as identified during the Regional Action Plan Workshop for Great Ape Conservation in Western Equatorial Africa, Brazzaville, May 2005 (Tutin *et al.* 2005)

[3] GIS data on logging concessions sourced from WRI (Equatorial Guinea 2002; Gabon 2004), GFW (Cameroon 2004), GTZ/WWF (Central African Republic 2005), CNIAF (Congo 2006).

Table 2. *Total area of the estimated geographic range of great apes in Western Equatorial Africa and priority conservation zones in relation to logging concessions, protected areas, and other habitat types.*

	Logging Concessions		Protected Areas †		Swamp Forest		Unsuitable Ape Habitat		Other (unclassified)		Total
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
Geographic Range of Great Apes in WEA	34,765,970	51.4%	11,320,375	16.8%	4,130,648	6.1%	5,838,850	8.6%	11,526,897	17.1%	67,582,740
Exceptional Priority Ape Conservation Zones	4,528,923	35.5%	6,236,212	48.9%	1,644,705	12.9%	265,536	2.1%	79,222	0.6%	12,754,599
Important Priority Ape Conservation Zones	957,392	39.7%	1,061,681	44.0%	119,060	4.9%	17,954	0.7%	254,604	10.6%	2,410,691

† IUCN categories I-IV, proposed protected areas and ape sanctuaries.

Although mechanized logging is often cited as the primary cause of faunal decline in tropical forests, our knowledge of the precise impact of logging on most mammal species and on forest dynamics is still incomplete (Johns and Skorupa 1987; Skorupa 1988; Johns 1992; Struhsaker 1997; White and Tutin 2001; Meijaard *et al.* 2005). Timber extraction and associated activities can alter ape habitats, affect food resources, disrupt social groups, fragment populations, and increase exposure to diseases. Hunting pressure also often increases due to improved access to remote forests via the transport networks constructed by forestry companies (Wilkie *et al.* 1992; Auzel and Wilkie, 2000). Even low hunting pressure adversely affects apes because they are long-lived species with slow rates of reproduction. Recent research suggests that following any dramatic decline, ape populations can take up to 120 years to recover (Walsh *et al.* 2003). Therefore, it is important to consider both direct and indirect effects of logging on resident ape populations when developing strategic plans to maintain high conservation value forests.

A subadult female chimpanzee* (Pan troglodytes troglodytes)*, Republic of Congo. Photo Crickette Sanz, MPI-EVA.

It is also important to recognize that gorillas and chimpanzees are likely to be affected differently by timber extraction and associated activities, which makes them complementary indicator species for alleviating the direct and indirect threats of logging on apes. Chimpanzees tend to be more affected by the ecological impacts of timber exploitation than gorillas who benefit from the rapid growth of herbaceous plants in secondary forests. In contrast, gorillas are generally more affected by increased hunting pressure then chimpanzees. These are the type of indicators that Schulte-Herbrüggen and Davies (2006) suggest for monitoring and assessing management practices aimed at assisting wildlife in timber concessions. Implementation of particular practices listed in this document may depend on targeting the conservation of one species of ape over another. Relative abundance, conservation status, and current threats to these apes are important factors that should influence selection of a "conservation target species" if necessary.

Emerging infectious diseases are also of great concern to both humans and wild ape populations in the Congo Basin (Huijbregts *et al.* 2003; Walsh *et al.* 2003; Rouquet *et al.* 2005; Leendertz *et al.* 2006). In particular, drastic declines in ape densities following Ebola haemorrhagic fever outbreaks at sites in Gabon and Congo have shown clearly that this virus poses a serious threat to the long-term survival of great apes in central Africa (Walsh *et al*. 2003). Ebola outbreaks in humans have been associated with declines in local ape populations, and ape remains recovered near outbreak sites have tested positive for the Ebola virus (Georges *et al.* 1999). Transmission from wild apes to humans has triggered human outbreaks, but it is evident from their high mortality that apes are not the natural host of this virus. The natural host of Ebola continues to elude researchers, despite attempts to discover its identity over the past 30 years (Leirs *et al.* 1999). Scientists have warned that if these threats are not mitigated, the compounded effects of Ebola and commercial hunting could further reduce ape populations by 80% in the next 30 years (Walsh *et al.* 2003; Walsh 2006).

The majority of remaining chimpanzee and gorilla populations reside in forests that have been allocated to commercial logging, and the forestry companies who manage these concessions have the influence and opportunity to promote the long-term preservation of these apes (Plumptre and Johns 2001; Tutin *et al.* 2005; Schulte-Herbrüggen and Davies 2006). The International Tropical Timber Organisation has proposed principles, guidelines and recommended actions for the conservation and sustainable use of biodiversity in tropical timber production forests (IUCN/ITTO in prep; See Box 1). Guidelines published by the Association Technique Internationale des Bois Tropicaux formulate how logging companies can reduce negative effects of timber harvesting on wildlife (ATIBT 2005). Building on this framework, we present some practical and specific recommendations for reducing the impact of commercial logging on gorillas and chimpanzees, which expand on and complement previous efforts to reduce hunting impacts in logging concessions (Ape Alliance 1998). These guidelines are based on research and experience, combined with the conservation expertise of colleagues actively working in this domain (see reference section and acknowledgements). We anticipate that these guidelines will serve as a basis for developing site-specific strategies for apes in logging concessions, particularly those in the priority sites identified for ape conservation.

Box 1
Biodiversity Conservation in Tropical Timber Production Forests

The fate of the tropical forests and the biodiversity found within these biomes are of global concern. Recognizing the threat exploitation of tropical forest resources pose to animal and plant species, the ITTO (The International Tropical Timber Organization) focuses on the conservation of biodiversity through the promotion of sustainable management in production forests (ITTO, 1993). Technical reports and guidelines produced by the ITTO are developed to affect change through policies at the international, national and local organizational levels. Member countries and stakeholders are encouraged to implement activities aimed at conserving biodiversity by promoting sustainable forest management. The ITTO has developed special themes on criteria and indicators, restoration and planted forests, forest law enforcement and the sustainable use and conservation of mangrove ecosystems aimed at reducing loss of biodiversity. Further, this organization promotes conservation by assisting countries to set aside and manage protected areas.

In 1993, the ITTO in collaboration with IUCN, published guidelines for the conservation of biological diversity in tropical production forests. This document highlighted the need for conserving biodiversity at the landscape level and provided stakeholders with activities to consider when planning conservation strategies in the context of production forests such as timber concessions. For over a decade, many projects and activities funded by ITTO have been implemented in tropical production forests providing an increased knowledge base on management intervention measures that have proven beneficial to sustainable forest management. Building on the experience and scientific knowledge gained, the ITTO are now revising these guidelines. The Guidelines for the Conservation and Sustainable Use of Biodiversity in Tropical Forests (IUCN/ITTO, in prep.) provides an updated list of recommended actions for improving biodiversity conservation in production forests, which can be subsequently adapted by forestry managers to local circumstances. The ape-specific guidelines presented in this document should be viewed as complementary to these efforts in providing detailed information for activities to conserve gorillas and chimpanzees in the production forests of WEA.

A group of western lowland gorillas (Gorilla gorilla gorilla)*, consisting of a silverback, two females and an infant, feeding on vegetation in a forest clearing. Photo ©Thomas Breuer, MPI-EVA / WCS.*

Section 3:
Incorporating Ape-Friendly Initiatives in Current Management Strategies

The purpose of this document is not to serve as a substitute for the general and technical guidelines that currently exist for minimizing the impacts of forestry activities on wildlife, but to suggest specific measures that can be adopted to reduce the impact of logging on great apes. Chimpanzees and gorillas in modern Africa face many anthropogenic modifications to their environment which can have consequences for their ecology and sociality. Several logging companies are keen to attain or maintain certification which involves incorporating environmental impact assessments, implementing monitoring programmes, and adopting management plans that ensure the integrity of high conservation value forests. While designing schemes that decrease the impact of timber extraction for all wildlife is extremely complex, listing the measures that will minimize impacts on apes is more straightforward and other species will also benefit. Adoption of ape-friendly logging practices will improve the conservation prospects of these endangered species, which sends a positive message to the public-at-large about the stewardship efforts of the timber industry. As previous examples have shown (see Box 2), these efforts can be promoted to improve the image of the logging companies that implement these programmes.

Forestry Certification. During the past few decades, timber certification schemes have emerged as a means of improving sustainable forest management (ITTO 2006). Specific principles, guidelines, and indicators have been proposed by organizations such as the Forest Stewardship Council (FSC) and groups associated with the Programme for the Endorsement of Forest Certification (PEFC) for maintaining the ecological integrity of residual forests and wildlife while allowing the harvest of sustainable yields of timber. Few timber companies in the Congo Basin have adopted management plans or certification schemes (Perez *et al.* 2005). Case studies from the Republic of Congo and Gabon suggest that well-managed production concessions adhering to guidelines

Box 2
Successfully Integrating Wildlife Management into Logging Concessions in Northern Congo

In the Republic of Congo, the "PROGEPP" model (Project for Ecosystem Management of the Periphery of the Nouabalé-Ndoki National Park) provides the first example of a successful integration of wildlife conservation and management in forestry concessions through a collaboration between the Wildlife Conservation Society, the Congolese Government, Congolaise Industrielle de Bois (CIB), and the local population (Elkan *et al.* 2005). Created in 1999, it began as a model for wildlife management in the buffer zone of the Nouabalé-Ndoki National Park (NNNP) and subsequently expanded to cover a zone of 1.3 million ha of production forests surrounding the NNNP and extending towards the Lac Télé Community Reserve as part of a 'Landscape Management Approach'.

PROGEPP is a multi-faceted programme which includes socioeconomic and ecological research, education, hunting regulation and zoning, wildlife-law enforcement, and development of activities and protein resources as alternatives to hunting and bushmeat. Estimated costs of implementing an integrative wildlife management approach based on the PROGEPP model vary from $1.25 per ha for a zone of medium threat to $1.50 per ha for a zone of high threat (Elkan *et al.* 2005).

This wildlife management programme was incorporated into the forestry management plan of the Kabo Concession adopted in May 2006, and also contributed to the Forest Stewardship Council (FSC) certification of the Kabo Concession, raising the bar for wildlife management standards in forestry concessions across the Congo Basin.

The PROGEPP model formed the basis of a MEFE (Ministère de l'Economie Forestiére et de l'Environnement) policy initiative that required forestry companies to directly support anti-poaching efforts in their concessions through the financing of USLABS (Unités de Surveillance et de Lutte Anti-Braconnage). These are currently being implemented in a number of concessions in northern Congo (IFO, ITBL, and BETOU).

designed to minimize deforestation and defaunation benefit wildlife such as great apes (Elkan *et al.* 2006; Laurance *et al.* 2006; Poulsen *et al.* in press). One of the shortcomings of most certification standards is the lack of clear and specific indicators to monitor the effectiveness of wildlife management (Schulte-Herbrüggen and Davies 2006). ATIBT has made notable efforts to increase consideration for wildlife in sustainable forestry management (ATIBT 2005), but implementation is hindered by lack of resources and complexity of such endeavors. The Bushmeat Crisis Task Force has provided a detailed review of the prospects and progress of addressing wildlife issues in timber concessions (Bass *et al.* 2003). Immediate incorporation of ape-specific conservation initiatives into management plans would substantially improve the conservation status of the large populations of chimpanzees and gorillas in logging concessions. The aim of this document is to provide an initial list of such ape-friendly recommendations for forestry companies operating in Western Equatorial Africa.

Reduced Impact Logging. Reduced impact logging (RIL) techniques are designed to minimize the environmental impact of timber extraction on forest, and their implementation will bring benefits for the entire ecosystem. As a general rule, we suggest that RIL techniques should be promoted in all production forests harbouring great ape populations — especially those that have been identified as having a high priority for ape conservation (Figure 1). The following examples show how existing RIL practices can be enhanced to benefit great apes.

1. **Conduct pre-harvest inventory and mapping of commercial tree species to define annual cutting blocks.** This may involve topographical surveys of wildlife habitat and areas of cultural value.

   Ape-specific Consideration: Include systematic recording of locations and areas which are of ecological or social significance to local ape populations so that any disturbance can be avoided during forestry operations. Resource-rich swampy forest clearings (also referred to as *bais*) are of particular importance to some western lowland gorillas (Magliocca *et al.* 1999; Parnell 2002). For chimpanzees, the core areas of their ranges are intensely used and defended from invasion by other groups (see Section 4.5b).

2. **Design harvesting protocols based on the ecology of timber species and regeneration ecology of the area.** Timber extraction roads should be designed to promote natural regeneration.

   Ape-specific Consideration: Gorillas consume large quantities of terrestrial herbaceous vegetation (in particular Marantaceae and Zingiberaceae), and are likely to capitalize on the availability of these resources as they fill light gaps created by canopy disturbance. Schemes such as enrichment planting can be detrimental to the establishment of undergrowth and should be avoided within areas known to harbour important gorilla populations.

3. **Implement pre-harvest planning of the road network including primary and secondary roads, skid trails and log landings that provide access to the harvest area.** Such planning efforts can substantially increase team coordination and also limit forest damage.

