Photo: The overriding threat to the survival of apes is habitat loss. Forest destruction on Sumatra, Indonesia. © Ulet Ifansasti/Greenpeace

CHAPTER 7

Ape Populations over Time: Case Studies from Gombe, Mount Halimun Salak, Sabangau and Wamba

Introduction

Our understanding of how changes in ape habitats affect the status of apes is dependent on robust monitoring of population density and distribution as well as ape socioecology. This chapter presents four long-term case studies, selected to be representative of distinct taxa as well as very different contexts. The case studies examine specific sites more closely, to highlight the status of their resident ape communities and evaluate the threats they face as well as the conservation efforts to protect them:

- Bornean orangutans in the Sabangau Forest, Central Kalimantan, Indonesia;
- chimpanzees in Gombe Stream National Park, Tanzania;

- bonobos of Wamba, in the Luo Scientific Reserve, Democratic Republic of Congo (DRC); and
- silvery gibbons in Mount Halimun Salak National Park, Java, Indonesia.

The overriding threat to the survival of apes is habitat loss due to logging, extractive operations and agricultural expansion—especially for palm oil cultivation—followed by hunting and disease. As extensive tracts of forest across Africa and Southeast Asia are lost, the forest ecosystems are degraded or destroyed. Water tables fall, soil fertility decreases as runoff increases, and the canopy that provides shade for other plants as well as food and homes for forest animals is drastically diminished.

"The overriding threat to the survival of apes is habitat loss due to logging, extractive operations and agricultural expansion."

The four case studies that follow describe some of the threats to particular ape populations and the challenges facing their conservation, as well as some of the approaches that have been used to prevent habitat loss and degradation, and to protect the apes. The examined threats range from industrial agriculture and logging to civil unrest and poaching. Rather than covering the whole range of issues and responses to those issues, the case studies provide illustrative examples of some of the threats that affect apes and their habitats. They also highlight the value of long-term engagement that considers a broad geographic scale in different political and economic contexts. The Max Planck Institute is currently conducting a temporal analysis of the global trends in demographics of ape populations utilizing data provided in the IUCN SSC APES Database (International Union for Conservation of Nature; Species Survival Commission; Ape Populations, Environments and Surveys Database) (IUCN SSC, n.d.).

In the first case study, Husson *et al.* assess the impact of logging and industrial agriculture on a peat swamp forest in Central Kalimantan, Indonesia. The Bornean orangutans were forced out of part of their historic range when logging commenced in one section of the forest and clearing for agriculture put pressure on another area. Together, logging and agriculture destroyed and fragmented much of the forest habitat. The orangutans retreated from the noise, human disturbance and hunting pressure, which led to crowding in poorer-quality forest that was not able to provide enough food for the increased numbers of animals. These refugee populations came into conflict with resident orangutan populations, in part through competition over limited food resources. Hitherto, little was known about this "compression effect" on orangutan populations; this case study concludes that it was probably the primary cause of a 40% drop in orangutan numbers in the Sabangau area in 2000–1.

There is, however, some encouraging news about the adaptability and resilience of orangutans. In Sabangau, their numbers are on the rise again: orangutans are moving back to forests that are naturally regenerating, and preliminary evidence indicates that orangutan populations can recover over time, as long as they have not been impacted too severely and are left undisturbed. The study strongly supports the idea that, under certain conditions, previously logged forest can support viable orangutan populations; such areas should not simply be dismissed as degraded, as that designation can lead them to be selected for alternative land uses.

In the second case study, Pintea *et al.* look at population trends among the chimpanzees of Tanzania's Gombe Stream National Park. Data going back to the 1960s show that both the chimpanzees' range and numbers have changed significantly in the past five decades, depending on their proximity to or location in the park. Groups whose range is within the park's borders have suffered less decline than those who range in habitats that straddle the park boundary. This demonstrates not only that protected areas can offer conservation benefits, but also that there are limits to what such areas can do to ward off threats to forest habitats and, specifically, to apes. When conservation measures are not in place in the landscape surrounding the protected area, the pressures on natural resources—land, forest products and wildlife—build and potentially cause significant declines in ape numbers. While the park has afforded some protection, the surrounding areas have witnessed rapid changes in land use as people increasingly convert forest to cash-crop agriculture, extract firewood and charcoal, and expand settlements and infrastructure.

The third case study examines the conservation of bonobos in the DRC's Luo Scientific Reserve. The bonobos of Wamba are the focus of Furuichi's study, which uses data going back 40 years. Local people in the Luo area have long sustained a taboo against the hunting and eating of bonobos, but the wars and political and economic upheavals that have plagued the DRC over the past two decades have led to in-migration and associated pressures that have altered local practices. Specifically, changes such as the presence of military and weaponry, as well as the settlement of populations for whom no such taboo exists, have resulted in an increase in hunting. Although bonobos are not deliberately hunted, they can fall victim to illegal snares set for other wildlife, which can result in injury or death. This case study—which is based on a research program that involves long-term community support—highlights the challenges of balancing conservation and the needs of people.

Finally, in the fourth case study, Nijman's review of research on silvery gibbons in Java's Mount Halimun Salak National Park highlights the gaps in our knowledge of many ape species and populations, and particularly gibbons. This study demonstrates the importance of research and the use of consistent survey methods, as well as the sharing of data in a way that makes comparison and the detection of trends possible. Although a number of silvery gibbon population surveys have been undertaken in the park over the past 30 years, a lack of comparability across the studies—due largely to the use of different survey methodologies as well as varying temporal and geographic focuses—has precluded accurate estimates of population size, density and changes over time. What is certain, however, is that the extent of forest habitat in Halimun Salak decreased by about 2% per year—or by a total of around 200 km^2 (20,000 ha)—between 1989 and 2004. Growing human populations, competition for resources in a region of high economic growth and corruption in key ministries, including those that oversee forestry and conservation, translate into an urgent need for improved and sustained research and intervention.

The four case studies support broader conclusions from ape conservation efforts across Africa and Southeast Asia, such as the following:

- Habitat loss, hunting and disease remain the main threats to ape survival in both Africa and Southeast Asia. The pressures vary, but underlying them in all landscapes is the push for development. In much of Africa, the threats are primarily driven by forest clearance for industrial and subsistence agriculture, as well as to accommodate the expanding human population. In other areas, they are linked to extractive industries, energy production, infrastructure and other impacts of economic and social development.
- Additional drivers of threats in many contexts come from political and state forces. Among them are politicians who advocate land development in advance of elections and armed forces that boost demand for meat from the hunting and trafficking of wildlife.
- Long interbirth intervals mean that ape populations are slow to recover, making them particularly vulnerable to even small drops in population size. Evidence indicates that certain species are able to

"Long inter-birth intervals mean that ape populations are slow to recover, making them particularly vulnerable to even small drops in population size."

Photo: Widespread forest clearance for industrial plantations, cultivation for food, mining, infrastructure and rural development, combined with illegal logging, fire and hunting, has dramatically reduced numbers of the endangered Bornean orangutan. © HUTAN Kinabatangan Orang-utan Conservation Project

adapt to some extent to disruption and loss of habitat, as long as the forest is left to regenerate at the end of the planned economic activity. While research shows that some orangutans have adapted in such cases, this finding does not necessarily apply to other ape taxa with different social and ranging habits.

- Long-term research is invaluable to the monitoring of change in ape habitat and populations, and to the design of appropriate conservation interventions. In the case studies where researchers are able to analyze data dating back several decades, it is possible to develop evidence-based recommendations to scale. Wherever monitoring is patchy, inconsistent or interrupted for long periods—such as with respect to the silvery gibbons discussed in the final case study—the knowledge base is correspondingly inadequate, which seriously complicates efforts to design effective interventions.
- Variations in survey methods make it difficult to compare findings, extrapolate results and make predictions. If the scope of studies varies significantly in terms of the temporal and geographic focus, or if potentially important habitats have been ignored, it is difficult to draw accurate conclusions concerning ape numbers, densities and population trends.
- High-intensity logging can result in crowding of apes in small forest refuges. Crowding has been a greater driver of declines in their numbers than simply the reduction in food availability or the increase in hunting pressure.
- Well-managed, low-intensity logging has far less of an impact on apes than uncontrolled, high-intensity logging. The speed and intensity of tree removal affect their survival more than the volume of trees removed.
- Previously logged forests can support healthy ape populations, depending on the species. They should not be dismissed as degraded and thereby designated for alternative land uses.
- The permanent or regular presence of people working in a forest for conservation purposes—including scientific researchers, forest monitoring patrols and local communities that manage the forest sustainably—contributes significantly to its protection.

Bornean Orangutans in the Sabangau Peat Swamp Forest

Context and Background

Widespread forest clearance for industrial plantations, cultivation for food, mining, infrastructure and rural development, combined with illegal logging, fire and hunting, has dramatically reduced numbers of the endangered Bornean orangutan, *Pongo pygmaeus* (Rijksen and Meijaard, 1999; Singleton *et al.*, 2004; Wich *et al.*, 2008; Husson *et al.*, 2009). The most recent population estimate, from 2004, counts at least 54,000 Bornean orangutans (Singleton *et al.*, 2004); that number is likely to have declined significantly in the past decade, owing to ongoing forest loss on Borneo, where the forest extent is shrinking by an estimated 10% every five years (Wich *et al.*, 2008). The best habitat is found in sites with a mosaic of habitat types, for example the alluvial–peatland–dryland forest mosaic of Mount Palung National Park, in West Kalimantan, where the highest Bornean orangutan densities have been recorded (Johnson *et al.*, 2005; Husson *et al.*, 2009). These ideal conditions are rare, however, following decades of conversion of the most fertile habitats in Borneo. Over time, peat swamp forests have assumed the role of the most important habitat for conservation in the 21st century, despite

their relatively low productivity and moderate orangutan densities (Cannon *et al.*, 2007; Husson *et al.*, 2009).