   Ape-specific Consideration: The total road network length should be minimized thereby limiting overall forest disturbance and minimizing potential access routes for illegal hunters. Such strategic road planning will also reduce the number of roads that must be traversed by apes within their home range, decreasing stress and risks.

4. **Felling procedures and removal practices should minimize residual damage to the forest and habitat.** In advance of timber extraction, cutting of lianas interconnected with felling tree crowns should be conducted in order to minimize collateral effects of felling on neighbouring trees. Logging companies should train employees in directional felling techniques. Damage caused during timber removal can also be reduced by winching logs to planned skid trails and ensuring that skidding machines remain on skid trails at all times.

   Ape-specific Consideration: Timber companies should consult with biologists to identify important, but rare, food species for apes in the logging concession. Annex I provides a compilation of the food species consumed by apes in Western Equatorial

Africa. Felling and removal practices should be implemented to minimize damage to those trees or lianas.

5. **After the extraction process, primary and secondary roads which are no longer necessary for transportation should be closed or controlled with barriers at major access points.**

   Ape-specific Consideration: Hunting of gorillas and chimpanzees for meat is a widespread threat in Central Africa, and it has been well-documented that incursions by illegal hunters into remote interior forests are facilitated by logging routes (Wilkie *et al.* 2001; Fa *et al.* 2006). Great apes are particularly vulnerable to several long-term effects of poaching (even at low levels) due to their slow reproductive rates, long developmental period, and complex social systems (Tutin 2001). Closing or monitoring of these routes will decrease the opportunities for illegal hunting and the costs required to effectively control these routes (Elkan *et al.* 2006).

Section 4: Ape-Specific Recommendations

4.1 Hiring/Coordination

It is necessary to define the roles and responsibilities of all parties involved in implementing ape-friendly recommendations. The issues and complexities linked to maintaining and monitoring wildlife in timber concessions are substantial. In order to address these issues and ensure effectiveness of activities, logging companies are encouraged to hire a staff member as a point-person to deal with wildlife issues. In several regions of WEA, studies conducted by scientists on great apes have produced a substantial knowledge base of their ecology and behaviour. Timber companies are encouraged to collaborate with these scientists as they can provide expertise and resources useful to forest managers interested in monitoring ape populations. Further, timber companies are often one of the only sources of local employment in remote regions, and by making efforts to hire from local communities they can also control the dramatic influx of job-seekers from distant regions. Preferential hiring from local populations can remove incentives for secondary immigration, which increases human pressures on apes.

a. Preferential Hire from Local Populations

Timber companies should give priority to recruiting and investing in the local population rather than importing labourers from distant towns (Elkan *et al.* 2006; Poulsen *et al.* in press). Human population growth rates are predicted to continue increasing in Central Africa, with industrial towns such as sawmills and logging camps becoming foci for this growth. Past experiences across Equatorial Africa suggest that demand for agricultural land and overexploitation of wildlife increase as human populations grow (Fa *et al.* 2003, 2006; Poulsen *et al.* in press). In order to minimize human population pressures on apes and other wildlife, incentives for secondary immigration into these settlements should be removed wherever possible (Elkan *et al.* 2006; Poulsen *et al.* in press).

b. Collaborate with Conservation Scientists

Conducting valid ape surveys is extremely challenging due to the inherent complications and biases in collecting and analyzing survey data in dense forest (Walsh and White 2005). Therefore, we suggest that logging companies establish collaborations with, or seek technical assistance from, the conservation or research communities to ensure that precise and meaningful data are collected. It will be mutually beneficial for timber companies interested in establishing ecological monitoring programmes to forge partnerships with local or international conservation organizations. Combining the expertise of scientists and timber company

officials to design and implement appropriate wildlife monitoring programmes has brought considerable benefits to wildlife in logging concessions in Congo (Elkan *et al.* 2006; Poulsen *et al.* in press). Further, involving self-financed scientists or conservation organizations in monitoring efforts can defray some of the financial and time costs of long-term monitoring programmes to the logging companies.

c. Designate a Point-Person for Wildlife Issues

It can be effective for forestry companies to designate a point-person for wildlife issues. This person serves as a liaison between the company and other stakeholders including local communities, local government authorities, conservation partners, and/or independent researchers. They can also ensure that the efforts and results of the timber company's initiatives to reduce the impact of mechanized logging on wild apes are well-documented and communicated to relevant interest groups.

d. Establish and Schedule Independent Reviews

It is recommended that timber companies develop and implement open, independent monitoring systems and processes. Company documents and technical studies should be made available to programme reviewers and evaluators to promote transparency. Feedback provided from independent reviews can be beneficial to the logging company in evaluating the success of the implementation of recommendations and defining future directions.

4.2 Ape Surveys

There are many areas in the Congo Basin where ape populations have not been surveyed. As shown in Figure 1, the majority of the geographical range of great apes is located in logging concessions. Collecting information on the distribution and population size of chimpanzees and gorillas during biological monitoring of production forests could make a substantial contribution to baseline data and ultimately to refining strategies for the long-term protection of wild apes in these regions (see Box 3). As described below, these data can now be contributed to the A.P.E.S. database which is an IUCN-sponsored initiative to archive all existing surveys of great apes and use this information to improve our understanding of their global conservation status.

a. Establish Ape Population Monitoring Programme

Monitoring ape populations over time is critical to detect any changes. Repeat surveys will thus be necessary at several locations within each concession before, during, and after timber extraction. Sufficient data will enable analysis of any trends detected and an understanding of the causes. It is important to be able to distinguish changes caused by forestry activities from normal population fluctuations due, for example, to variations in food availability between seasons and years.

A robust monitoring system provides important benefits to great ape conservation efforts, such as: i) a reliable and more immediate assessment of the impacts of logging on the apes and ii) an important wildlife management presence on the ground which can relay to the competent authorities real-time information on human-related threats in the timber concession such as hunting, as well as signs of emerging disease. Assessment of the impact of logging on apes can be enhanced by monitoring control areas that will not be logged, either within the concession or in a neighbouring protected area. Such efforts will provide the data essential for assessing population trends and implementing an adaptive management programme (Possingham *et al.* 2001).

b. Conduct Standardized Ape Surveys

Several different methods have been used to survey great ape populations, some of which have been shown to be less consistent and/or accurate than others. It is critical that information on great ape populations and relevant (human and environmental) covariates in the region are systematically recorded with a sufficient degree of accuracy and precision for subsequent monitoring. Rigorous implementation of

standardized survey methods will facilitate comparisons between time periods, different sites, or other logging concessions (Plumptre and Johns 2001; Struhsaker 1997). The quality of survey information can be improved by ensuring that staff collecting these data are well-trained in survey methods and that research protocols are designed to provide relevant information for ape population assessment (IUCN/SSC Primate Specialist Group in prep). It is also important that survey information is accessible to conservation projects to assess the conservation status of great apes in the region and for future monitoring of ape populations. As a result, it is strongly recommended that collaborative relationships be established between logging companies and wildlife biologists to plan and execute robust data collection protocols (see Section 4.1b).

Box 3
Using Wildlife Survey Data to Enhance Ape Conservation

Wildlife surveys conducted by timber companies during forestry inventories and/or ecological monitoring could provide valuable information for the conservation of great apes. There are many large tracts of forest in WEA where the status of chimpanzee and gorilla populations is unknown or available information is outdated. Data from ape survey and monitoring efforts in timber concessions will help to address this void and provide essential information for strategic conservation planning. Further, apes can serve as indicator species for assessing the performance of activities aimed at maintaining wildlife populations in timber concessions. As shown by the following examples, recent surveys conducted through collaborations between scientists and timber companies have found viable ape populations in production forests and this information has been used to make specific suggestions for adaptive management policies to ensure the long-term preservation of chimpanzees and gorillas in exploited forests.

Campo/Ma'an Forests, Cameroon

Surveys in the logged forests of Campo/Ma'an in Cameroon revealed high chimpanzee densities and gorilla numbers (Matthews and Matthews, 2004). The Cameroonian Ministry of Environment and Forests provided information on the intensity of timber extraction in Camp Ma'an, which was shown to be relatively low at between 1.9 to 4.8 m^3/ha in each compartment (Matthews and Matthews, 2004). Hunting pressures could have had a more severe impact on these ape populations than habitat degradation. After reviewing the available information from this region, Tutin *et al.* (2005) have suggested that the conservation status of apes in this region could be enhanced by implementing anti-poaching and biomonitoring programmes.

Ntonga Forests, Cameroon

Surveys were conducted in unprotected areas adjacent to the Dja Faunal Reserve in south-central Cameroon to determine the potential for great ape conservation in the region (Dupain *et al.* 2004). Both chimpanzee and gorilla densities are relatively high in the Ntonga Forests which consists mostly of secondary forest (Dupain *et al.* 2004). It was suggested that conservation of these forests could be improved through designation of Communal Wildlife Zones. The Dja conservation complex features a range of such participatory approaches to conservation (Tutin *et al.* 2005).

Kabo Forests, Republic of Congo

Faunal inventories conducted by Congolaise Industrielle de Bois and WCS as a component of the "Project for Ecosystem Management of the Periphery of the Nouabalé-Ndoki National Park" have shown that there are healthy gorilla populations in *terra firma* forest outside of the National Park (Poulsen *et al.* 2005). Survey and long-term monitoring efforts in these production forests are continuing and promise to provide further insights into mitigating the effects of logging operations on apes in northern Congo, which has been identified as a stronghold for gorilla and chimpanzee conservation.

The A.P.E.S. Database

The A.P.E.S. (Ape Populations, Environment, and Surveys) database provides a resource for researchers and forestry companies who have conducted or are planning wildlife surveys that include information about ape populations. The A.P.E.S. database offers archival records of great ape survey data, provides downloadable information on survey methods, and features an online catalogue of great ape populations. Scientists participating in the management of the A.P.E.S. database can also provide technical assistance in data analysis and interpretation.

c. *Obtain Baseline Ape Abundance Estimates*

Ape abundance estimates should be collected prior to initiation of logging to enable accurate monitoring of subsequent population trends (Plumptre and Johns 2001). Ape abundance can vary dramatically between forest types, so baseline data are needed for each concession before timber extraction begins, as extrapolation from other areas may be erroneous. This information can be used immediately to identify high concentrations of ape nests which correspond, in the case of chimpanzees, to core areas of the home range, or more generally to favoured habitats which should receive special management consideration (Morgan *et al.* 2006).

d. *Contribute Information to A.P.E.S. Database*

The A.P.E.S. (Ape Populations, Environments, and Surveys) database was established in 2007 by the IUCN/SSC Primate Specialist Group as a depository for ape survey data in order to assess the global status of great apes (http://apes.eva.mpg.de). Entering survey data from logging concessions into the open-access A.P.E.S. database will increase the value of information collected during forest inventories and make possible meta-analyses that can assist monitoring of ape conservation status over larger spatial scales. Contributors retain ownership of their data, and reserve the right to refuse any third party access to their survey information. As a benefit to contributors, the scientists managing the database will be available to provide advice and assistance with analyses of ape survey data. Further, contributions to this data-sharing initiative will provide an excellent indication to the international community of the willingness and commitment of logging companies to conserve ape populations in their concessions.

4.3 Conservation Zones

Protected areas in WEA are usually surrounded by a mosaic of forest types, habitats and human land-use zones. Designating special zones for wildlife protection and establishing buffer zones around protected areas or reserves may enhance wildlife protection within core conservation areas, but available data suggest that production forests could also be highly important for long-term ape conservation (see Box 3). Many of the protected areas in WEA contain high densities of great apes. However, it is well documented that gorillas and chimpanzees can also survive in timber concessions when illegal hunting is low, suggesting this type of production forest is of great ecological value to the survival of apes in WEA.

a. *Designate Wildlife Conservation Zones*

Ape surveys may indicate certain areas which are particularly important for gorilla or chimpanzee populations. Whenever possible, these areas should be set aside as conservation areas within the concession and left unlogged. Otherwise, special measures should be implemented to further reduce the impact of logging on apes in these particularly sensitive areas. Several recent surveys in production concessions have resulted in such recommendations (Dupain *et al.* 2004; Laurance *et al.* 2006). Survey results should be shared with government officials to assess the possibility of obtaining formal protected status for such important regions and/or obtaining economic incentives (i.e., alleviation of taxes) for abstaining from logging these areas.

b. *Establish Buffer Zones around Protected Areas*

Chimpanzees residing near forest edges have low rates of survival compared to populations residing further from human pressures (Wrangham 2001; Humle 2003). Mounting evidence suggests that designating buffer zones between active logging concessions and protected areas benefits both apes and humans residing in the area. Without buffer zones, chimpanzees and gorillas may raid the crops of local farmers (Jones and Sabater Pi 1971; Humle 2003). This causes conflict

between wild apes and humans, which can have lethal consequences (Plumptre, Cox and Mugume 2003). Increasing the distance that separates wild apes from human settlements by creating buffer zones can prevent such incidents. The feasibility of establishing buffer zones around protected areas and key sites (e.g., forest clearings for gorillas) will depend upon site-specific conditions such as proximity to human settlements, hunting pressure and natural barriers. The Wildlife Conservation Society recommends that RIL methods are implemented in the 5km buffer zones around National Parks in Gabon (White pers. comm.). Further, we recommend a 1km buffer zone of no access between protected area boundaries and active logging operations. A 250m buffer zone should also be established for key sites within logging zones that are important to apes, such as forest clearings. This is adequate to serve as an artificial peripheral zone for chimpanzee and gorilla groups that straddle park boundaries and logging concessions.

4.4 Road Planning

Efficient transport networks are essential for the timber industry, but they have both short- and long-term effects on ape conservation, as reviewed below. The initial effects of road construction on forest ecology are considerable (Johns 1983; Malcolm and Ray 2000), but the lasting impact on wildlife populations (of uncontrolled hunting which is facilitated by these roads) is particularly devastating. We make several suggestions for road placement and construction to reduce negative impacts on apes and other wildlife. Strategic planning of roads and extraction routes can decrease costs incurred by timber companies (Holmes *et al.* 2000).

a. Plan Roads Away from Protected Areas

Primary roads should not be constructed adjacent to the borders of protected areas as they facilitate access by vehicle and foot traffic to these sensitive areas (Wilkie *et al.* 2001). Wherever topography allows, primary roads should be constructed at least 5km from protected areas to limit access by hunters, and to accommodate the apes' home ranges, especially those of groups which straddle a park boundary. Road planning should also take into account the existence of buffer zones around protected areas and important sites for apes. It is recommended that RIL methods are implemented within the 5km buffer zone around protected areas, which would include low impact protocols such as constructing only temporary small dry season roads.

b. Adopt Reduced Road Widths

The following estimates are based on the general principle that road width and forest disturbance should be minimized without compromising safety or efficiency. The graded portion of primary roads should not exceed 7.5m in width and secondary roads 4.5m in width. The total width of forest cleared for primary roads, including graded portion and shoulders, should not exceed 12.5m. For secondary roads, the total width, including graded portion of road and shoulders, should not exceed 8.5m. Although these width classes are below those currently implemented in some regions of Central Africa, they are in line with size classes recommended in published reviews (Dykstra and Heinrich 1992; Fimbel *et al.* 2001). Observations in Guinea indicate that chimpanzees' perception of the risks of crossing roads increases with road width (Hockings *et al.* 2006).

c. Place Road Networks in Certain Habitats

Wherever possible, primary and secondary roads should be established in either open canopy forest, or through monodominant forests (typically dominated by Leguminosae) (Blake 2002). Graded roads should not be constructed in closed canopy forest, as considerably more fruit-bearing tree species important to apes are found in this habitat. Road construction in open or monodominant forest will cause less disturbance and minimize the loss of tree species that are important in

ape diets. It should also be noted that riparian areas are of considerable importance to some ape populations and we recommend following RIL methods of establishing "no cut zones" buffering permanently flowing waterways.

d. Minimize Secondary Roads

The number of secondary roads opened should be kept to an absolute minimum, placed no more frequently than at 2km intervals along primary roads. For a chimpanzee community with a circular home range of approximately 20km^2 and diameter of 5km, increasing the distance between secondary roads from 1km (currently used in northern Congo, CIB 2006) to 2km intervals could reduce the total length of roads that traverse their range from 20km to less than 11km. If secondary roads of 23m width are placed at 1km intervals, approximately 45ha of forest will be destroyed within a single chimpanzee home range. This could be halved by increasing the interval between secondary roads to 2km.

e. Reuse Old Roads rather than Build New Roads

Old logging road networks should be reused in preference to opening new road networks. However, this should not be pursued at the expense of increased damage to forest canopy.

4.5 Harvesting Protocol

Taking apes into consideration during the planning phase of timber harvesting can reduce unnecessary disruptions to their feeding ecology and socio-spatial organization. Of great importance is considering ways to minimize the destruction of important ape food trees (see Annex I). Further, logging operations that consider the compartment size and sequence of extraction sites may decrease the degree of social disruption experienced during logging activities. Chimpanzees and gorillas have complex social systems with a multitude of interactions, both within and between social groups in a community or population. Multiple social groups should be preserved within blocks of continuous forest habitat to maintain the long-term viability of these ape populations. Route construction and tree harvesting activities should also be planned so that teams work away from geographical features which could act as ecological barriers to great apes.

a. Identify Important Ape Food Trees for Protection

A pre-harvest inventory and mapping of marketable and non-marketable tree species (stems >50cm dbh) should be conducted. Research has shown that gorillas use medium to large trees as preferred food resources (Doran *et al.* 2002). Geo-referencing of tree inventory data in a GIS system for the concession will be of benefit to logging companies as subsequent harvests will increasingly include trees other than mahoganies. Maps of tree species can be used to optimize extraction routes and coordinate teams so that the overall amount of time spent in the forests and machinery hours are reduced (Byron 2001; Krueger 2004). Strategic extraction routes will not only reduce short- and long-term pressures on resident apes and other wildlife, but are also likely tor reduce harvesting costs to timber companies.

Enumerating tree species in the logging concession will also provide important data for identifying keystone ape food resources that should not be damaged during timber extraction. Gorilla and chimpanzee diets show significant overlap in Western Equatorial Africa, but each ape has particular dietary preferences. Annex I provides a summary of ape feeding ecology in this region, but it is important to assess the ape populations and habitat types in the area before selecting which food items to protect. With regards to important fruiting trees, studies have shown that Sapotaceae, Irvingiaceae and Moraceae include many species important to great apes (Tutin and Fernandez 1993; Doran *et al.* 2002; Rogers *et al.* 2004; Morgan and Sanz 2006).

b. *Design Compartment Size and Sequence*

Chimpanzees have structured territorial ranges, which limit their ability to respond to active disturbance by moving away from it. They use core areas of their home ranges intensively, and aggressively defend them from other groups. Core areas are generally no larger than 5km^2 and usually centrally located in a home range of 7 to 26km^2 (Newton-Fisher 1997; Herbinger *et al.* 2001). If felling were conducted at multiple sites within an area the size of their core range and over a short span of time, an entire social group of chimpanzees could be displaced. This in turn could result in social upheaval and increased lethal conflict between groups. Such aggressive inter-community interactions are thought to have reduced chimpanzee densities after logging at Lopé, Gabon (White and Tutin 2001). Neighbouring core areas of chimpanzee groups are on average less than 4km apart (Morgan 2007). It has also been suggested that "refuges" of primary forest are particulary important to chimpanzees (Matthews and Matthews, 2004). This can be accomodated during logging by implementing small and dispersed logging compartments. Therefore, we recommend that parcels (usually 0.25km^2) to be exploited simultaneously should not lie within 4km of each other or areas of road construction.

Observations of chimpanzee communities at multiple sites provide supportive evidence that staggering timber extraction to occur at different times across logging compartments may be key to avoiding potential declines in chimpanzee populations due to logging operations (Hashimoto 1995; Plumptre and Johns 2001). Similar observations were made of orangutans inhabiting logged forests (MacKinnon 1974). However, it may not only be the size and distribution of active parcels, but the shape of the annual allowable cut which also merits further consideration (Arnhem pers. comm.). Strategic planning measures including size, time-sequence, and possibly shape could effectively reduce disturbance to single groups and provide refuge to apes during logging operations.

c. *Work Inward from Barriers or Boundaries*

Large rivers, ridgelines, and forest edges may serve as physical barriers or social boundaries to ape populations. When logging within 1km of such a potential boundary, it is advisable to work inward from the river or edge to avoid pushing apes toward an impassable river or inhospitable habitat. Further if chimpanzee community boundaries are known, then an extraction process originating from a chimpanzee community boundary area that works inward will be less disruptive than forcing social groups toward their community boundaries or into the range of another group.

4.6 Training and Education

In addition to mitigating the negative impacts of timber extraction on forests and wildlife, logging companies can also implement proactive educational measures in forestry camps and local communities to alleviate pressures on wild ape populations. Many forestry companies already provide basic health services to their employees. Extension of vaccination and preventative health programmes will benefit forestry staff and the wildlife in the production forests where they are working. A work force that is uninformed of emerging health issues can put both apes and company employees at risk. Within WEA, it is essential for forestry managers to ensure that employees are well-informed about emerging infectious diseases and that protocols are developed for detecting and reporting Ebola outbreaks in logging concessions.

a. *Detect/Report Ebola Outbreaks in Concessions*

Logging company personnel working in concessions are likely to be among the first to become aware of new Ebola outbreaks, either by sighting ape carcasses or through communication with hunters in the immediate area. In high-risk areas, it is extremely important that forestry personnel are aware of the threat of Ebola and have the means to convey relevant information to local authorities and conservation organizations. Developing a communications network will maximize early

detection of an outbreak and ensure a rapid response by the appropriate health officials. This type of information could help to overcome the main obstacle in identifying the natural host of this virus: the lack of timely information about the ecology of Ebola virus in remote tropical forests.

b. Initiate Educational Programme for Employees

Providing resources and opportunities for forestry employees to be trained in wildlife policy will improve their abilities to implement those policies and contribute to management planning processes. Educational campaigns can be jointly organized and implemented by timber company representatives for wildlife issues, government officials from ministries of the environment and forestry, conservation partners, and perhaps others. Important points to cover in educational programmes include:

1. Review of wildlife laws and of penalties for infractions;
2. Review of logging company rules and regulations and of sanctions for infractions;
3. Overview of protected species that inhabit the logging concession;
4. Basic information on the natural history of key species and habitats;
5. Briefing on infectious diseases such as Ebola, how to avoid infection and the risk of contact with ape carcasses;
6. Information about reporting infractions or seeking further information/resources to ensure that rules and regulations are upheld by company employees.

c. Implement an Employee Health Programme

Wild chimpanzees and gorillas have not developed antibodies to some common human pathogens. Cases of human viruses and bacteria that have been transmitted from humans to apes include influenza, adenovirus, rhinovirus, respiratory syncitial virus, pneumococcoal pneumonia, herpes viruses, measles, polioviruses, Shigella, and gastrointestinal parasites (Homsy, 1999; Woodford *et al.* 2002). It is strongly recommended that an employee health programme is implemented to prevent zoonotic and anthropozoonotic exchanges. The following are some of the Wildlife Conservation Society's recommendations (Reed and Orbell, 2007) for all personnel working in the forests of WEA:

1. Vaccination for Polio (inactive), Tetanus, Yellow Fever, Measles
2. Tuberculosis screening
3. Annual medical exams
4. Intestinal parasite treatment every three months
5. Basic first aid kit should be carried by all teams working in the forest

Further, it is the employer's responsibility to ensure that ill workers are not sent on forest missions.

Both forestry employees and wildlife in central African forests are at risk of contracting infectious diseases (Huijbregts *et al.* 2003; Walsh *et al.* 2003). Outbreaks of Ebola in humans have started with the handling of wild ape carcasses found in the forest (Rouquet *et al.* 2005). It has also been established that wild chimpanzees and gorillas carry various strains of simian immunodeficiency virus (SIV), and that the central subspecies of chimpanzee are the natural reservoirs of human immunodeficiency virus (HIV-1) (Keele *et al.* 2006; van Heuverswyn *et al.* 2006). It is, therefore, in the best interests of forestry companies to educate their employees about infectious diseases, provide health services, and keep detailed health records for each employee.

4.7 Employee Code of Conduct

The increased hunting pressures that are typically associated with timber operations must be controlled to protect great apes in WEA. Studies from northern Congo provide detailed recommendations on how hunting pressure can be reduced with a multi-faceted approach (Elkan *et al.* 2006; Poulsen *et al.* in press). Several teams work in forestry concessions throughout the logging process which can result in disturbance, displacement, or decline of local ape populations (see Section 6). Further, it has been documented that forestry teams may be involved in or facilitate the hunting of gorillas and chimpanzees. Timber companies should subsidize ecoguard patrols in the logging concessions. Although some small-scale hunting may be allowed in hunting zones, forestry personnel should be strictly prohibited from hunting or facilitating hunting activities in timber concessions.

a. Ban Hunting

Timber companies should prevent their employees from being directly or indirectly involved in illegal hunting, and ban all hunting in timber production zones. Forestry companies should not facilitate hunting by providing guns or ammunition.

b. Prohibit Facilitation of Hunting

Prohibiting the transport of bushmeat on company vehicles has proven an effective means of decreasing the prevalence of illegal hunting in timber concessions (Elkan *et al.* 2006).

c. Subsidize Ecoguard Patrols

We encourage timber companies to subsidize the costs of wildlife protection by ecoguards who are not company employees. Trained and armed ecoguard units should patrol both active and inactive forestry concessions for illegal hunting activities. Mobile units should conduct frequent, random and well-organized patrols to monitor active logging concessions for signs of illegal poaching activities.