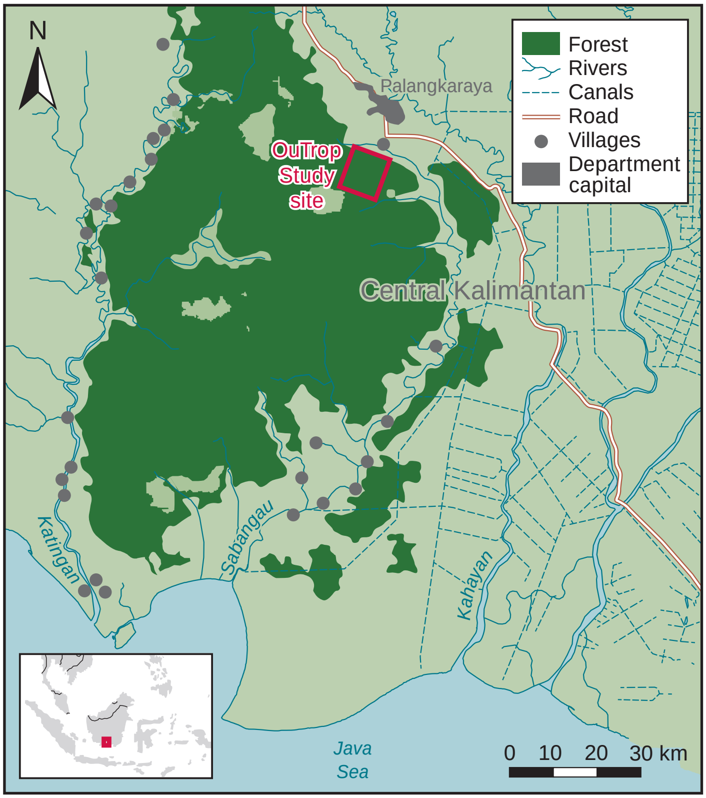
Five of the eight largest orangutan populations are found in peat swamp (Singleton *et al.*, 2004). Ongoing agricultural development places these populations at risk; by 2006, 45% of Southeast Asia's peat swamp forests had been deforested, primarily for oil palm plantations (Hooijer *et al.*, 2006). Today, a strong international focus and financial commitment to protect carbon-rich peat soils provide hope for the protection of Indonesia's peatlands (Murray, Lubowski and Sohngen, 2009; Solheim and Natalegawa, 2010).

The Sabangau Forest, which supports the biggest population of the Bornean orangutan, is the largest remaining peat swamp forest on Borneo (Morrogh-Bernard *et al.*, 2003; Wich *et al.*, 2008). The Sabangau catchment covered a total of 9,200 km^2 (920,000 ha) between the Kahayan and Katingan rivers in Central Kalimantan prior to 1995 (see Figure 7.1). The largely forested area was designated for logging under the Indonesian concession system, whereby only permit-holding companies could remove timber of a specified size and species for a limited period of time.

The situation began to change in 1996, when the eastern catchment was designated for conversion as part of the disastrous 10,000 km^2 (1 million-ha) agricultural scheme known as the Mega Rice Project (Notohadiprawiro, 1998). By 2007, widespread drainage and fires had destroyed all but 670 km^2 of the original 2,300 km^2 (67,000 of 230,000 ha) of forest (Cattau, Husson and Cheyne, 2014). In the western catchment, the logging concessions began to expire in 1997, but although the law mandated a set-aside period, a massive wave of organized, indiscriminate illegal logging started (Currey *et al.*, 2001). Uncontrolled deforestation continued until

FIGURE 7.1

The Sabangau Catchment between the Kahayan and Katingan Rivers, Central Kalimantan, Indonesia



Note: Forest cover is from 2007.

Courtesy of OuTrop

2004–5, when the government—supported by non-governmental organizations (NGOs) with a conservation focus—implemented direct action to halt it, following the designation of 5,780 km² (578,000 ha) as the Sabangau National Park (Cattau *et al.*, 2014).

Little is known about the impact of logging on orangutans, other than that densities are predictably lower in logged compared to unlogged forests (Davies, 1986; Felton *et al.*, 2003; Husson *et al.*, 2009). If persistent hunting occurs at the same time as logging, however, the effects of hunting can outweigh those of logging (Marshall *et al.*, 2006). While only a handful of studies have assessed post-logging orangutan behavior, they do provide evidence that orangutans rest less, travel more and feed on lower-quality foods in logged compared to unlogged forests (Rao and van Schaik, 1997; Hardus *et al.*, 2012; Morrogh-Bernard *et al.*, 2014); all of these behavioral changes have a negative impact on an orangutan's energy balance. Research has shown that orangutans move away from sites that are being actively logged and crowd into unlogged areas (MacKinnon, 1974; Rijksen and Meijaard, 1999; Morrogh-Bernard *et al.*, 2003); to date, the long-term consequences of such overcrowding are not well understood.

This case study uses the results of the first 15 years of ongoing research on orangutan densities to assess the impacts of illegal logging on resident orangutans. In particular, it examines why the population declined by focusing on the impact of a prolonged period of logging-induced refugee crowding—also known as the compression effect—and it describes what has happened in the ten years since logging stopped.

Methodology and Results

The research for this case study was carried out as part of a multi-disciplinary research project that is jointly run by the Orangutan Tropical Peatland Project (OuTrop) and the Centre for International Cooperation in Sustainable Management of Tropical Peatlands (CIMTROP) in the Natural Laboratory for the Study of Peat Swamp Forest—an area covering roughly 500 km² (50,000 ha) in the western Sabangau River catchment, in Central Kalimantan. Since 1998, the University of Palangkaraya has managed this integral part of the larger Sabangau Forest for research purposes.

The entire study area is tropical rainforest standing atop a dome of peat whose depth ranges from 0.8 m to 13 m and whose radius is about 15 km. This forest is classified into three major habitat sub-types based on tree species composition and forest structure (Shepherd, Rieley and Page, 1997; Page *et al.*, 1999). Each sub-type occupies a distinct zone along a gradient of peat depth and increasing distance from the river (see Figure 7.2A), as follows:

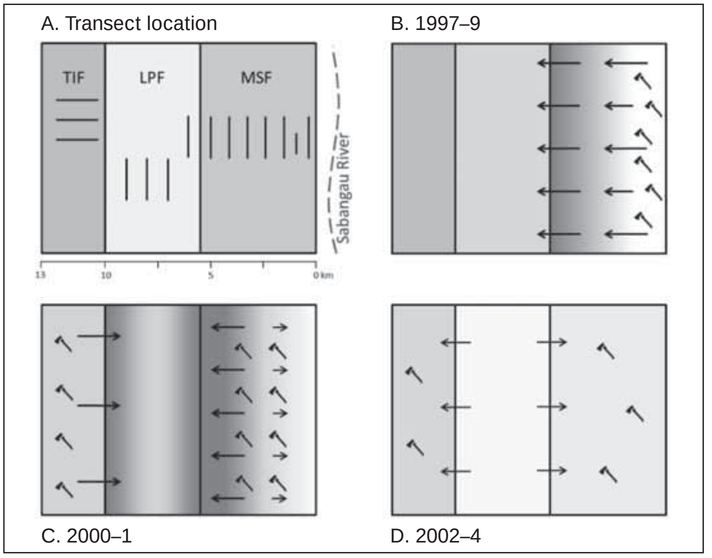
- **Mixed peat swamp forest (MSF):** This diverse sub-type, characterized by a large quantity of commercial timber trees, is found on the shallowest peat in the region, from the limits of river flooding to 5.5 km inland from the forest edge. The study divides mixed peat swamp forest into two regions: the perimeter (0–2.5 km from the forest edge) and the interior (2.5–5.5 km from the forest edge) because of markedly different logging patterns between these two regions.
- **Low pole forest (LPF):** Relatively stunted and depauperate, these areas are found 5.5–10 km from the forest edge on peat that is 6–10 m deep; they have few trees of commercial timber size.
- **Tall interior forest (TIF):** Productive and diverse, these areas crown the top of the dome on peat that is 10–13 m thick; they have many commercial timber trees.

Orangutan densities have been estimated for each habitat type on an annual basis since 1999, based on local surveys of their sleeping platforms, or "nests," along permanent straight-line transects using standard survey methods and nest parameters (van Schaik, Azwar and Priatna, 1995; Husson *et al.*, 2009). Obtaining accurate orangutan densities from nest surveys is not straightforward (Husson *et al.*, 2009; Marshall and Meijaard, 2009; Wich and Boyko, 2011); nevertheless, nest counts are favored when time or resources are limited and are especially useful for identifying population trends over time.

To identify annual changes and trends in population size, these density estimates were extrapolated across a sample area of 10 km × 13 km centered on the survey locations (see Figure 7.2A). Extrapolating across the entire Sabangau Forest is less reliable because of the very large size of the forest and difficulties in determining the extent of each habitat sub-type. Figures 7.2B–D show the changing locations of intensive logging and the subsequent movement of orangutans. Figure 7.3 charts annual orangutan densities for each habitat sub-type and the estimated annual population in the sample area; it includes data from 1996 that pre-date the illegal logging (Morrogh-Bernard *et al.*, 2003).