An incentive programme and formal procedures for reporting infractions by logging company employees to local government officials should be established. Logging companies should impose strict penalties on employees guilty of an infraction.

d. Implement Road Check Points for Bushmeat

Mandatory checkpoints along logging roads should be strategically located and all vehicles searched for illegal meat. These checkpoints should be moved in a non-predictable manner, and surprise, temporary checkpoints set up on roads in logging concessions. Official operations of logging company vehicles should be conducted only between 6 a.m. and 6 p.m. when visibility is optimal. However, checkpoints should also be staffed at night and trucks searched with torches. In addition to checkpoints, vehicle activity can be monitored by mounting commercially-available satellite modem tracking devices on company vehicles to remotely monitor vehicle activity and routes. Further, only employees who are scheduled to work should be carried on trucks entering or leaving concessions. Installation of surveillance cameras on the roof of truck cabins can also be an effective means of documenting whether illegal bushmeat or unauthorized passengers have been transported on company vehicles. Drivers should be sanctioned for any wildlife regulation infractions involving their vehicles.

e. Implement Snare Patrols and Removal

Regular patrols should be conducted in both timber concessions and around sawmills or permanent camps to detect snares (wire or nylon leg traps). Research has shown that gorilla and chimpanzee populations are susceptible to snare injuries which can have debilitating or fatal consequences (Waller and Reynolds 2001; Quiatt *et al.* 2002). Removal and destruction of snares can have immediate benefits in reducing snare injuries to wild apes and indiscriminate killing of other species.

f. *Establish Professional Accountability*

Establishing guidelines for professional accountability can act as a deterrent to unlawful behaviour by company employees. Field supervisors should be responsible for following through on sanctions against logging company employees found guilty of unlawful activities or violation of rules laid down by logging companies for their employees. However, experience with one logging company has shown this can be difficult to implement as forestry executives may be reluctant to strictly punish highly-skilled trained workers (Elkan *et al.* 2006).

g. *Implement a Standardized Reporting System*

It is of the utmost importance to establish communication between ecoguards, government law enforcement bodies, and logging company management. Sawmill and field team supervisors should be regularly briefed on the results of ecoguard patrols.

Timber companies that contribute to ecoguard patrols and facilitate law-enforcement efforts in their logging concessions will find it useful to measure patrol effectiveness. The frequency of snare removal, illegal firearm seizures, arrests, and prosecutions can be used to determine the effectiveness of patrols and protection programmes. These data should be standardized so that the "unit catch" can be measured against "unit effort", such as "number of arms seized per patrol-day," and data can be compared over time and between sites.

h. *Reduce Size of Forestry Teams*

Forestry prospection teams have the longest extended stays in timber production zones. It is currently common practice in northern Congo for family members (wives and children) to accompany prospection teams. This practice should be discontinued immediately, and teams should be restricted to company employees who are conducting inventories and necessary support staff. Reduction in the absolute number of individuals cooking, eating, washing, and generating waste in forested areas is likely to be the most effective means of decreasing their impacts on both forests and wildlife.

i. *Provide Food for Forestry Teams*

Logging companies should purchase and provide food for forest missions, rather than giving cash allowances for food purchasing that is often substituted by hunting and gathering of forest products (fruits, nuts, honey, leaves). This results in competition with wild apes who consume many of the same food resources gathered by humans. Further measures, such as prohibiting the debarking of non-exploited trees for sleeping cots and cutting down of trees for honey gathering, could easily be enforced by logging company personnel.

j. *Enforce Sanitation Measures in Forest Camps*

It would be beneficial to both human and wildlife health if basic sanitation measures were implemented by forestry teams. Latrines should be built for all temporary and permanent forest camps. Food refuse should be disposed of carefully to ensure that it does not attract wildlife. Garbage pits for biodegrable and non-toxic waste should be established for all camps. All metal waste (including food tins, gas lamp cartridges, etc.) should be transported to the logging headquarters for disposal rather than discarded or buried in the forest. Garbage pits and latrines should be placed >50m from the nearest waterway and sealed when not in use. Garbage pits and latrines should be continuously be monitored by forestry staff to avoid animal raiding.

4.8 Harvesting: Felling and Extraction

Great ape populations in production forests could greatly benefit from efforts to reduce disturbance to their habitats during timber felling and extraction. As described in previous sections, RIL methods and strategic planning can reduce the number of trees destroyed during route construction and timber harvesting. Felling and extraction teams can also implement special measure (such as directional felling) to avoid damaging trees that are important food resources for apes. Reducing the degree of forest canopy damage will also favour the preservation of important ape tree foods and chimpanzee nesting sites. Further, it has been shown that chimpanzees in WEA use complex tools to extract termites from their earthen nests and logging operations should avoid destroying large termite mounds when possible, as they may of cultural significance to ape populations in the Congo Basin.

a. Avoid Damaging Trees Important in Ape Diets

Logging operations modify the diet of gorillas and chimpanzees directly through the destruction of important food trees and indirectly by the subsequent invasion of secondary vegetation. Gorillas may benefit from the herbaceous terrestrial vegetation which fills these light gaps, but it is important to remember that these apes also incorporate a large number of tree foods in their dietary regime. Annex I includes a list of timber species that are consumed by chimpanzees and gorillas in WEA. In addition, tree species which are known to be important in ape diets are listed and efforts should be taken to protect the mature stems of these species during timber operations. Ape food preferences may differ between regions and this information should be taken into account when developing site-specific initiatives to reduce the impact of mechanized logging on apes. For example, *Chrysophyllum lacourtiana* is an important food for apes in northern Congo and

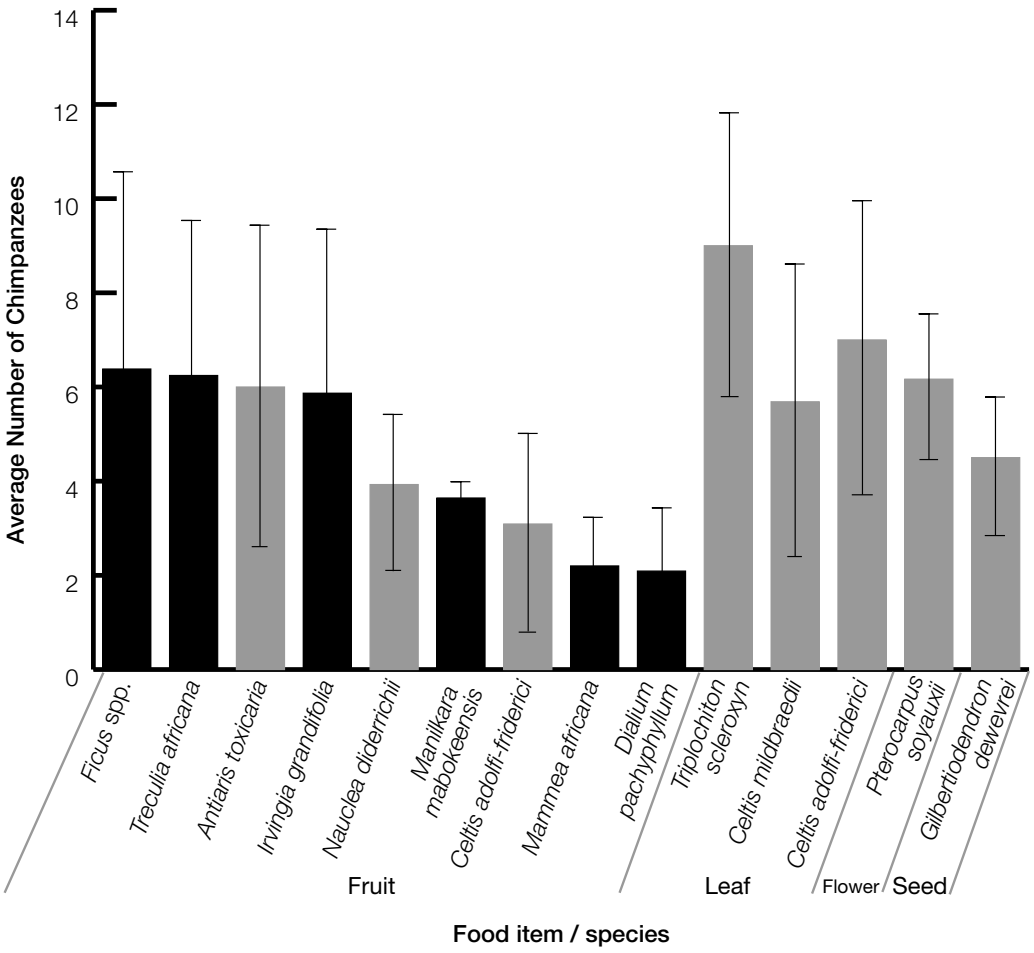

Figure 2. *Comparison of mean chimpanzee party size at different food sources obtained from scan observations. Vertical bars represent standard deviations. Exploited trees are shown in grey; non-exploited species in black.*

these trees attract large numbers of apes and elephants during their fruiting periods. It has also been shown that leaves are an important component of ape diets in northern Congo, where gorillas and chimpanzees have been observed to consume *Celtis* leaves on an almost daily basis.

b. Limit Forest Canopy Loss

Due to the relationship between light gaps and resultant forest structure, scientists suggest that no more than two adjacent trees should be felled at any single location (Plumptre *et al.* 1997; Struhsaker 1997) and that resultant light gaps should be no closer than 150m (Struhsaker 1997). Based on two decades of research on the effects of logging on the forest and wildlife in Uganda, Struhsaker (1997) recommends that canopy openings should be limited to between 2% to 5% of an exploitable area. Even with 6% canopy damage, substantial habitat change can take place with long-term consequences (Malcolm and Ray 2000). Research has indicated that female chimpanzees have lower reproductive success in more heavily exploited forests than females living in intact habitats (Emery-Thompson *et al.* 2007). Lowered reproductive rates were found in areas with timber outtake rates of 17.0 m^3/ha and 20.9 m^3/ha.

c. Implement Directional Felling

Apes will also benefit from general measures to reduce damage to their habitat. Through pre-planning and coordination, directional felling can minimize the secondary damage caused during tree harvesting. Parallel felling along access roads will allow for positioning of tree stems along the road with less associated extraction damage. It is recommended that logging companies provide cutting teams with training in proper felling techniques as part of general training in RIL practices. Forestry teams should avoid creating large and closely-spaced light gaps.

d. Minimize Impacts of Log Extraction

Gorillas show a tendency to forage in trees larger than 50cm dbh (Doran *et al.* 2002). Therefore, secondary roads and skidder trails should deviate around large trees (>50cm dbh) that will not be harvested. This general rule will also reduce forest canopy loss and reduce damage to ape food resources during extraction operations.

e. Avoid Damage to Chimpanzee Tool Sites

Termites are an important part of chimpanzees' diet in some parts of Western Equatorial Africa, and they prefer to "fish" for termites at mounds which are relatively old, rare and slow in establishment. We recommend that soil from termite mounds is not used to facilitate the establishment of trees in forestry zones (a practice used in some forestry concessions in Central African Republic), or in nursery settings, as the consequences of such destruction of food sources on chimpanzee ecology and behaviour are not yet known.

Section 5:
Conclusions

Although the most desirable option for long-term maintenance of tropical biodiversity is via protected areas (Bruner *et al.* 2001), the reality is that the majority of forests in Western Equatorial Africa have been designated as timber concessions. This poses a significant potential threat to remaining ape populations, which are sensitive to the impacts of logging and associated activities. Past efforts to manage impacts on wildlife in production forests indicate that ape-friendly initiatives could be implemented in timber concessions with positive results for local ape populations and for conservation in general (ATIBT, 2005; Elkan *et al.* 2006; Poulsen *et al.* in press).

As outlined in the above sections, there are many opportunities and methods by which timber companies can reduce the impacts of mechanized logging on apes. Many of these initiatives would be of minimal cost to forestry operations. Further, the benefits of these actions could greatly outweigh the expense. To summarize, benefits to the timber companies include:

1. Demonstrating to local government, forestry certification officials, conservation organizations, and timber consumers that timber companies are committed to preserving forests and wildlife;
2. Promoting a positive image of logging companies to the public-at-large, through a combination of ape-friendly logging strategies and increased transparency in forestry operations;
3. Increasing efficiency of timber harvesting operations through GIS mapping of trees, strategic planning of roads, and extraction routes. Although this requires more financial investment in planning phases, such practices have resulted in increased profit margins directly related to improved efficiency during harvesting and extraction (Byron, 2001).
4. Minimizing the financial and time costs of ecological monitoring in forestry concessions by forging collaborations with conservation and/or academic partners;
5. Reducing infractions of local wildlife laws by logging company employees through education and enforcement of wildlife policies, thereby increasing compliance with government law enforcement;
6. Limiting the risks to logging company staff of infection by Ebola and other pathogens carried by wildlife.

We hope that, as stewards of the majority of remaining chimpanzee and gorilla habitat in Western Equatorial Africa, forestry companies will take advantage of their opportunities to enhance the conservation prospects of these endangered apes. These guidelines were produced in the hope of facilitating the process, by suggesting practical recommendations and summarizing relevant information for reducing the impact of mechanized logging on apes in WEA.

Section 6:
Review of Research on the Impact of Logging on Apes in Africa

The expansion of mechanized logging throughout the forests of central Africa is one of the most widespread threats to the remaining populations of gorillas and chimpanzees (Tutin *et al.* 2005). Rates of deforestation in Africa have been estimated at 0.4–0.5% forest loss per year, and it has been predicted that total forest cover in Central Africa will decline by more than 30% in the next 50 years (Robinson and Crowley 2003; Mayaux *et al.* 2005). Both gorillas and chimpanzees reside in the rich tropical forests that contain high densities of preferred ape fruit trees as well as valuable timber trees, which can lead to direct conflict with logging company interests. Like other mammals with low reproductive rates and large home ranges, survival prospects for great apes worsen with increasing human encroachment and fragmentation of habitat, as shown by case studies across West Africa (Kormos *et al.* 2003). The extreme fragmentation of forest blocks in East and West

Africa provides compelling reason for us to make every effort to protect the large expanses of continuous forest remaining in central Africa and the great apes that live there. The potential for timber companies to contribute to the conservation of chimpanzees and gorillas in Western Equatorial Africa is high and virtually essential for the long-term survival of these endangered apes.

Studies on the effects of logging on great apes over the past 20 years are equivocal; research has shown both increases and decreases in gorilla densities in response to logging, whereas chimpanzee densities are generally reduced in logged forests, with some exceptions (Skorupa 1988; Hashimoto, 1995; Marchesi *et al.* 1995; Plumptre and Reynolds 1994, 1996; White and Tutin, 2001; Matthews and Matthews, 2004). However, results clearly indicate that removal of important food resources and the degree of forest disturbance are important factors in determining primate responses to logging (Chapman *et al.* 2005a, 2006). The conflicting results from past studies may be due to the low precision of survey methods, or to research methods that compare different areas rather than effects on the same area relative to baseline estimates (Plumptre and Johns 2001). This situation is further complicated by the failure of many studies to distinguish the effects of logging from associated threats such as bushmeat hunting (Walsh 2006) and/or changes due to the introduction of foreign pathogens (Chapman *et al.* 2005b).

Studies in Gabon at sites logged at different times saw initial declines in gorilla numbers, but no real discernible pattern in terms of density of individuals/km^2 has emerged (Tutin and Fernandez 1984; White and Tutin 2001). In fact, recent surveys in Cameroon found relatively high gorilla densities in logged forest (Dupain *et al.* 2004). The diets and ranging behaviours of western lowland gorillas may enable them to better cope (or even thrive) in secondary forests, whereas chimpanzees seem to be less successful in degraded habitats. It is plausible that gorillas maintain or show increased numbers post-logging due to the extensive regeneration of secondary herbaceous vegetation (preferred food of gorillas) that flourishes in the light gaps created by logging (Matthews and Matthews, 2004). However, recent studies have shown that gorillas actively avoid human disturbance and forestry operations, including timber inventory teams and felling crews (Remis 2000; Matthews and Matthews 2004; Morgan *et al.* in prep). It follows logically that gorillas would also be negatively impacted by timber extraction, but rigorous before-and-after studies in the same area are not yet available. Most previous studies have compared logging in different areas and are thus largely inconclusive, as gorilla densities can vary dramatically over relatively small spatial scales (Tutin and Fernandez, 1984; Fay and Agnagna 1992; Matthews and Matthews 2004).

The negative effects of logging on wild chimpanzee populations are clearer. In Gabon, the selective exploitation of trees and associated noise caused social disruption in chimpanzees (White and Tutin 2001). The authors suggest that logging activities which extend over a 5–10km band of forest could displace an entire community from their habitual home range. Such a shift may have instigated social upheaval and territorial conflicts with neighbouring chimpanzee communities (White and Tutin 2001). Chimpanzees in Uganda avoided human presence (Plumptre *et al.* 1997; Plumptre and Johns 2001) and changed their ranging patterns when logging of their home range began (Fawcett 2000; Reynolds 2005). Gorillas also avoid areas of human activity, but differences in spatial organization between the ape species could be shaping their different responses to timber exploitation (Matthews and Matthews, 2004; Morgan *et al.* in prep.). Chimpanzees are highly territorial, and inter-group aggression can escalate into lethal interactions, whereas gorilla groups have completely overlapping ranges. It may, therefore, be easier for gorillas to return when forestry teams have departed than for chimpanzees who may have suffered severe disruption to their socio-spatial organization.

Chimpanzees show differing responses to the intensity of timber extraction and to the degree of change in habitat composition. In the Kibale Forest of Uganda, chimpanzee density declined as habitat changes increased (Skorupa 1988). A simple explanation for this is that chimpanzees prefer mature forest, despite being capable of incorporating a wide spectrum of habitat types into their range. Skorupa (1986, 1988) suggested that chimpanzees were among a guild of mature-forest specialists that were more likely to be adversely affected by timber exploitation than other sympatric primates. Measures of logging intensity coupled with research on chimpanzees suggest that the reproductive success of females occupying heavily disturbed areas was only half that of females occupying areas of undisturbed and lightly logged forest within the same community

(Emery-Thompson *et al.* 2007). The authors suggest that changes of habitat quality contributed significantly to differences in reproductive success of female chimpanzees (Emery-Thompson *et al.* 2007).

Preservation of Habitat Quality. Preservation of habitat quality has been shown to reduce the negative impacts of mechanized logging on chimpanzees in East Africa, providing a scientific foundation as well as practical insights for the making of specific recommendations to reduce the impact of logging on apes in other regions. The most compelling evidence to date indicates that decreasing chimpanzee densities were associated with higher levels of habitat change in logged forests at Kibale in Uganda (Johns and Skorupa 1987). However, chimpanzee densities in the Budongo forest did not significantly differ between mechanically logged and unlogged compartments (Plumptre and Reynolds 1994, 1996; Plumptre 2001). The lack of impact on chimpanzee densities could have been because high-quality food species were not removed during low-impact logging and/or due to the subsequent generation of important food resources in mechanically logged compartments which were previously monodominant forest (Plumptre and Johns 2001). Similar findings were reported from the Kalinzu forest in Uganda, where high chimpanzee densities in logged forests were most likely linked to colonization by *Musanga cecropoides*, a species consumed by chimpanzees (Hashimoto 1995).

In Western Equatorial Africa, timber companies have focused in large part on the extraction of *Entandrophragma* spp., which is not eaten by gorillas and chimpanzees. However, the number of tree species attractive to the international market has expanded in the last 10 years through advances in forestry technology and changes in timber product market values. Consequently the food sources of gorillas and chimpanzees in logging concessions are now directly impacted. For example, in northern Congo, 39% of tree species exploited are included in the chimpanzees diet (Morgan pers. obs.). Research in the Nouabalé-Ndoki National Park indicates that several timber trees are food resources (fruits, leaves, flowers, seeds) for wild chimpanzees, and that these trees may also have important social value as they attract relatively large gatherings of these apes (see Figure 2 from Morgan 2007). Several forests in WEA are being inventoried for second harvest rotations, and it is important to consider implications for local ape populations when selecting tree species to be exploited.

From the perspective of chimpanzee and gorilla conservation, minimizing disturbance to old growth forest or similar habitats (i.e., mixed species forest with a continuous canopy) is important for maintaining forest quality. Minimizing both removal of large trees and damage to the canopy is recommended for the conservation of frugivorous primates (Skorupa 1988). A higher density of fruit trees are found in closed canopy old growth and mixed species forest than in forest types with an open canopy (Blake 2002). Chimpanzees in Congo preferentially use closed forest habitats when foraging, resting and socializing (Morgan *et al*. 2006). Furthermore, closed canopy forest forms a higher proportion of the chimpanzees' core area than in the less-used areas of their range (Morgan 2007). Western lowland gorillas prefer nesting in habitats with dense undergrowth which is usually associated with open canopy forests, but are also known to forage opportunistically on fruit in closed canopy forest. Several tree species (e.g., Irvingiaceae) found in closed canopy forests produce long-lasting fruit crops that are important in the diet of wild gorillas and chimpanzees. The value of these forests to the apes can be preserved by minimizing damage to residual stands, conserving 75% of mature-core species, and ensuring less than 20% canopy reduction in forests taller than 15m.

Impact of Road Networks. Several studies have emphasized that changes in logging road construction methods could significantly decrease the negative impacts on forest structure and diversity (Gullison and Hardner 1993; Malcolm and Ray 2000). Effects on forest structure and composition are related to road network density, road width, spatial layout and traffic intensity (Malcolm and Ray 2000; Wilkie *et al.* 2000; Blake 2002). Secondary roads may be smaller than primary transport roads, but they occur at higher densities (e.g., secondary roads in northern Congo are spaced at 1km intervals). To give this biological meaning, a chimpanzee community with a range of 20km^2 will have to cope with approximately 20km of roads within their home range during timber extraction.

Strategic road placement can significantly decrease the amount of closed canopy forest destroyed during route construction (Malcolm and Ray 2000; Blake 2002). Canopy loss can be reduced by

deviation of secondary roads around large trees of non-exploited species (Malcolm and Ray 2000), which would benefit great apes by preserving habitat quality. Blake (2002) recommended that, where possible, secondary roads be placed in open canopy forest to reduce canopy loss. The lower density of trees in open and monodominant forests also makes road construction more cost effective as fewer trees need removing. In addition, Plumptre and colleagues (1997) recorded an increase in the diversity of fruit-bearing species following logging of monodominant forests, with particular benefit to frugivorous primates and birds.

Reducing road density and size will not only improve the ecological quality of forests, but also improve the safety of apes who are forced to traverse these routes to access all areas of their home range. A study in Guinea found that the width of roads bisecting the chimpanzees' range had important implications for their ranging and grouping behaviour (Hockings *et al.* 2006). The risk perceived was found to be greater when chimpanzees crossed a 12m wide road with motorized traffic than a 3m wide road that was used only by pedestrians; the chimpanzees waited significantly longer before crossing the larger road (Hockings *et al.* 2006). These observations, and reports from road kill rates of other wildlife, indicate that roads pose a danger to wild apes, which is compounded by habitat encroachment and increased hunting facilitated by the road networks. We have made several specific recommendations for limiting the negative consequences of timber extraction routes for apes, which include reducing their density and width, and placing these roads as far as possible from protected areas.

Increased Hunting Pressure. Increased hunting of wildlife is directly associated with improved access to remote forests facilitated by forestry activities (Wilkie *et al.* 1992; Auzel and Wilkie 2000). Even before timber extraction takes place, illegal hunters are able to exploit wildlife during timber inventories and road construction phases. Indeed, wildlife will be most vulnerable at this time if the animals have no previous experience of hunting and respond naïvely by not fleeing from humans (Morgan and Sanz 2003; Werdenich *et al.* 2003). Although chimpanzees have been preyed upon by humans throughout history, there has been a recent shift from subsistence hunting to commercial trade, which has greatly intensified the exploitation of apes and other wildlife (Tutin and Oslisly 1995; Wilkie 2001; Fa *et al.* 2006).

The bushmeat trade has a lasting impact on ape populations, thriving on the road networks created for timber extraction (Wilkie and Carpenter 1999). Roads provide easy access to previously remote areas, enabling unregulated hunting practices. In areas where roads and villages have been established, gorillas, chimpanzees, elephants, monkeys and duikers all decrease in number (Wilkie *et al.* 2001; Fa *et al.* 2006). Left unchecked, illegal hunting can lead to the elimination of wildlife within a few kilometres of access routes (Redford 1992). Walsh *et al.* (2003) found that ape populations in Gabon declined by more than half between 1983 and 2000. The primary cause of this decline was commercial hunting facilitated by the rapid expansion of mechanized logging. Without the implementation of strict conservation measures this is the likely outcome for all apes residing in the last large tracts of intact forest in Western Equatorial Africa that have recently opened for timber exploitation (Walsh 2006).

Section 7: Acknowledgements

We thank Liz Williamson, Caroline Tutin and Emma Stokes for the invitation and guidance in developing the guidelines described here. This document was largely inspired by the visionary conservation ideas and efforts of Caroline Tutin who has worked tirelessly during her research career for the preservation of wild apes in the Congo Basin.

Special thanks are due to Mimi Arandjelovic, Eric Arnhem, Stephen Blake, Christophe Boesch, Christina Ellis, Heather Eves, Matthew Hatchwell, Liz Macfie, Fiona Maisels, John Poulsen, Bjorn Schulte-Herbrüggen, Matthew Woods, David Wilkie, Lee White, Janette Wallis, and Anthony Rylands for providing insightful comments and suggestions. We are very grateful to these reviewers who have generously lent their time and expertise to improving this document. Emma Stokes is to be credited for the map of logging concessions and priority ape conservation areas. This publication was kindly sponsored by a grant to Conservation International from the United States Fish and Wildlife Service (Great Ape Conservation Fund).

Section 8: Literature Cited

Ape Alliance. 1998. The African Bushmeat Trade: A Recipe for Extinction. Ape Alliance, Cambridge. http://www.4apes.com/bushmeat/

ATIBT. 2005. *The Requirements of a Practical Forest Management Plan for Natural Tropical African Production Forests: Application to the Case of Central Africa. Volume 3. Wildlife Aspects.* Association Technique Internationale des Bois Tropicaux. Paris, France. http://atibt.com/pdf/plan_amenagement_atibt_Volet_III_francais.pdf

Auzel, P. and Wilkie, D.E. 2000. Wildlife use in northern Congo: Hunting in a commercial logging concession. In: J.G. Robinson and E.L. Bennett (eds.), *Hunting for Sustainability in Tropical Forests*, pp.413–426. Columbia University Press, New York.