FIGURE 7.2

Shifts in Orangutan Distribution in Sabangau Forest, 1997–2004



Notes: LPF = low pole forest (stunted and depauperate); MSF = mixed peat swamp forest; TIF = tall interior forest (productive and diverse). Darker shading indicates higher orangutan density. Box A marks the location of each habitat sub-type and survey transects. Boxes B–D show areas of high-intensity logging (axe symbols) and the resulting movement of orangutans (arrows) during three time periods. In B (1997–9), illegal logging had started and was intense near the river, prompting orangutans to move inland, away from the disturbance. In C (2000–1), illegal logging had spread throughout the mixed peat swamp forest and reached the tall interior forest, causing orangutans to crowd into the low pole forest and transition zones. By D (2002–4), the orangutan population had crashed. Logging slowed down during this period and the surviving orangutans moved back to their preferred habitats.

Courtesy of OuTrop

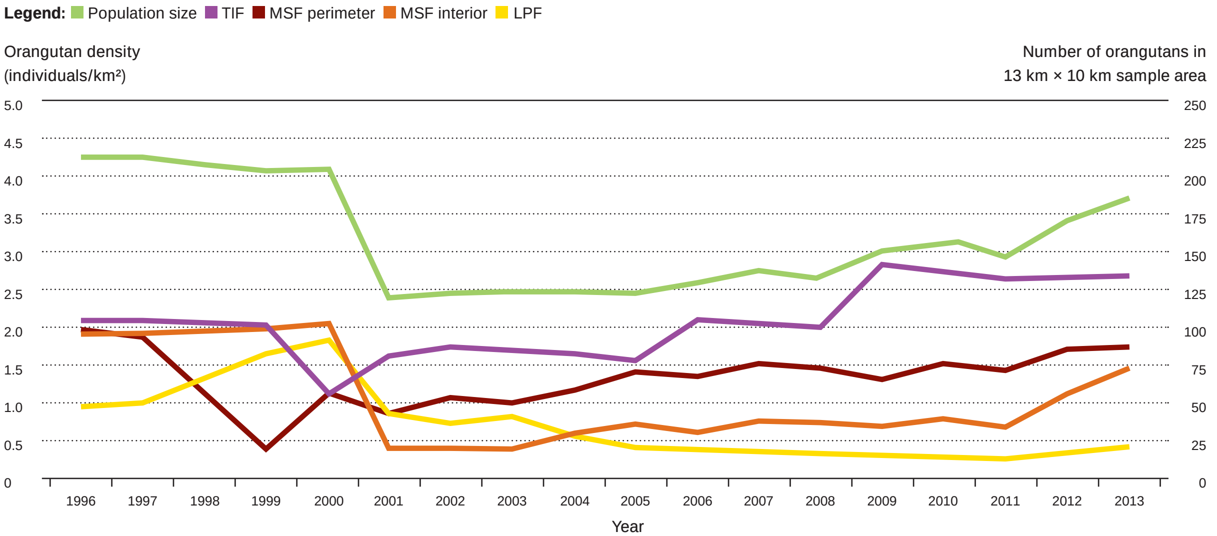
Discussion

The Orangutan Population of Sabangau and the Impact of Logging Disturbance

Early research identified Sabangau as home to the largest extant population of Bornean orangutans (Morrogh-Bernard *et al.*, 2003).

FIGURE 7.3

Orangutan Density in Each of the Three Habitat Sub-types and Population Size in the Sabangau Forest Sample Area, 1996–2013



Notes: LPF = low pole forest (stunted and depauperate); MSF = mixed peat swamp forest; TIF = tall interior forest (productive and diverse).

Courtesy of OuTrop

They were concentrated in two of the three main habitat sub-types: the expansive mixed peat swamp forest and the small area of tall interior forest, where they were found at moderate densities of about 2 individuals/km². The low-canopy, nutrient-poor low pole forest, which makes up about one-third of the total area of Sabangau, can support only very low orangutan densities (<1 individual/km²) and is clearly a sub-optimal habitat. Adult males use the low pole forests as a corridor between preferred habitats, and non-dominant or maturing individuals also use it during seasonal periods of higher than normal fruit production (Husson *et al.*, 2009).

No surveys were conducted prior to the start of commercial logging, so it is likely that the first density surveys underestimated the true potential of Sabangau in its pristine state. Nevertheless, the commercial logging of 1993–7 was of low intensity and carried out by a relatively small number of people who were only active in a small part of the forest at any one time, and who targeted a restricted number of tree species. The illegal logging epidemic that started in 1997, by contrast, involved large numbers of people who targeted all species of value, worked in independent groups, used environmentally damaging techniques and left very few refuge areas for orangutans. The tall interior forest in the study area was not reached until 2000, and the low pole forest has not been significantly affected. By 2003, most logging activity was deep inside the forest and was decreasing markedly, due to CIMTROP's anti-logging patrols and the significantly reduced volume of high-value timber left standing. In 2004, the cutting down of large timber was stopped completely in the study area and, by the following year, it had also been brought to a halt throughout most of the western Sabangau catchment.

An orangutan's initial response to logging is to move away from human presence and the noise of chainsaws and falling trees (MacKinnon, 1974). Such movement is easier for the wide-ranging adult males, whereas adult females have stable home ranges, which they appear incredibly reluctant to leave (Husson *et al.*, 2009; Singleton *et al.*, 2009). Female orangutan ranges can exceed 2.5 km^2 (250 ha) (Singleton *et al.*, 2009); this may allow the apes to escape logging by making biased use of their range. The mass movement of male and female orangutans into unlogged areas results in refugee crowding, particularly if other orangutans are already resident in these areas (Rijksen and Meijaard, 1999). The dramatic drop in densities in the mixed peat swamp forest perimeter between 1996 and 1999, and the corresponding rise in the unlogged low pole forest—while overall population numbers remained stable—is clear evidence of this dynamic.

A behavioral study that was carried out in Sabangau immediately after logging ended shows that orangutans made selective use of their habitat by seeking out areas where tall trees were still standing and by avoiding the most damaged areas (Morrogh-Bernard *et al.*, 2014). The more logged an area was, the less frugivorous was their diet and the more time they spent traveling. This negative impact on their energy balance is presumably the reason for lower population densities in logged forest (Davies, 1986; Rao and van Schaik, 1997; Felton *et al.*, 2003; Husson *et al.*, 2009; Hardus *et al.*, 2012; Morrogh-Bernard *et al.*, 2014). Orangutans demonstrate a high degree of dietary flexibility and can maintain their pre-logging densities in lightly logged or well-managed concessions (Meijaard *et al.*, 2005; Ancrenaz *et al.*, 2010). In Sabangau, however, a highly intense period of logging led to a sudden and dramatic population crash.

Timeline of a Population Crash

The population crash between 2000 and 2001 was preceded by massive shifts in orangutan distribution, as shown in Figures 7.2 and 7.3. Illegal logging started in the mixed peat swamp forest perimeter in 1997–8 and led orangutans to move deeper into the forest, away from the disturbance. By 1999 orangutan density here had declined to one-fifth of its 1996 level, which led to knock-on effects throughout the mixed peat swamp forest; a large number of orangutans were displaced into the sub-optimal low pole forest habitat as competition for resources in the mixed peat swamp forest interior increased. In late 1999, loggers reached the tall interior forest, displacing more orangutans into the low pole forest. Orangutan density in the tall interior forest was halved from 1999 to 2000 and their density in the low pole forest during that time was the greatest ever recorded.

Despite these massive shifts in distribution, orangutan numbers remained constant during this period. Many were now concentrated in the low pole forest and the mixed peat swamp–low pole forest transition zone, which, by late 2000, was the only part of the forest that remained unaffected by illegal logging. This area was acting as a refuge for displaced orangutans, and the crowded population was inevitably overshooting the carrying capacity of this habitat. In 2001, densities in both low pole forest and the mixed peat swamp forest interior declined sharply; the researchers estimated that approximately 40% of the orangutan population died during this short period. They concluded that refugee crowding in this zone had led to starvation for many members of the resident population, as well as for the displaced apes. Refugee crowding caused by high-intensity logging appears to have superseded the direct effects of reduced food availability in logged forest—as well as secondary effects such as hunting—as the main reason for orangutan population decline in Sabangau.

This finding has important implications for forestry management. It is apparent that well-managed, low intensity logging has far less impact on orangutans than uncontrolled, high-intensity logging (Husson *et al.*, 2009; Ancrenaz *et al.*, 2010); in fact, orangutan densities in unlogged areas do not differ significantly from those in sustainably logged areas in Sabah (Ancrenaz *et al.*, 2005). By providing clear evidence that refugee crowding caused a population crash, the study demonstrates that in determining the impact of logging on orangutans, what matters is not necessarily the volume of timber removed within certain limits, but rather the speed and manner with which it is removed.

Population Recovery after Logging

> Fire remains the greatest threat to the forest in Sabangau, as it is a quick, albeit illegal, way to clear land for agriculture.

Only after the cessation of illegal logging in 2004 did orangutan densities return to their original rank order by habitat type: primarily tall interior forest, followed by mixed peat swamp forest and then low pole forest. At this stage, the surviving orangutan population was probably living at densities below the carrying capacity of the logged habitat, which, together with natural forest regeneration, made population growth possible. Rapid growth is not expected, as orangutans have a very slow life history, with first reproduction at 15 years of age and a 6–9-year interbirth interval (Wich *et al.*, 2009a); see the Socioecology section, page xv). A slow but steady increase in orangutan density and population size has been recorded during the ten years since the logging stopped. The researchers conclude that this is primarily the result of reproduction but also partly due to net immigration of mature males as a result of continued forest shrinkage at the landscape level. Densities have increased at a faster rate in the best habitat sub-types, and there has been no evident increase in the low pole forest.

Based on nest density surveys conducted in this small sample area, the overall population declined from 212 in 1996 to 119 at its nadir, in 2001, before recovering to 185 in 2013. The ongoing population growth indicates that orangutan densities can return to pre-logging levels if left alone to recover. This finding supports the conclusion of an earlier survey, which found that orangutan densities in a forest that had been logged 22 years prior to the study were not significantly lower than those in an unlogged forest nearby (Knop, Ward and Wich, 2004). This research underscores the abovementioned point, namely that previously logged forests can support healthy orangutan populations and should not be dismissed as degraded or designated for alternative land uses (Meijaard *et al.*, 2005).

Sabangau at the Landscape Level

If the pattern of refugee crowding and the resultant die-off described above actually occurred throughout the Sabangau Forest—and illegal logging was indeed present throughout—then, based on a crude analysis of the area of each habitat sub-type, it may be assumed that the population was roughly halved, from about 8,700 orangutans before the crash to around 4,800 thereafter.

Of course this only tells one part of the story. Although orangutan populations have been recovering since the logging ended, the area of remaining habitat continues to shrink at the landscape level. The national park's boundary is neither clearly defined nor well known locally, and it is often willfully ignored or rejected. Almost 1,000 km^2 (100,000 ha) of forest has been lost in fires since 1997, and forest continues to be lost at the margins. Forest loss is driven by human population growth—primarily by the development of settlements and agricultural smallholdings—as well as by the expansion of transport networks and local demand for products such as scaffolding timber and granite rocks. Fire remains the greatest threat to the forest in this area, however, as it is a quick, albeit illegal, way to clear land for agriculture.

This destruction is cyclical and progressive. As areas of heavily burned forest on the margins of settlements are no longer a priority for protection, they are soon claimed by people and developed. Regrowing shrubs are burned off and fire thus spreads deeper into the original forest. Newly acquired fields still flood in the wet season, so more drainage channels are cut, lowering dry-season water tables. Meanwhile, fire prevention and fire-fighting actions are woefully inadequate and underresourced, and law enforcement is virtually absent.

Analysis of Landsat images reveals that the total area of forest in the western catchment declined from 6,700 km² (670,000 ha) in 1991, to 5,500 km² (550,000 ha) in 2000, to 4,950 km² (495,000 ha) in 2007. The rate of loss has slowed since Sabangau was accorded formal protection in 2004, but it has not ceased. Researchers estimate that roughly 6,500 orangutans currently live in the western Sabangau catchment, based on 2013 density surveys and 2007 forest cover estimates. If the period 2007–13 had witnessed forest loss at the previously recorded rate, however, this number could have been as low as 5,800, which would have represented a decline of 15% since the last published estimate of 6,900 individuals in 2008 (Wich *et al.*, 2008).

It thus follows that if Sabangau and its orangutan population are to be protected effectively, encroachment, fires and logging must be halted. Even if these steps are taken, however, conservation efforts are complicated by the fragility and interconnectedness of the tropical peat swamp forest ecosystem. Tropical peatlands form under precise hydrologic and climatic conditions; they are very sensitive to changes at the interface between peat soils and the overlying forest, particularly with respect to hydrologic integrity and nutrient availability (Page *et al.*, 1999). Illegal logging has changed that balance, not least because the hundreds of timber-extraction channels are draining the peatland of its water. Draining one part of a peatland impacts the entire ecosystem, resulting in peat degradation and subsidence throughout, which in turn undermines mature trees and increases fire risk. Climate change is predicted to increase rainfall seasonality and cause drier dry seasons, further exacerbating the problem (Johnson, 2012).

Protecting Sabangau is thus a daunting task, but the forest's global importance as a carbon store and for biodiversity conservation makes this task essential. Effective conservation will require significant and costly peatland rehabilitation and restoration work in order to slow, halt and eventually reverse the effects of drainage and peat degradation, together with improved protected-area management to prevent further encroachment and forest destruction. Many laudable efforts are under way, spearheaded by NGOs and community groups, but there is a need for much greater international attention and conservation action, at a much larger scale.

> "Draining one part of a peatland impacts the entire ecosystem, resulting in peat degradation and subsidence throughout."

The Chimpanzees of Gombe

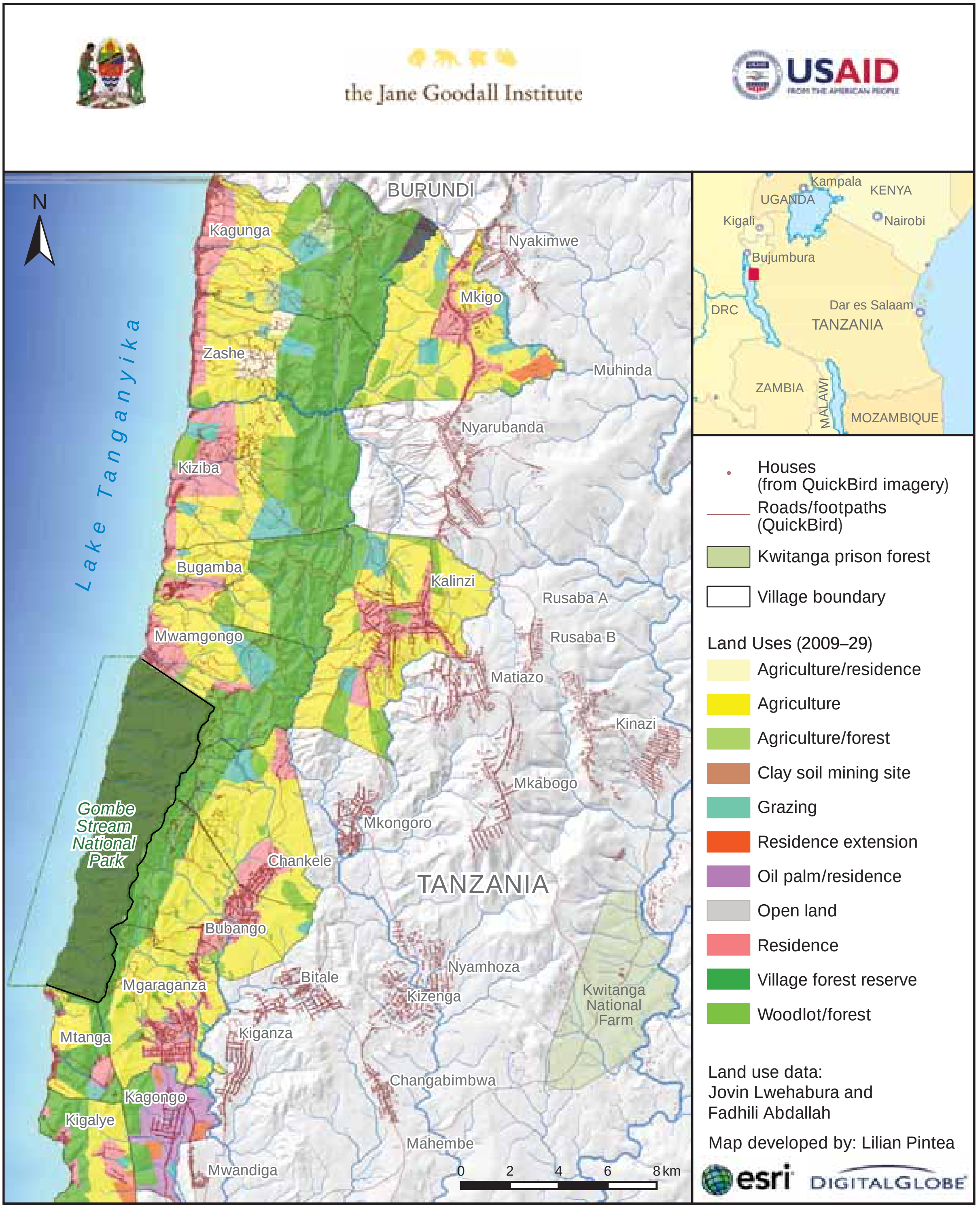
Context and Background

Gombe Stream National Park is on the eastern shore of Lake Tanganyika in the Kigoma region of western Tanzania (see Figure 7.4). Established in 1968 and covering a land area of 36 km² (3,569 ha), it was recently extended into the lake to cover an additional 20 km² (2,072 ha) of water. Although small, Gombe is rich in biodiversity, with a mosaic of evergreen and semi-deciduous forests, dense woodlands, open woodlands including Zambesian miombo, grasslands with scattered trees, and upper ridge grasslands with rocks along the crest of the rift escarpment (Goodall, 1986; Collins and McGrew, 1988).

Gombe is the longest continuously running great ape research site in the world. Jane Goodall's studies of wild chimpanzees (*Pan troglodytes schweinfurthii*) began in 1960, focusing on the central Kasekela community. The park also contains two other chimpanzee communities, Mitumba in the north and Kalande in the south. Between

FIGURE 7.4

Gombe Stream National Park and Village Land Use Plans in the Greater Gombe Ecosystem



Courtesy of JGI

1972 and 1978, the park was home to the Kahama community, which had split from the Kasekela community in the early 1970s. The park also had a Rift community in the 1960s. Figure 7.5 shows current and historic chimpanzee communities' home ranges and habitat change between 1972 and 2012.

Habituation of the chimpanzees in the Mitumba community did not start until 1985 because of concerns that it would put them at risk of poaching when they ranged outside the park. Full habituation to human observers was achieved in 1994. The Kalande community has been monitored since 1999, but it remains unhabituated to close observation.