Bass, M.S., Aviram, R. and Parker, K. 2003. Timber certification: Prospects and progress in addressing wildlife issues in Central Africa. In: Uncertain Future: The Bushmeat Crisis in Africa. Bushmeat Crisis Task Force. http://www.bushmeat.org/docs.html

Blake, S. 2002. "Ecology of forest elephant distribution and its implications for conservation". Ph.D. Thesis, University of Edinburgh, Edinburgh.

Bruner, A., Gullison, R.E., Rice, R. and da Fonseca, G.A.B. 2001. Effectiveness of parks in protecting tropical biodiversity. *Science* 291:125–128.

Byron, N. 2001. The economics of sustainable forest management and wildlife conservation in tropical forests. In: R. Fimbel, A. Grajal, and J.G. Robinson (eds.), *The Cutting Edge: Conserving Wildlife in Logged Tropical Forests,* pp.635–648. Columbia University Press. New York.

Butynski, T.M. 2003. The robust chimpanzees *Pan troglodytes*: Taxonomy, distribution, abundance and conservation status. In: R. Kormos, C. Boesch, M.I. Bakarr, and T.M. Butynski (eds.), *West African Chimpanzees: Status and Conservation Action Plan,* pp.5–12. IUCN - The World Conservation Union, Gland, Switzerland http://www.primate-sg.org/action.plans.htm

Chapman, C.A., Struhsaker, T.T. and Lambert, J. E. 2005a. Thirty years of research in Kibale National Park, Uganda, reveals a complex picture for conservation. *International Journal of Primatology* 26:539–555.

Chapman, C.A., Gillespie, T.R. and Goldberg, T. 2005b. Primates and the ecology of their infectious diseases: How will anthropogenic change affect host-parasite interactions? *Evolutionary Anthropology* 14:134–144.

Chapman, C.A., Lawes, M.J. and Eeley, H.A.C. 2006. What hope for African primate diversity? *African Journal of Ecology* 44:116–133.

CIB. 2006. *Plan d'amenagement de l'unité forestière d'aménagement de Kabo (2005–2034).* Congolaise Industrielle des Bois et Ministère de l'Economie Forestière et de l'Environnement, Brazzaville, Congo.

Doran, D., McNeilage, A., Greer, D., Bocian, C., Mehlman, P. and Shah, N. 2002. Western lowland gorilla diet and resource availability: New evidence, comparisons, and reflections on indirect sampling methods. *American Journal of Primatology* 58:91–116.

Dupain, J., Guislain, P., Nguenang, G.M., de Vleeschouwer, K. and van Elsacker, L. 2004. High chimpanzee and gorilla densities in a non-protected area on the northern periphery of the Dja Faunal Reserve, Cameroon. *Oryx* 2:209–216.

Dykstra, D. and Heinrich, R. 1992. Sustaining tropical forests through environmentally sound harvesting practices. *Unasylva* 43:9–15.

Elkan, P.W., Elkan, S.W., Moukassa, A., Malonga, R., Ngangoue, M. and Smith, J.L.D. 2006. Managing threats from bushmeat hunting in a timber concession in the Republic of Congo. In: W.F. Laurance and C.A. Peres (eds.), *Emerging Threats to Tropical Forests*, pp.393–415. University of Chicago Press, Chicago.

Emery-Thompson, M., Kahlenberg, S., Gilby, I. and Wrangham, R.W. 2007. Core area quality is associated with variance in reproductive success among female chimpanzees at Kanyawara, Kibale, National Park. *Animal Behaviour* 73:501-512.

Fa, J.E., Currie, D. and Meeuwig, J. 2003. Bushmeat and food security in the Congo Basin: Linkages between wildlife and people's future. *Environmental Conservation* 30:71–78.

Fa, J.E., Seymour, S., Dupain, J., Amin, R., Albrechtsen, L. and Macdonald, D. 2006. Getting to grips with the magnitude of exploitation: Bushmeat in the Cross-Sanaga river region, Nigeria and Cameroon. *Biological Conservation* 129:497–510.

Fawcett, K. 2000. "Female relationships and food availability in a forest community of chimpanzees". Ph.D. Thesis, University of Edinburgh, Edinburgh.

Fay, J.M. 1997. "The ecology, social organization, populations, habitat and history of the western lowland gorilla (*Gorilla gorilla gorilla* Savage and Wyman 1847)". Unpublished Ph.D. Thesis, Washington University, Saint Louis, MO.

Fay, J.M. and Agnagna, M. 1992. Census of gorillas in northern Republic of Congo. *American Journal of Primatology* 27:275–284.

Fimbel, R., Grajal, A. and Robinson, J.G. 2001. Logging and wildlife in the tropics: Impacts and options for conservation. In: R. Fimbel, A. Grajal, and J.G. Robinson (eds.), *The Cutting Edge: Conserving Wildlife in Logged Tropical Forests,* pp.667–695. Columbia University Press. New York.

Georges, A.J., Leroy, E.M., Renaut, A.A., Benissan, C.T., Nabias, R.J., Ngoc, M.T., Obiang, P.I., Lepage, J.P.M., Bertherat, E.J., Benoni, D.D., Wickings, J., Amblard, J.P., Lansoud-Soukate, J.M., Milleliri, J.M., Baize, S., and Georges-Courbot, M.C. 1999. Ebola Hemorrhagic fever outbreaks in Gabon, 1994–1997: Epidemiologic and health control issues. *Journal of Infectious Diseases* 179:65–75.

Gullison, R.E. and Hardner, J.J. 1993. The effects of road design and harvest intensity on forest damage caused by selective logging: Empirical results and a simulation model from the Bosque Chimanes, Bolivia. *Forest Ecology and Management* 59:1–14.

Hashimoto, C. 1995. Population census of the chimpanzees in the Kalinzu Forest, Uganda: Comparison between methods with nest counts. *Primates* 36:477–488.

Herbinger, I., Boesch, C. and Rothe, H. 2001. Territory characteristics among three neighboring chimpanzee communities in the Taï National Park, Cote d'Ivoire. *International Journal of Primatology* 22:143–167.

van Heuverswyn, F., Li, Y., Neel, C., Bailes, E., Keele, B.F., Liu, W., Loul, S., Butel, C., Liegeois, F., Bienvenue, Y., Ngolle, E.M., Sharp, P.M., Shaw, G.M., Delaporte, E., Hahn, B.H. and Peeters, M. 2006. SIV infection in wild gorillas. *Nature, Lond.* 444:164.

Hockings, K.J., Anderson, J.R. and Matsuzawa, T. 2006. Road crossing in chimpanzees: A risky business. *Current Biology* 16:668–670.

Holmes, T.P., Blate, G.M., Zweede, J.C., Pereira Jr., R., Barreto, P., Boltz, F. and Bauch, R. 2000. Financial costs and benefits of reduced-impact logging relative to conventional logging in the Eastern Amazon. Tropical Forest Foundation, Washington, DC. http://www.srs.fs.usda.gov/econ/pubs/tph001.htm

Homsy, J. 1999. *Ape Tourism and Human Diseases: How Close Should We Get?* International Gorilla Conservation Program, Kampala, Uganda www.igcp.org/files/ourwork/Homsy_rev.pdf

Huijbregts, B., de Wachter, P., Obiang, L.S.N. and Akou, M.E. 2003. Ebola and the decline of gorilla *Gorilla gorilla* and chimpanzee *Pan troglodytes* populations in Minkebe Forest, north-eastern Gabon. *Oryx* 37:437–443.

Humle, T. 2003. Chimpanzees and crop raiding in West Africa. In: R. Kormos, C. Boesch, M.I. Bakarr, and T.M. Butynski (eds.), *West African Chimpanzees: Status and Conservation Action Plan,* pp.147–150. IUCN - The World Conservation Union, Gland, Switzerland. http://www.primate-sg.org/action.plans.htm

ITTO. 1993. *Guidelines for the Conservation of Biological Diversity in Tropical Production Forests*. ITTO Policy Development Series, No. 5. International Timber Trade Organisation (ITTO), Yokohama, Japan.

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

IUCN/ITTO. In prep. Guidelines for the Conservation and Sustainable Use of Biodiversity in Tropical Timber Production Forests. IUCN - The World Conservation Union (IUCN), Gland, Switzerland, and International Tropical Timber Organization (ITTO), Yokohama, Japan.

Johns, A.D. 1983. Wildlife can live with logging. *New Scientist* 99:206–211.

Johns, A.D. 1992. Species conservation in managed tropical forests. In: J. Sayer and T.C. Whitmore (eds.), *Realistic Strategies for Tropical Forest Conservation*, pp.15–53. IUCN – The World Conservation Union, Gland, Switzerland.

Johns, A.D. and Skorupa, J.P. 1987. Response of rain forest primates to habitat disturbance: A review. *International Journal of Primatology* 8:157–191.

Jones, C. and Sabater Pi, J. 1971. Comparative ecology of *Gorilla gorilla* (Savage, Wyman) and *Pan troglodytes* (Blumenbach) in Río Muni. *Bibliotheca Primatologica* 13:1–96.

Keele, B.F., Van Heuverswyn, F., Li, Y., Bailes, E., Takehisa, J., Santiago, M.L., Bibollet-Ruche, F., Chen, Y., Wain, L.V., Liegeois, F., Loul, S., Ngole, E.M., Bienvenue, Y., Delaporte, E., Brookfield, J.F.Y., Sharp, P.M., Shaw, G.M., Peeters, M. and Hahn, B.H. 2006. Chimpanzee reservoirs of pandemic and non-pandemic HIV-1. *Science* 313:523–526.

Kormos, R., Boesch, C., Bakarr, M.I. and Butynski, T.M. 2003. *West African Chimpanzees: Status and Conservation Action Plan.* IUCN - The World Conservation Union, Gland, Switzerland. http://www.primate-sg.org/action.plans.htm

Krueger, W. 2004. Effects of future crop tree flagging and skid trail planning on conventional diameter-limit logging in a Bolivian tropical forest. *Forest Ecology and Management* 188:381–393.

Kuehl, H., Maisels, F., Ancrenaz, M. and Williamson, E.A. In prep. *Guidelines for Surveys and Monitoring of Great Ape Populations*. IUCN - The World Conservation Union, Gland, Switzerland.

Laurance, W.F., Croes, B.M., Tchignoumba, L., Lahm, S.A., Alfonso, A., Lee, M.E., Campbell, P. and Ondzeano, C. 2006. Impacts of roads and hunting on Central African Rainforest mammals. *Conservation Biology* 4:1251–1261.

Leendertz, F.H., Pauli, G., Maetz-Rensing, K., Boardman, W., Nunn, C., Ellerbrok, H., Jensen, S. A., Junglen, S. and Boesch, C. 2006. Pathogens as drivers of population declines: The importance of systematic monitoring in great apes and other threatened mammals. *Biological Conservation* 131:325–337.

Leirs, H., Mills, J.N., Krebs, J.W., Childs, J.E., Akaibe, D., Woollen, N., Ludwig, G., Peters, C.J. and Ksiazek, T.G. 1999. Search for the Ebola virus reservoir in Kikwit, Democratic Republic of the Congo: Reflections on a vertebrate collection. *Journal of Infectious Diseases* 179:155–163.

MacKinnon, J. 1974. The behaviour and ecology of wild orang-utans (*Pongo pygmaeus*). *Animal Behaviour* 22:3–74.

Magliocca, F., Querouil, S. and Gautier-Hion, A. 1999. Population structure and group composition of western lowland gorillas in the north-western Republic of Congo. *American Journal of Primatology* 48:1–14.

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

Marchesi, P., Marchesi, N., Fruth, B. and Boesch, C. 1995. Census and distribution of chimpanzees in Côte d'Ivoire. *Primates* 36:591–607.

Matthews, A. and Matthews, A. 2004. Survey of gorillas (*Gorilla gorilla gorilla*) and chimpanzees (*Pan troglodytes troglodytes*) in Southwestern Cameroon. *Primates* 45:15–24.

Mayaux, P., Holmgren, P., Achard, T., Eva, H., Stibig, H. and Branthomme, A. 2005. Tropical forest cover change in the 1990s and options for future monitoring. *Philosophical Transactions of the Royal Society B. Biological Sciences* 360:373–384.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. and O'Brien, T. 2005. Life after logging: Reconciling wildlife conservation and production forestry in Indonesian Borneo. Center for International Forestry Research (CIFOR), Bogor, Indonesia. http://www.cifor.cgiar.org/mla/_ref/publication/life_after_logging.htm

Morgan, D. 2007. "Socio-ecology of Chimpanzees in the Goualougo Triangle, Republic of Congo". Ph.D. Thesis, University of Cambridge, Cambridge, UK.

Morgan, D. and Sanz, C. 2003. Naive encounters with chimpanzees in the Goualougo Triangle, Republic of Congo. *International Journal of Primatology* 24:369–381.

Morgan, D. and Sanz, C. 2006. Chimpanzee feeding ecology and comparisons with sympatric gorillas in the Goualougo Triangle, Republic of Congo. In: G. Hohmann, M.M. Robbins, and C. Boesch (eds.), *Feeding Ecology in Apes and Other Primates: Ecological, Physical and Behavioral Aspects*, pp.97–122. Cambridge University Press, Cambridge, UK.

Morgan, D., Sanz, C., Onononga, J.R. and Strindberg, S. 2006. Ape abundance and habitat use in the Goualougo Triangle, Republic of Congo. *International Journal of Primatology* 27:147–179.

Morgan, D., Sanz, C., Onononga, J.R., Stokes, E., Lonsdorf, E. and Strindberg, S. In prep. The effects of logging practices on great apes in the Ndoki Forests, Republic of Congo. XXX

Moutsambote, J.M., Yumoto, T., Mitani, M., Nishihara, T., Suzuki, S. and Kuroda, S. 1994. Vegetation list and plant species identified in the Nouabale-Ndoki forest, Congo. *Tropics* 3:277–293.

Newton-Fisher, N.E. 1997. "Tactical behaviour and decision making in wild chimpanzees". Ph.D. Thesis, University of Cambridge. Cambridge, UK.

Parnell, R. 2002. Group size and structure in western lowland gorillas (*Gorilla gorilla gorilla*) at Mbeli Bai, Republic of Congo. *American Journal of Primatology* 56:193–206.

Pérez, M.R., Ezzine De Blas, D., Nasi, R., Sayer, J.A., Sassen, M., AngoueAngoué, C., Gami, N., Ndoye, O., Ngono, G., Nguinguiri, J.-C., Nzala, D., Toirambe, B. and Yalibanda, Y. 2005. Logging in the Congo Basin: A multi-country characterization of timber companies. *Forest Ecology and Management* 214:221–236.

Plumptre, A.J. 2001. The effects of habitat change due to selective logging on the fauna of forests in Africa. In: W. Weber, L.J.T. White, A. Vedder, and L. Naughton-Treves (eds.), *African Rain Forest Ecology and Conservation: An Interdisciplinary Perspective*, pp.463–479. Yale University Press, New Haven.

Plumptre, A.J. and Johns, A.G. 2001. Changes in primate communities following logging disturbance. In: R. Fimbel, A. Grajal, and J.G. Robinson (eds.), *The Cutting Edge: Conserving Wildlife in Logged Tropical Forests*, pp.71–92. Columbia University Press, New York.

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

Plumptre, A.J. and Reynolds, V. 1996. Censusing chimpanzees in the Budongo Forest, Uganda. *International Journal of Primatology* 17:85–99.

Plumptre, A.J., Reynolds, V. and Bakuneeta, C. 1997. The effects of selective logging in monodominant tropical forest on biodiversity. Report to Project R6057, Overseas Development Administration (ODA), London.

Plumptre A.J., Cox, D. and Mugume, S. 2003. The Status of Chimpanzees in Uganda. *Albertine Rift Technical Report Series* No. 2. Wildlife Conservation Society, New York.

Possingham, H.P., Andelman, S.J., Noon, B.R., Trombulak, S. and Pulliam, H.R. 2001. Making smart conservation decisions. In: M.E. Soulé and G. Orians (eds.), *Conservation Biology: Research Priorities for the Next Decade*, pp.225–244. Island Press, Covelo, CA.

Poulsen, J.R., Clark, C.J. and Malonga, R. 2005. Recensement et distribution des grands mammifères et activités humaines dans l'unité forestière d'aménagement de Kabo. Rapport au WCS, CIB, FFEM, et AFD, Kabo, République du Congo-Brazzaville. 72pp.

Poulsen, J.R., Clark, C.J. and Mavah, G. In press. Wildlife management in a logging concession in Northern Congo: Can livelihoods be maintained through sustainable hunting? In: G. Davies and D. Brown (eds.), *Bushmeat and Livelihoods*. Blackwell Publishers, Oxford, UK.

Quiatt, D., Reynolds, V. and Stokes, E.J. 2002. Snare injuries to chimpanzees (*Pan troglodytes*) at 10 study sites in East and West Africa. *African Journal of Ecology* 40(3):303–305.

Redford, K. 1992. The empty forest. *BioScience* 42:414–422.

Reed, P. and Orbell, I. 2007. Recommandations pour la préservation de la santé de la faune au Gabon. Wildlife Conservation Society (WCS), Gabon, and Wildlife Conservation Society (WCS), Field Veterinary Programme, New York.

Remis, M.J. 2000. Preliminary assessment of the impacts of human activities on gorillas *Gorilla gorilla gorilla* and other wildlife at Dzanga-Sangha Reserve, Central African Republic. *Oryx* 34:56–65.

Remis, M.J., Dierenfeld, E.S., Mowry, C.B. and Carroll, R.W. 2001. Nutritional aspects of western lowland gorilla (*Gorilla gorilla gorilla*) diet during seasons of fruit scarcity at Bai Hokou, Central African Republic. *International Journal of Primatology* 22:807–836.

Reynolds, V. 2005. *The Chimpanzees of the Budongo Forest: Ecology, Behaviour, and Conservation*. Oxford University Press, Oxford, UK.

Robinson, J. and Crowley, H. 2003. Fact Sheet: The Context for Conservation. Wildlife Conservation Society, New York. http://wcs.org/centralafrica/FactSheets/ContextForConservation.pdf

Rogers, M.E., Abernethy, K.A., Bermejo, M., Cipolletta, C., Doran, D., McFarland, K., Nishihara, T., Remis, M.J., and Tutin, C.E.G. 2004. Western gorilla diet: A synthesis from six sites. *American Journal of Primatology* 64:173–192.

Rouquet, P., Froment, J.M., Bermejo, M., Kilbourn, A., Karesh, W., Reed, P., Kumulungui, B., Yaba, Y., Delicat, A., Rollin, P.E. and Leroy, E.M. 2005. Wild animal mortality monitoring and human Ebola outbreaks, Gabon and Republic of Congo 2001–2003. *Emerging Infectious Diseases* 11:283–290.

Sabater Pi, J. 1979. Feeding behaviour and diet of chimpanzees (*Pan troglodytes troglodytes*) in the Okorobiko Mountains of Río Muni (West Africa). *Zeitschrift fuer Tierpsychologie* 50:265–281.

Schulte-Herbrüggen, B. and Davies, G. 2006. Wildlife conservation and tropical timber certification. *ZSL Conservation Report* No. 6. Zoological Society of London, London. http://www.zsl.org/field-conservation/bushmeat-and-forest/wildlife-conservation-and-tropical-timber-certification,558,AR.html

Skorupa, J.P. 1986. Response of rain forest primates to selective logging in the Kibale Forest, Uganda. In: K. Benirschke (ed.), *Primates: The Road to Self-Sustaining Populations*, pp.57–70. Springer Verlag, New York.

Skorupa, J.P. 1988. “The effect of selective timber harvesting on rain-forest primates in Kibale Forest, Uganda”. Ph.D. Thesis, University of California, Davis.

Struhsaker, T.T. 1997. *Ecology of an African Rain Forest: Logging in Kibale and the Conflict between Conservation and Exploitation*. University of Florida Press, Gainesville.

Tutin, C.E.G. 2001. Saving the gorillas (*Gorilla g. gorilla*) and chimpanzees (*Pan t. troglodytes*) of the Congo Basin. *Reproduction, Fertility and Development* 13:469-476.

Tutin, C.E.G. and Fernandez, M. 1984. Nationwide census of gorilla and chimpanzee populations in Gabon. *American Journal of Primatology* 6:313–336.

Tutin, C.E.G. and Fernandez, M. 1985. Foods consumed by sympatric populations of *Gorilla gorilla* and *Pan troglodytes* in Gabon: Some preliminary data. *International Journal of Primatology* 6:27–43.

Tutin, C.E.G. and Fernandez, M. 1993. Composition of the diet of chimpanzees and comparisons with that of sympatric lowland gorillas in the Lopé Reserve, Gabon. *American Journal of Primatology* 30:195–211.

Tutin, C.E.G. and Oslisly, R. 1995. *Homo, Pan,* and *Gorilla*: Coexistence over 60,000 years at Lopé in central Gabon. *Journal of Human Evolution* 28:597–602.

Tutin, C.E.G., Stokes, E., Boesch, C., Morgan, D., Sanz, C., Reed, P., Blom, A., Walsh, P., Blake, S. and Kormos, R. 2005. *Regional Action Plan for the Conservation of Chimpanzees and Gorillas in Western Equatorial Africa*. Conservation International. Washington, DC. http://www.primate-sg.org/action.plans.htm

Waller, J.C. and Reynolds, V. 2001. Limb injuries resulting from snares and traps in chimpanzees (*Pan troglodytes schweinfurthii*) at the Budongo Forest, Uganda. *Primates* 42:135–139.

Walsh, P.D. 2006. Ebola and commercial hunting: Dim prospects for African apes. In: W.F. Laurance and C.A. Peres (eds.), *Emerging Threats to Tropical Forests*, pp.175–197. University of Chicago Press, Chicago.

Walsh, P.D. and White, L.J.T. 2005. Evaluating the steady state assumption: Simulations of gorilla nest decay. *Ecological Applications* 15:1342–1350.

Walsh, P.D., Abernethy, K.A., Bermejo, M., Beyers, R., de Wachter, P., Akou, M.E., Huijbregts, B., Mambounga, D.I., Toham, A. K., Kilbourn, A.M., Lahm, S.A., Latour, S., Maisels, F., Mbina, C., Mihindou, Y., Obiang, S.N., Effa, E.N., Starkey, M.P., Telfer, P., Thibault, M., Tutin, C.E.G., White, L.J.T. and Wilkie, D.S. 2003. Catastrophic ape decline in western equatorial Africa. *Nature, Lond.* 422:611–613.

Werdenich, D., Dupain, J., Arnhem, E., Julve, C., Deblauwe, I. and van Elsacker, L. 2003. Reactions of chimpanzees and gorillas to human observers in a non-protected area in south-eastern Cameroon. *Folia Primatologica* 74:97–100.

White, L.J.T. and Tutin, C.E.G. 2001. Why chimpanzees and gorillas respond differently to logging: A cautionary tale from Gabon. In: W. Weber, L.J.T. White, A. Vedder and L. Naughton-Treves (eds.), *African Rain Forest Ecology and Conservation: An Interdisciplinary Perspective*, pp.449–462. Yale University Press, New Haven.

Wilkie, D.S. 2001. Bushmeat trade in the Congo Basin. In: B.B. Beck, T.S. Stoinski, M. Hutchins, T.L. Maple, B. Norton, A. Rowan, B.F. Stevens, and A. Arluke (eds.), *Great Apes and Humans: The Ethics of Coexistence*, pp.86–109. Smithsonian Institution Press, Washington, DC.

Wilkie, D.S. and Carpenter, J. 1999. Bushmeat hunting in the Congo Basin: An assessment of impacts and options for mitigation. *Biodiversity and Conservation* 8:927–955.

Wilkie, D.S, Shaw, F.E., Rotberg, G.F., Morelli, G. and P. Auzel, P. 2000. Roads, development, and conservation in the Congo basin. *Conservation Biology* 14:1614–1622.

Wilkie, D.S., Sidle, J.G. and Boundzanga, G.C. 1992. Mechanized logging, market hunting, and a bank loan in Congo. *Conservation Biology* 6:570–580.

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: R. Fimbel, A. Grajal, and J.G. Robinson (eds.), *The Cutting Edge: Conserving Wildlife in Logged Tropical Forests,* pp.375–399. Columbia University Press, New York.

Williamson, E.A., Tutin. C.E.G., Rogers, M.E. and Fernandez, M. 1990. Composition of the diet of lowland gorillas at Lopé in Gabon. *American Journal of Primatology* 21:265–277.

Wrangham, R. 2001. Moral decisions about wild chimpanzees. In: B.B. Beck, T.S. Stoinski, M. Hutchins, T.L. Maple, B. Norton, A. Rowan, E.F. Stevens and A. Arluke (eds.), *Great Apes and Humans: The Ethics of Coexistence*, pp.230–244. Smithsonian Institution Press, Washington, DC.

Woodford, M.H., Butynski, T.M. and Karesh, W.B. 2002. Habituating the great apes: The disease risks. *Oryx* 36:153–160.

Annex 1

List of chimpanzee and gorilla tree foods recorded at different ape study sites in Western Equatorial Africa. Tree species logged (Perez** et al. **2005; CIB 2006) are listed with their timber names. Secondary timber species are differentiated by an asterisk from primarily exploited tree species in this region. Species highlighted in red are those reported to be important in ape diets (Tutin and Fernandez, 1993; Doran** et al. **2002; Morgan and Sanz, 2006) and should be protected during timber operations.