Methodology

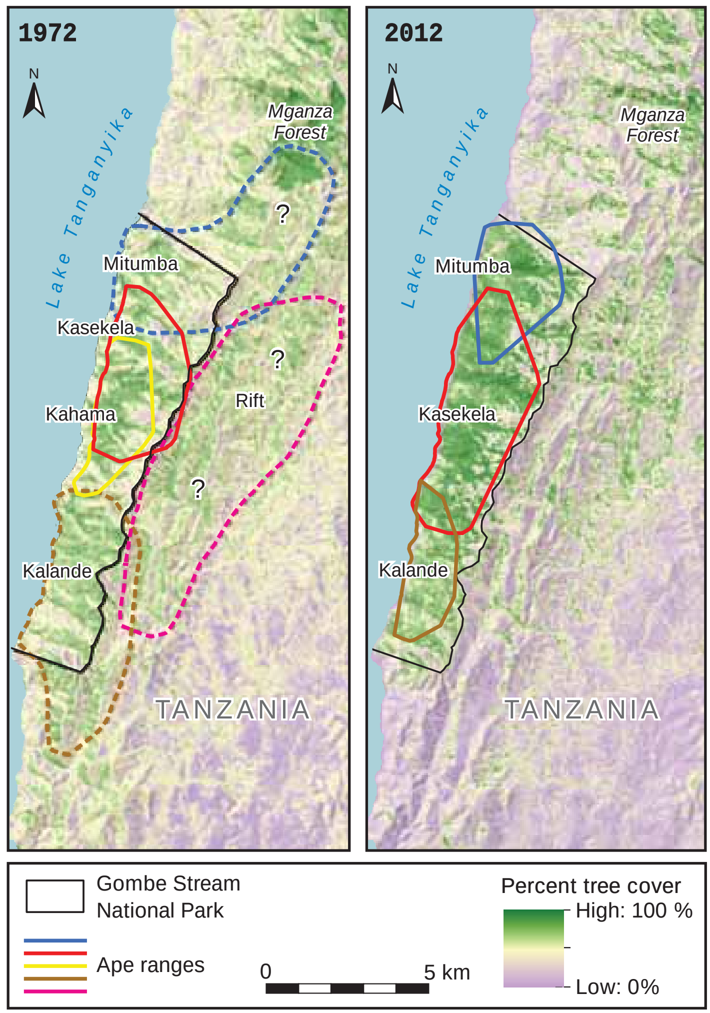
Population estimates for habituated Kahama, Kasekela and Mitumba chimpanzee communities are based on direct observations. Mitumba community population estimates for the years after 1994 are more reliable, as the apes were fully habituated to human observers by then. Kalande community numbers since 2002 are based on occasional sightings of individuals, genetic monitoring of fecal samples with microsatellites, and extrapolation from the immigrants to Kasekela and the number of bodies found dead from disease, intergroup aggression and poaching (Pusey *et al.*, 2007; Rudicell *et al.*, 2010).

Territorial ranges of habituated Kasekela and Mitumba chimpanzees have been estimated by using geographic information systems (GIS) and by drawing a polygon enclosing 99% of 1973–2004 and 2012–13 location points (Williams *et al.*, 2002). The 1973 Kalande and Mitumba community ranges are estimates based on incidental observations of chimpanzees inside and outside the park. The existence and location of the Rift community is based on a small number of reported sightings that indicated there was a community east of the Rift in the 1960s (Pusey *et al.*, 2007; J. Goodall, personal communication, 2014; see Figure 7.5). The 2004 and 2013 Kalande community ranges were estimated based on incidental sightings.

Chimpanzee habitat monitoring includes analyses of remote sensing data from as early as 1947, using a combination of historical aerial photos and medium- and high-resolution

FIGURE 7.5

Historic and Current Chimpanzee Home Ranges and Habitat Change



Notes: The tree canopy cover is estimated using Landsat Multispectral Scanner imagery for 1972 (Pintea, 2007) and Landsat Thematic Mapper and Enhanced Thematic Mapper Plus imagery for 2012 (Hansen *et al.*, 2013). Historic chimpanzee community home ranges are from 1973 (Pusey *et al.*, 2007). Current ranges for Kasekela and Mitumba cover 2012–13. The current Kalande range is from 2007, as estimated in Rudicell *et al.* (2010).

Courtesy of JGI

imagery acquired by Landsat, SPOT and other satellite programs (Pintea *et al.*, 2002). Since 2001, vegetation, human infrastructure and land use inside and outside of Gombe have been regularly monitored with very high-resolution satellite imagery (less than one meter) acquired from QuickBird, WorldView and Ikonos satellites (Pintea *et al.*, 2011).

Causes of Change in Population Size and Ranging Patterns

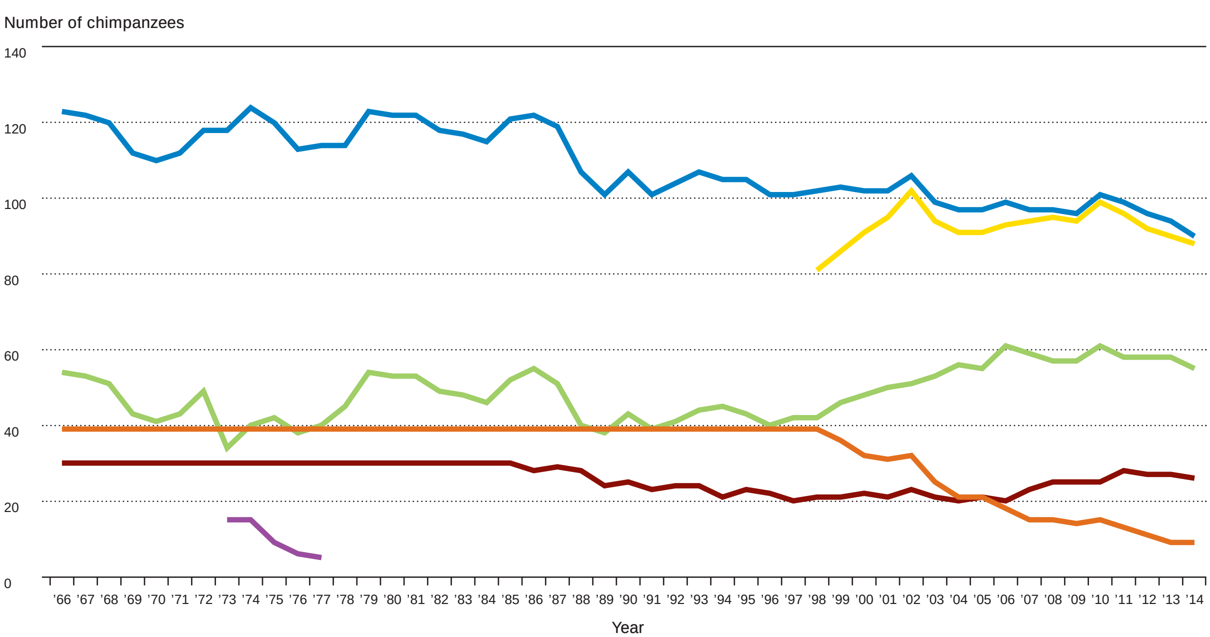
Chimpanzee numbers in Gombe have fallen from a peak of 120–125 at the end of the 1960s to approximately 90 in 2014 (Pusey *et al.*, 2007). In the early 1970s the Kasekela community split to form the offshoot Kahama community, which Kasekela community chimpanzees wiped out by 1978. In 1994, Gombe chimpanzee numbers stabilized at around 100 individuals, but by 2014 they had declined to 90 individuals. Recently, the Kasekela community experienced a drop, but with five births in 2014, some of this loss has been replaced. Numbers in the Mitumba community have remained relatively stable while the Kalande community has lost most of its members (see Figure 7.6).

Chimpanzee ranging patterns have also changed dramatically since 1960. For the past five decades, the Kasekela home range has been inside the park, but it has fluctuated and increased by 287%—from 5.4 km^2 (539 ha) in 1973 to 15.5 km^2 (1,549 ha) in 2004, and to 16 km^2 (1,600 ha) in 2013 (Pusey *et al.*, 2007; Pintea *et al.*, 2011). In contrast, Mitumba and Kalande community ranges, which covered habitats inside and outside the park, both suffered drastic decreases outside the protected area (see Figure 7.5). The Kalande range has also declined inside the park as a result of the expansion of the Kasekela range.

FIGURE 7.6

Community and Total Population Size (Full Counts) of Gombe Chimpanzees, 1966–2014

Legend: Kasekela, Kahama, Mitumba, Kalande (max.), Sum (min.), Sum (max.)



Courtesy of JGI

Causes of Population Changes

Habitat Change and Loss

Rising human populations are the main cause of deforestation in the Gombe region. In Kigoma region, human population density grew from an estimated 12.4 people/km^2 in 1967 to 17.1 in 1978, to 22.6 in 1988, 44 in 2002 and 57 in 2012 (Pintea *et al.*, 2011; L. Pintea, personal communication, 2015). Habitat within the park has remained relatively well protected, but the loss of forest and woodlands outside the park between 1972 and 1999—driven by rapid population growth and the influx of refugees who fled civil wars in Burundi and the DRC—has had a devastating effect on the park's chimpanzees (Pintea *et al.*, 2002, 2011; Pusey *et al.*, 2007).

There are three main causes of habitat change and loss:

- conversion of habitat to cash crops, such as oil palm, or food crops, such as beans, cassava and corn;
- extraction of firewood and charcoal production; and
- expansion of settlements and infrastructure development (JGI, 2009).

The Kasekela chimpanzees, located in the center of the park, have been the least affected by deforestation, however the Mitumba and Kalande communities have lost key food resources outside the park to agricultural conversion and settlements (see Figure 7.5).