			Field Site							
Timber Name	**Family**	**Scientific Species Name**	**Okorobiko, Guinea [a]**	**Goualougo, Congo [b]**	**Ndoki, Congo [c]**	**Mondika, Congo [d]**	**Belinga, Gabon [e]**	**Lope, Gabon [f,g]**	**Ndakan, C.A.R. [h]**	**Bai Hokou, C.A.R. [i]**
	Anacardiaceae	*Pseudospondias microcarpa*	■					■		
		Trichoscypha acuminata	■	■			■	■	■	
	Annonaceae	*Anonidium mannii*		■	■	■	■		■	■
		Greenwayodendron suaveolens		■	■	■	■	■	■	■
		Hexalobus crispiflorus		■		■		■	■	
		Uvariastrum germainii/pierreanum			■	■		■		
	Apocynaceae	*Tabernaemontana crassa*		■	■	■			■	
		Tabernaemontana penduliflora		■	■	■			■	
		Tabernaemontana spp.		■						■
FROMAGER*	Bombacaceae	*Ceiba pentandra*		■	■				■	
AIELE	Burseraceae	*Canarium schweinfurthii*	■					■		
		Dacryodes buttneri					■	■		
		Dacryodes normandii						■		
		Santiria trimera	■	■	■	■	■	■		■
DOUSSIÉ	Caesalpiniaceae	*Afzelia bipindensis*		■						
EBIARA*		*Berlinia* spp.						■	■	
ETIMOÉ		*Copaifera mildbraedii*		■		■			■	
MAMBODÉ*		*Detarium macrocarpum*		■	■	■		■	■	
		Dialium lopense						■		
		Dialium spp.	■	■	■	■	■	■	■	■
MOVINGUI		*Distemonanthus benthamianus*						■		
TALI		*Erythrophleum ivorense/suaveolens*		■	■	■				
LIMBALI*		*Gilbertiodendron dewevrei*		■	■	■			■	
KEVAZINGO		*Guibourtia* spp.					■	■		
TCHITOLA		*Oxystigma oxyphyllum*							■	
	Clusiaceae	*Pentadesma butyracea*						■		
	Ebenaceae	*Diospyros dendo*			■			■		
		Diospyros ituriensis		■		■			■	■
		Diospyros polystemon						■		
	Euphorbiaceae	*Drypetes* spp.		■		■	■	■	■	■
		Uapaca guineensis						■	■	
	Flacourtiaceae	*Oncoba (Caloncoba) welwitschii*			■	■			■	
	Guttiferae	*Mammea africana*	■	■	■		■	■	■	
	Irvingiaceae	*Irvingia excelsa*		■		■			■	■
		Irvingia gabonensis	■		■		■	■	■	
		Irvingia grandifolia		■	■			■		
		Klainedoxa gabonensis		■	■	■	■	■	■	■
KANDA*	Lauraceae	*Beilschmiedia* spp.		■				■	■	■
IZOMBE	Luxemburgiaceae	*Testulea gabonensis*						■		

continued on next page

Timber Name	Family	Scientific Species Name	Field Site							
			Okorobiko, Guinea [a]	Goualougo, Congo [b]	Ndoki, Congo [c]	Mondika, Congo [d]	Belinga, Gabon [e]	Lope, Gabon [f,g]	Ndakan, C.A.R. [h]	Bai Hokou, C.A.R. [i]
SAPELLI	Meliaceae	*Entandrophragma cylindricum*								■
	Mimosaceae	*Parkia bicolor*						■		
		Parkia filicoidea						■		
DABÉMA*		*Piptadeniastrum africanum*						■		
		Tetrapleura tetraptera		■	■	■			■	■
AKO*	Moraceae	*Antiaris toxicaria*		■					■	
		Ficus spp.	■	■	■	■	■	■	■	■
IROKO		*Milicia (Chlorophora) excelsa*		■	■			■	■	■
		Myrianthus arboreus		■	■	■	■	■	■	
		Treculia africana		■	■	■		■	■	■
ILOMBA	Myristicaceae	*Pycnanthus angolensis*	■		■		■	■	■	
AZOBÉ	Ochnaceae	*Lophira alata*						■		
	Olacaceae	*Heisteria parvifolia*					■	■		
ANGUEUK*		*Ongokea gore*						■	■	
	Palmae	*Elaeis guineensis*						■		
LATI*	Papilionaceae	*Amphimas ferrugineus / pterocarpoides*							■	
		Angylocalyx pynaertii		■	■	■			■	
		Dalhousiea africana		■					■	
PADOUK		*Pterocarpus soyauxii*		■		■		■	■	■
	Passifloraceae	*Barteria dewevrei/fistulosa*				■		■	■	
BODIOA*	Rhizophoraceae	*Anopyxis klaineana*							■	
BILINGA	Rubiaceae	*Nauclea diderichii*	■	■	■	■	■	■	■	
	Sapindaceae	*Lecaniodiscus cupanoides*		■				■	■	
		Pancovia laurentii		■	■	■			■	
		Zanha golungensis		■				■		■
MUKULUNGU*	Sapotaceae	*Autranella congolensis*		■		■				
MOABI		*Baillonella toxisperma*					■	■		
		Chrysophyllum africana						■		
LONGHI ABAM*		*Chrysophyllum lacourtiana*	■	■	■	■	■		■	
LONGHI		*Chrysophyllum* spp.	■	■		■			■	
		Chrysophyllum subnudum						■		
		Manilkara mabokeensis		■		■				
	Scytopetalaceae	*Scytopetalum* spp.						■		
	Sterculiaceae	*Cola lizae*						■		
EYONG*		*Eribroma oblongum*		■					■	
KOTO		*Pterygota bequaertii*							■	
AYOUS		*Triplochiton scleroxylon*		■						
	Tiliaceae	*Duboscia macrocarpa*			■	■		■	■	■
		Duboscia spp.		■						■
		Grewia coriacea	■		■		■	■		
		Grewia spp.		■		■		■	■	
DIANIA GF*	Ulmaceae	*Celtis adolfi-friderici*		■	■	■			■	
OHIA*		*Celtis mildbraedii, C. zenkeri*		■	■	■			■	■
DIANIA PF*		*Celtis tessmannii*		■	■	■	■	■		
	Verbenaceae	*Vitex doniana or welwitschii*		■		■		■	■	

[a]Sabater Pi, 1979; [b]Morgan and Sanz, 2006; [c]Moutsambote *et al.* 1994; [d]Doran *et al.* 2002; [e]Tutin and Fernandez, 1985; [f]Tutin and Fernandez, 1993; [g]Williamson *et al.* 1990; [h]Fay 1997; [i]Remis *et al.* 2001

Contacts and Resources for Further Information

IUCN/SSC Primate Specialist Group, Section on Great Apes
http://www.primate-sg.org/
Email: sga_coordinator@conservation.org

Ape Populations, Environments, and Surveys (A.P.E.S.) Database
http://apes.eva.mpg.de
Email: apes@eva.mpg.de

Bushmeat Crisis Task Force (BCTF)
http://www.bushmeat.org/
Email: info@bushmeat.org

Occasional Papers of the IUCN Species Survival Commission

1. *Species Conservation Priorities in the Tropical Forests of Southeast Asia.* Edited by R.A. Mittermeier and W.R. Konstant, 1985, 58pp. (Out of print)
2. *Priorités en matière de conservation des espèces à Madagascar.* Edited by R.A. Mittermeier, L.H. Rakotovao, V. Randrianasolo, E.J. Sterling and D. Devitre, 1987, 167pp. (Out of print)
3. *Biology and Conservation of River Dolphins.* Edited by W.F. Perrin, R.K. Brownell, Zhou Kaiya and Liu Jiankang, 1989, 173pp. (Out of print)
4. *Rodents. A World Survey of Species of Conservation Concern.* Edited by W.Z. Lidicker, Jr., 1989, 60pp.
5. *The Conservation Biology of Tortoises.* Edited by I.R. Swingland and M.W. Klemens, 1989, 202pp. (Out of print)
6. *Biodiversity in Sub-Saharan Africa and its Islands: Conservation, Management, and Sustainable Use.* Compiled by Simon N. Stuart and Richard J. Adams, with a contribution from Martin D. Jenkins, 1991, 242pp.
7. *Polar Bears: Proceedings of the Tenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group,* 1991, 107pp.
8. *Conservation Biology of Lycaenidae (Butterflies).* Edited by T.R. New, 1993, 173pp. (Out of print)
9. *The Conservation Biology of Molluscs: Proceedings of a Symposium held at the 9th International Malacological Congress, Edinburgh, Scotland, 1986.* Edited by Alison Kay. Including a Status Report on Molluscan Diversity, written by Alison Kay, 1995, 81pp.
10. *Polar Bears: Proceedings of the Eleventh Working Meeting of the IUCN/SSC Polar Bear Specialist Group, January 25–28 1993, Copenhagen, Denmark*. Compiled and edited by Øystein Wiig, Erik W. Born and Gerald W. Garner, 1995, 192pp.
11. *African Elephant Database 1995.* M.Y. Said, R.N. Chunge, G.C. Craig, C.R. Thouless, R.F.W. Barnes and H.T. Dublin, 1995, 225pp.
12. *Assessing the Sustainability of Uses of Wild Species: Case Studies and Initial Assessment Procedure.* Edited by Robert and Christine Prescott-Allen, 1996, 135pp.
13. *Tecnicas para el Manejo del Guanaco [Techniques for the Management of the Guanaco].* Edited by Sylvia Puig, Chair of the South American Camelid Specialist Group, 1995, 231pp.
14. *Tourist Hunting in Tanzania.* Edited by N. Leader-Williams, J. A. Kayera and G. L. Overton, 1996, 138pp.
15. *Community-based Conservation in Tanzania.* Edited by N. Leader-Williams, J. A. Kayera and G.L. Overton, 1996, 226pp.
16. *The Live Bird Trade in Tanzania.* Edited by N. Leader-Williams and R.K. Tibanyenda, 1996, 129pp.
17. *Sturgeon Stocks and Caviar Trade Workshop.* Proceedings of a workshop held on 9–10 October 1995 Bonn, Germany by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Agency for Nature Conservation. Edited by Vadin J. Birstein, Andreas Bauer and Astrid Kaiser-Pohlmann. 1997, viii + 88pp.
18. *Manejo y Uso Sustentable de Pecaries en la Amazonia Peruana.* Richard Bodmer, Rolando Aquino, Pablo Puertas, Cesar Reyes, Tula Fang and Nicole Gottdenker, 1997, iv + 102pp.
19. *Proceedings of the Twelfth Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 3–7 February 1997, Oslo, Norway.* Compiled and edited by Andrew E. Derocher, Gerald W. Garner, Nicholas J. Lunn and Øystein Wiig, 1998, v + 159pp.
20. *Sharks and their Relatives - Ecology and Conservation.* Written and compiled by Merry Camhi, Sarah Fowler, John Musick, Amie Bräutigam and Sonja Fordham, 1998, iv + 39pp. (Also available in French)
21. *African Antelope Database 1998.* Compiled by Rod East and the IUCN/SSC Antelope Specialist Group, 1999, x + 434pp.
22. *African Elephant Database 1998.* R.F.W. Barnes, G.C. Craig, H.T. Dublin, G. Overton, W. Simons and C.R. Thouless, 1999, vi + 249pp.
23. *Biology and Conservation of Freshwater Cetaceans in Asia.* Edited by Randall R. Reeves, Brian D. Smith and Toshio Kasuya, 2000, viii + 152pp.
24. *Links between Biodiversity Conservation, Livelihoods and Food Security: The sustainable use of wild species for meat.* Edited by S.A. Mainka and M. Trivedi, 2002, ix + 137pp. (Also available in French)
25. *Elasmobranch Biodiversity, Conservation and Management. Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997.* Edited by Sarah L. Fowler, Tim M. Reed and Frances A. Dipper, 2002, xv + 258pp.
26. *Polar Bears: Proceedings of the Thirteenth Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 23–28 June 2001, Nuuk, Greenland.* Compiled and edited by N. J. Lunn, S. Schliebe and E. W. Born, 2002, viii + 153pp.
27. *Guidance for CITES Scientific Authorities: Checklist to assist in making non-detriment findings for Appendix II exports.* Compiled by A.R. Rosser and M.J. Haywood, 2002, xi + 146pp.
28. *Turning the Tide: The Eradication of Invasive Species. Proceedings of the International Conference on Eradication of Island Invasives.* Edited by C.R. Veitch and M.N. Clout, 2002, viii + 414pp.
29. *African Elephant Status Report 2002 : an update from the African Elephant Database.* J.J. Blanc, C.R. Thouless, J.A. Hart, H.T. Dublin, I. Douglas-Hamilton, C.G. Craig and R.F.W. Barnes, 2003, vi + 302pp.
30. *Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock and Human Health.* Compiled and edited by Steven A. Osofsky; Associate editors: Sarah Cleaveland, William B. Karesh, Michael D. Kock, Philip J. Nyhus, Lisa Starr and Angela Yang. 2005, xxxiii +220pp.
31. *The Status and Distribution of Freshwater Biodiversity in Eastern Africa.* Compiled by W. Darwall, K. Smith, T. Lower and J.-C. Vié, 2005, viii + 36pp.
32. *Polar Bears: Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group,20–24 June 2005, Seattle, Washington, USA.* Compiled and edited by Jon Aars, Nicholas J. Lunn and Andrew E. Derocher. 2006. v + 189pp.
33. *African Elephant Status Report 2007: An update from the African Elephant Database.* Compiled and edited by J.J. Blanc, R.F.W. Barnes, C.G. Craig, H.T. Dublin, C.R. Thouless, I. Douglas-Hamilton and J.A. Hart. 2007. vi + 275pp.

Many of these publications are available online at: www.iucn.org/themes/ssc/publications/thematic_pubs.htm

IUCN
The World Conservation Union

Rue Mauverney 28
1196 Gland
Switzerland

Tel +41 22 999 0000
Fax +41 22 999 0002
mail@iucn.org

www.iucn.org

World Headquarters