Habitat changes inside the park have also affected chimpanzee communities unequally. Since 1972, because of fire control and protection in the Kasekela and Mitumba community ranges in the northern part of the park, tree canopy density and evergreen vines that contain important chimpanzee foods have increased in the forests and open woodlands on lower slopes (Pintea *et al.*, 2011). That growth is reflected in significant changes in the chimpanzees' diets. Adult Kasekela males dramatically increased their feeding time on forest species in 1997–2001 as compared to 1974–6, consuming the fruits of two vines, *Dictyophleba lucida* and *Saba comorensis* var. *florida*; meanwhile, they substantially reduced their feeding time on open woodland species, such as *Diplorhynchus condylocarpon* (Pintea *et al.*, 2011).

The vegetation in the southern Kalande range inside the park, which has changed the least, is dominated by deciduous miombo woodlands that are still frequently burned. Chimpanzees can live in a variety of vegetation types, from dry savannah woodlands and woodland–forest mosaics to humid-canopy rain forests (Teleki, 1989); in drier habitats, where food tends to be more scattered and fruiting occurs at different times, chimpanzees need larger home ranges (Kano, 1972; Baldwin, McGrew and Tutin, 1982; Moore, 1996; Pruetz *et al.*, 2002). The Kalande community probably suffered the most from habitat changes inside and especially outside the park because of the decrease in both their range size and habitat quality (Pintea *et al.*, 2011).

Disease

Disease is a leading cause of chimpanzee deaths in the Gombe Stream National Park (Goodall, 1986; Lonsdorf *et al.*, 2006; Pusey *et al.*, 2007; Rudicell *et al.*, 2010). Of 130 deaths among Kasekela chimpanzees between 1960 and 2006, 58% were due to illness (Williams *et al.*, 2008). Since researchers are not always able to find chimpanzee remains, they cannot systematically confirm causes of death and must often speculate as to the source of disease. One possible source of disease transmission to chimpanzees is human–chimpanzee interaction, which has been increasing both inside and outside the park (Leendertz *et al.*, 2006b). Moreover, Simian immunodeficiency viruses (SIVcpz) are present in Gombe; the discovery that they are pathogenic in chimpanzees suggests that disease may have had, and may continue to have, more devastating effects than previously expected (Keele *et al.*, 2009; Rudicell *et al.*, 2010).

Deliberate Killing by Humans

During more than five decades of study at Gombe, at least ten chimpanzees are known or suspected to have been killed by poachers (Pusey *et al.*, 2007). The Greater Gombe Ecosystem Conservation Action Plan (GGE–CAP) states that chimpanzees may be killed for a variety of reasons, including:

- to protect crops from crop raiding;
- to protect women and children from real or perceived threats, such as when they spend time in agricultural buffer zones or enter chimpanzee habitat to collect firewood and other natural resources;
- to retaliate when a chimpanzee shows signs of aggression toward a human, or to preempt such aggression;
- for fear that chimpanzees may transmit diseases to humans; and
- to prevent chimpanzee habitat from being co-opted as an extension of Gombe Stream National Park—a common fear that has its roots in the evictions that occurred when Gombe Stream Game Reserve was officially established in 1943.

Poaching for food or body parts has not been considered a major threat, although that could change with an influx of refugees from countries with other cultural traditions. Similarly, the killing of adult chimpanzees to obtain infants for sale is not a threat, but it may become one due to the increasing proximity between humans and habituated chimpanzees on land that is not protected or patrolled by Tanzania National Parks (TANAPA).

Intraspecific Aggression

Chimpanzees cooperate to attack and sometimes kill individuals in neighboring communities (Wrangham, 1999; Wilson *et al.*, 2014b). Intraspecific aggression accounted for 24% of male and 15% of female known deaths in the Kasekela community between 1960 and 2006 (Williams *et al.*, 2008). The Mitumba and Kalande communities, whose ranges previously extended beyond the edge of the park (see Figure 7.5), are especially vulnerable, at risk of being caught in a slowly closing trap of habitat loss, disease and poaching on one side, and increasing pressure from the more powerful Kasekela community on the other (Pusey *et al.*, 2007).

Reducing Threats

In 1994, the Jane Goodall Institute (JGI) began working with local communities outside Gombe Stream National Park through the Lake Tanganyika Catchment Reforestation and Education project, which aims to stop the rapid degradation of the area's natural resources. To promote community engagement in the conservation of the area —which is essential for the success of the conservation and development programs —agriculture, health, social infrastructure, community development and clean water provision were integrated into the project. These interventions initially focused on areas close to village centers, but remote sensing and spatial analysis using GIS from 1972, 1999 and 2003 showed that most habitat loss took place farther away from villages (Pintea *et al.*, 2002). Since 2005, conservation efforts have focused on forest patches that provide the most benefits to people and chimpanzees.

In 2006 JGI and its partners started a conservation action planning process for the Greater Gombe Ecosystem (JGI, 2009). As part of the process, stakeholders agreed on conservation objectives, prioritized strategies to abate the most important human threats and spatially delineated a core conservation area for protection and restoration. The core area was defined by mapping human structures, roads and footpaths from 60-cm QuickBird satellite images and by overlaying chimpanzee sightings outside the park, historical habitat distribution and steep slopes that are important to maintain watersheds and ecosystem services. JGI then facilitated village-by-village land use plans with communities that voluntarily set up village forest reserves in places that had been prioritized by the GGE–CAP. Six years later, in March 2015, key experts and stakeholders convened to undertake a systematic review of the GGE–CAP and its implementation, along with other plans in western Tanzania, using Open Standards for the practice of conservation (CMP, 2013). The participants reviewed information on changes in chimpanzee status and threats, identified future conservation needs and coordinated strategies to meet these needs.

Habitat Loss

The first iteration of the GGE–CAP identified village-level participatory land use planning as one of the most promising and cost-effective conservation strategies for addressing habitat loss and degradation and supporting natural vegetation regeneration outside the park (JGI, 2009). Between 2005

FIGURE 7.7

Natural Regeneration of Miombo Woodland in the Kigalye Village Forest Reserve, as Detected by 2005 and 2014 Satellite Imagery

Map data: Google, DigitalGlobe

and 2009, 13 local communities voluntarily assigned 97 km^2 (9,690 ha) as village forest reserves connected to Gombe (see Figure 7.4). JGI and its partners are now facilitating the establishment of community-based organizations (CBOs), developing by-laws and building local capacity to implement village land use plans to restore and manage village forest reserves. In 2006, initiatives to build village governments' capacity to patrol their own forests were put in place. Since 2005, village forest monitors have been patrolling these reserves using Android smartphones and tablets that are enabled with a Global Positioning System (GPS), as well as Open Data Kit software to facilitate mobile data collection.

> Deliberate killing remains a serious threat to the Gombe chimpanzees.

Natural regeneration of miombo woodlands can be seen in some village forest reserves using 2005 and 2014 DigitalGlobe satellite imagery on Google Earth (see Figure 7.7). Forest monitors have also recorded evidence that chimpanzees at least occasionally use forests outside the park; the largest number of nest sightings was recorded in 2014 in the village forest reserves close to the border with Burundi. This finding confirms that a northern community still exists outside Gombe and might be using habitats across Tanzania and Burundi's borders. Discussions are now taking place to examine the possibility of extending community forest management, land use planning, and forest restoration and monitoring approaches into Burundi to protect and restore habitats and connectivity across the national borders.

Disease

Conservation efforts have focused on tackling disease and combating transmission among Gombe's chimpanzees; they have also introduced measures to reduce the risk of disease transmission from humans to chimpanzees, including by:

- imposing a minimum observation distance for tourists and researchers;
- instituting a one-hour observation time for tourists;
- establishing a one-week quarantine for researchers;
- introducing a shift system to reduce the number of people in the park; and
- requiring a routine health check for researchers whenever they return from travels abroad.

A health-monitoring program asks researchers to record signs of chimpanzee illness on daily health sheets and to collect fecal samples for virology and parasitological studies from observation targets. By improving health infrastructure, hiring new staff to keep track of sick individuals, and carrying out more frequent health check-ups and training for JGI and TANAPA staff, disease management will be steadily improved.

Poaching

Deliberate killing remains a serious threat to the Gombe chimpanzees. The fact that the Kalande community—which has not been habituated to human observers—was more severely affected by poaching than the Mitumba and Kasekela communities suggests that the presence of researchers and rangers in the forest plays an important role in protecting chimpanzees; the continuation of the long-term study of Gombe's chimpanzees could therefore be seen as a potential strategy for safeguarding their survival. Participation of local people, such as forest monitors, is also critical to protecting Gombe's chimpanzees and conserving their habitat.

Specific Recommendations

Regular updating and reviews of conservation action plans and management plans enable the assessment of lessons learned by various stakeholders and representatives of different interest groups and highlight the impact of interventions to date. These steps allow for different stakeholders in the landscape to guide the strategic restoration and maintenance of the larger Greater Gombe Ecosystem for the benefit of biodiversity, natural resources and sustainable human livelihoods (JGI, 2009); they are also designed to help to improve strategies and actions for the next five years.

Further research is needed to assess and manage the risks associated with an increase in the rates of human–chimpanzee interactions. This will support the emphasis on law enforcement—raising awareness about the illegality of killing chimpanzees—and foster a stronger understanding of human–chimpanzee coexistence and effective methods of managing conflict.

It is critical to increase the ability of local communities and CBOs to implement village land use plans and to enhance the management of forest reserves. Empowering communities and decision-makers with respect to forest monitoring, through the use of appropriate technologies for remote environments, has been shown to be extremely effective. Numerous mobile, cloud and web-based mapping technologies are adaptable to low bandwidth environments.

The presence of researchers and rangers in the forest contributes to the protection of chimpanzees. Long-term research can thus be considered a tool in a more comprehensive conservation strategy. It is essential, however, that such studies also include and engage local forest monitors and communities.

The Bonobos of Wamba in the Luo Scientific Reserve, DRC

Context, Challenges and Background

In 1973, primatologist Takayoshi Kano travelled by bicycle through a vast area of the Congo Basin—then in a country known as Zaïre, but since 1997 as the DRC—looking for a suitable site to start ecological and behavioral studies of bonobos. It was a difficult mission, as bonobos had already disappeared from some areas. Eventually, he settled in Wamba village, where people welcomed him.

The people of Wamba traditionally believed that in the distant past, the youngest brother in a bonobo family that lived in the forest got tired of eating raw food. He roamed the forest alone, crying, and when god saw him, he helped him by giving him fire with which to cook food. He started eating cooked food and built a village. Wamba tradition holds that he was the ancestor of today's villagers; as a result, they respected bonobos as their brothers and never hunted or ate them. Bonobos thus had little fear of people, which proved to be a significant enabling factor in the development of Kano's research project.

"Empowering communities and decision-makers with respect to forest monitoring has been shown to be extremely effective."

Kano decided to send a student to the site to start a long-term research project, which has now continued for more than 40 years (Kano, 1992; Kano *et al.*, 1996; Furuichi *et al.*, 2012). For the first ten years, the taboo against eating bonobos was well observed; there was no suspected poaching until 1984, when a hunter from outside of Wamba killed a young adult male bonobo. In 1987, soldiers were sent to capture two or three baby bonobos, reportedly as a gift for a visiting dignitary. Spurred by these incidents, the research project, by then known as the Wamba Committee for Bonobo Research (WCBR), submitted a proposal to the Congolese Center for Research in Ecology and Forestry (CREF), and through cooperative efforts, the area was officially established as the Luo Scientific Reserve in 1992. The reserve covers 481 km^2 (48,100 ha) on both sides of the Luo (Maringa) River (see Figure 7.8).

Since the villagers' traditional respect for bonobos had helped the apes to survive, five human settlements were allowed to remain in the northern section of the Luo

Scientific Reserve. Traditional subsistence activities, such as hunting using traditional arrows or snares and rotational slash-and-burn cultivation for cassava and other crops, were also permitted to continue. The idea was to conserve and study bonobos by supporting the traditional coexistence between people and the bonobos.

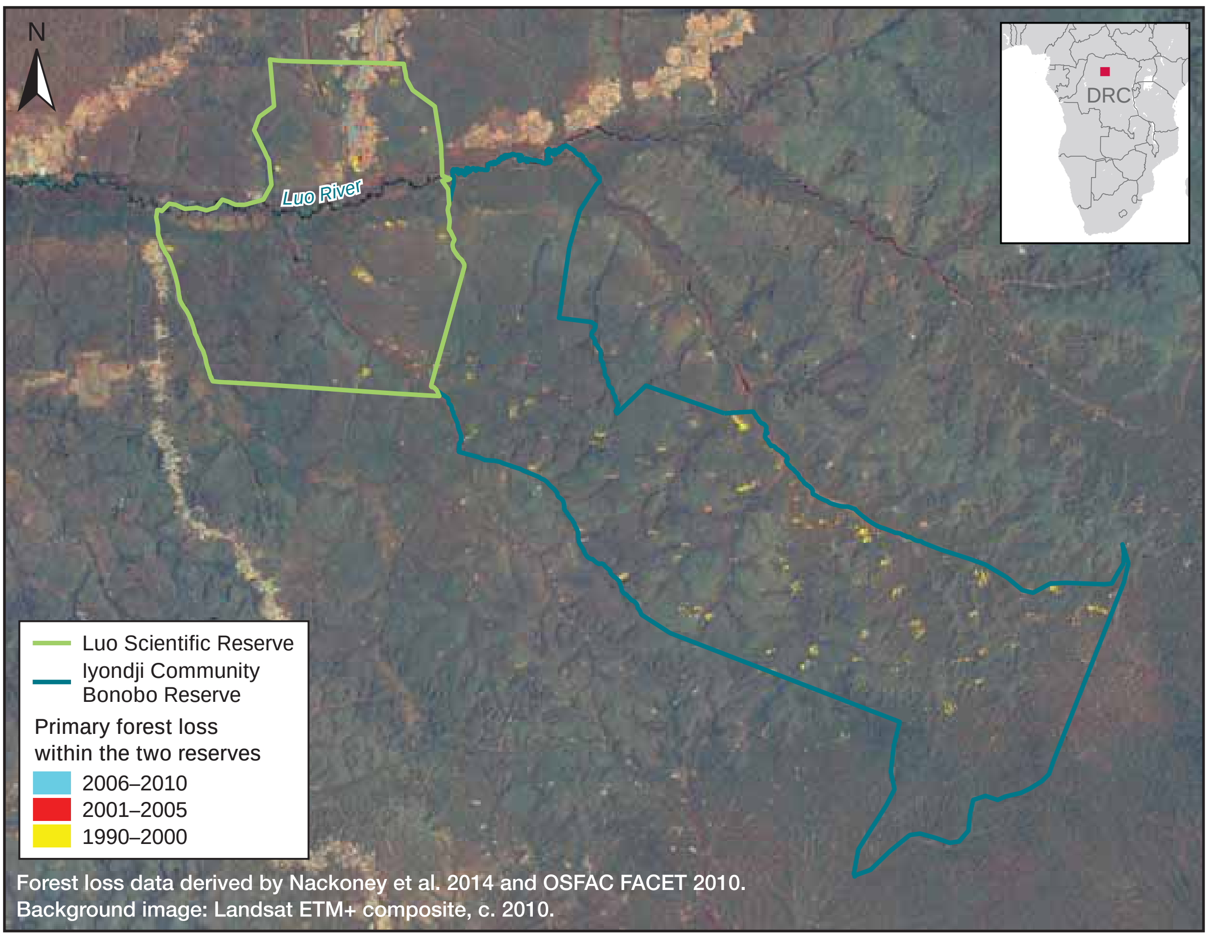
While the project was initially successful, reconciling the conservation of animals and their forest environment with the wellbeing of local people subsequently proved very difficult, particularly when adverse political and economic factors affected local conditions.

Methodology: Changes in the Number of Bonobos in the Reserve

Since the habituation of a group of bonobos known as the E1 group (then a subgroup of E group) in 1976, researchers have continuously observed their daily ranging from sleeping site to sleeping site. The E1 group ranges in the northern section of the reserve, which also includes human settlements. The number of bonobos in the group has been dramatically affected by changes in political and economic conditions (see Figure 7.9).

FIGURE 7.8

Primary Forest Loss in the Luo Scientific Reserve and Iyondji Community Bonobo Reserve, 1990–2010



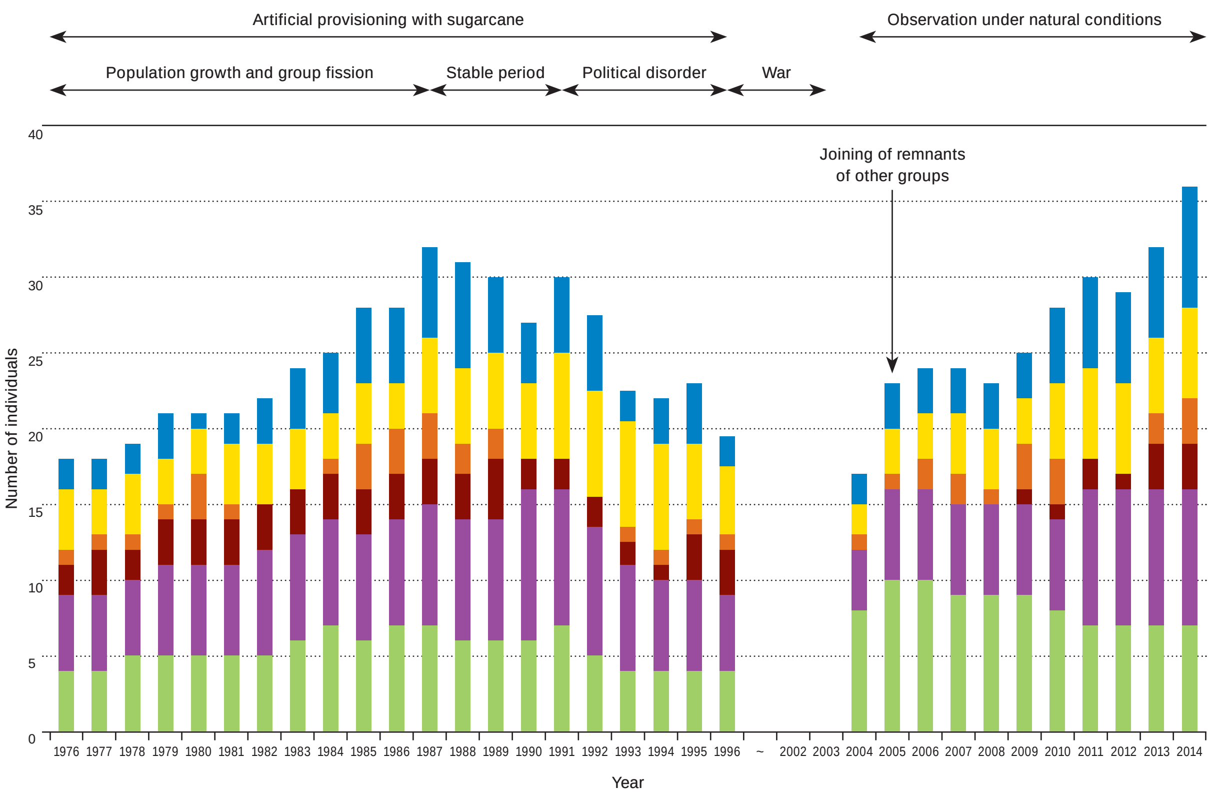
Data source: Nackoney *et al.* (2014)

Courtesy of Janet Nackoney

FIGURE 7.9

Changes in the Number of Bonobos in the E1 Group (Full Counts), 1976–2014

Legend: Adult males, Adult females, Adolescent males, Adolescent females, Infantile and juvenile males, Infantile and juvenile females



Courtesy of the Wamba Committee for Bonobo Research

Over the course of the first ten years of the project, when poaching pressure was low to non-existent, E1's population increased steadily. Between 1982 and 1983, the E group split into two independent subgroups, E1 and E2. Both groups expanded their ranging area and E1's population continued to increase until 1987. In 1991, however, E1's population began to decrease rapidly. Deteriorating political and economic conditions led to riots in the capital city, Kinshasa, and the Wamba researchers were forced to leave the country. While there is no confirmed information on exactly what happened in Wamba during this period, some people reportedly began to hunt and eat bonobos. They may have abandoned their taboo against killing bonobos due to severe economic conditions, or, if they had returned to Wamba from the capital to escape the unrest, they may have forgotten or dismissed the taboo. The researchers returned in 1994, but the number of bonobos continued to decrease until 1996, when civil war broke out in the DRC.

During the two periods of war in the DRC—1996–8 and 1998–2003—researchers could do no more than to provide assistance to the bonobo sanctuary in Kinshasa, which founder Claudine André-Minesi had named Lola ya Bonobo. Fearing that logging companies would resume their activities as soon as the war was over, which could have resulted in the extermination of bonobos in many areas, researchers visited Wamba with the support of National Geographic in 2002, when the war appeared to be ending, and resumed their studies immediately following the cease-fire in 2003.

While relieved to find that E1 group numbers had not decreased significantly during the war, the research team eventually discovered that three of the six bonobo groups that had been in the northern section of the Luo Scientific Reserve before the war had disappeared. The total number of bonobos in the northern section had decreased from approximately 250 in 1986 to approximately 100 in 2004. The research team set out to find out what had caused this decrease in the number of groups—and in the total number of bonobos—without seriously affecting the numbers of the main study group.

Perforated Forest: A Stealthy Influence of War

The Wamba researchers assumed that the main cause of the loss of bonobos during the war had been hunting, especially by, or on the orders of, soldiers. Many of the soldiers deployed in the Luo Scientific Reserve were from other areas of the country and did not share the taboo against killing and eating bonobos. In fact, one of the study team's original research assistants was repeatedly ordered by soldiers to guide them to the E1 group's sleeping sites. Although he intentionally guided them to the wrong sites several times, he was finally forced to guide them to a sleeping site after they threatened to kill him.

Local people may also have hunted bonobos, to eat or to sell the meat, as a means of surviving the war. When researchers first visited Wamba after the war, government soldiers were still deployed there, using the research camp as headquarters. Although there was no actual fighting in the Wamba area, the people said that they sometimes fled deep into the forest for fear of the nearby fighting and harassment by government soldiers. Some people had small houses and cassava fields in the forest, but were forced to return to the village if found by soldiers. Hunting bonobos is not only prohibited by the traditional taboo, but also by law, although control and enforcement was minimal during the war. The research team therefore concluded that the bonobo population had suffered a decline as a result of the movement and hunting activities of people in formerly remote areas.

An analysis of changes in vegetation cover that occurred during the war helped determine the causes of deforestation and increased hunting pressure. On the basis of Landsat Thematic Mapper and Enhanced Thematic Mapper Plus satellite imagery, primary forest loss and degradation rates were compared across two decades, 1990–2010 (Nackoney *et al.*, 2014; see Figure 7.8). The analysis covered both the Luo Scientific Reserve and the Iyondji Community Bonobo Reserve, which had been created in 2012 (Sakamaki *et al.*, 2012; Dupain *et al.*, 2013). The annual rates of primary forest loss between 1990 and 2000—the decade of political disorder and warfare—were more than double the annual rates of the largely post-war decade 2000–10. Satellite images and analysis showed an increased prevalence of small, scattered clearings in the forest during the war. Between 2000 and 2010, however, the number of new forest clearings decreased; instead, clearings around the agricultural areas surrounding settlements expanded. These findings confirm that people who had been forced into the forest by war generally returned to the villages afterwards.

Researchers who surveyed the southern part of the Iyondji Reserve, where a greater number of small clearings appeared during the war, reported that the density of bonobos in that area was very low, compared with the northern part of the Iyondji Reserve and the Luo Scientific Reserve. Although the forest in that area is still intact, small, scattered settlements appear to have a much larger influence on fauna than expected. The Lomako Forest, another long-term study site for bonobos, showed a 75% decline in the bonobo population in just four years during the civil war, demonstrating the now well-documented empty forest syndrome (Redford, 1992). The mechanism by which biodiverse and species-rich forests become empty during war could be explained by an increase of small-scale, scattered forest clearance.

The decrease in the number of bonobo groups in the northern section of the Luo Scientific Reserve has been linked to the increase in hunting deep in the forest, by and on the order of soldiers, and for subsistence by local people. It may also explain why some groups of bonobos ranging farther from human settlements disappeared, while the main study group ranging in the forest around the village did not decrease. Although those bonobos sometimes became targets of hunting by soldiers, they were probably not the primary target for local people. Another possible explanation of the presence of bonobos around the village is the difficulty of hunting illegally without being seen by other people. Furthermore, as illustrated in the case of the research assistant being unwilling to help the soldiers, some people of Wamba were dedicated to conserving the bonobos of the main study group.

Survivorship of Bonobos

The number of bonobos in the main study group, E1, is steadily increasing, and the population is larger now than it was at its former peak in 1987, when the apes were being provisioned artificially during parts of the year. The study team, which has habituated three groups of bonobos in the Luo Scientific Reserve and two groups in the Iyondji Reserve, follows two groups continuously from sleeping site to sleeping site.

Photo: An elder female bonobo tries to remove a wire snare from the hand of an adolescent female as other females look on. Wamba, DRC. © Takeshi Furuichi, Wamba Committee for Bonobo Research

Since the ceasefire in 2003, there has been no reported incident of specific hunting of bonobos. Illegal hunting using shotguns (primarily for hunting monkeys) does occur in the reserve, however, and bonobos are often captured in snares set for bush pigs and large antelopes (Tokuyama *et al.*, 2012). In July 2014, while following the E1 group in the forest, the study team observed a newly immigrated young female who was caught in a snare. Although the team helped her to escape from the snare by cutting the stick (the bonobos usually achieve this even without help), the wire was still bound tightly around her fingers. The following morning, one elder female was seen trying to remove the wire while other females looked on (see the photo on page 219). They failed and the study team anticipated that either her fingers or the wire would drop off sometime in the near future. This event illustrates typical female bonobo behavior: they associate and help each other (Furuichi, 2011).

Research activities contribute to the local economy through employment and much of the income goes directly to the local community; however, only a limited number of people directly benefit from employment provided by the research station. Some villagers still engage in poaching, not only for their subsistence but also as a form of protest against the research activities. The frequency of gunshots fluctuates greatly from year to year; the incidence of such illegal activities can serve as an indicator of the extent to which conservation efforts succeed in maintaining the balance between the welfare of local people and the protection of bonobos.

Recommendations

A large proportion of great apes live in isolated patches of forest surrounded by human habitation. Successful conservation requires the protection of such vulnerable and isolated populations. In all forest habitats, even in strictly protected areas in which no humans reside, it is difficult to eliminate illegal and destructive activities. The WCBR encourages involvement of local people from the inception of all conservation activities and the development of programs that directly benefit them, such as tourism, research and support for education, medical services and road maintenance.

Improved and effective communication, trust and understanding between local communities, the CREF, the Ministry of Scientific Research and bonobo researchers would facilitate efforts towards both conservation and development. The strict prohibition of all human activities in protected areas can be counter-productive; through dialogue among all stakeholders, strategies designed to combat illegal hunting and other destructive activities can readily emerge.

It is inevitable, however, that during times of conflict or instability, and in the absence of the rule of law, people will engage in activities that put their short-term needs above those of the longer term and sustainable development. During these periods, the presence of the WCBR and the engagement with the local communities can protect the forest and the wildlife in the reserve.

Building relationships between all stakeholders in the area, including local and national authorities, is essential. Their influence, especially during electoral campaigns —when they speak directly with local people and build alliances with particular groups —has the potential to strengthen or to substantially weaken conservation efforts. It is important that all groups understand the benefits of protecting nature and the possible negative impacts that result from the disappearance of wildlife. Engagement with traditional structures via individuals such as village elders can further strengthen enforcement around illegal activities and build support for conservation. These actions could be complemented by a strengthening of support for the CREF, especially with respect to enhancing law enforcement, such as through patrolling and monitoring of illegal activities in the forest.

The Silvery Gibbons in Mount Halimun Salak National Park, Java, Indonesia

Context and Background

The island of Java—Indonesia's political, economic and industrial center—is one of the most densely populated areas in the world. The silvery gibbon (*Hylobates moloch*) is restricted to the provinces of Banten, Central Java and West Java, excluding the capital, Jakarta. That area, hereafter western Java, is home to some 86 million people who live at an average population density of 1,150 people/km^2; by 2020, the population is expected to increase to 98 million, and the density to 1,300 people/km^2 (BPS, n.d.). Java is largely deforested and most of the remaining forest fragments cover parts of the volcanoes and mountains on the island. The remainder of the island is a mosaic of rice fields, agricultural land, cities and villages (Nijman, 2013).

Over the past five years, Indonesia's economy has grown at a rate of 6.0%–6.5%; western Java contributes about one-quarter of the country's total growth (BPS, n.d.). Levels of corruption are high: Indonesia ranks 107 out of 175 on the Corruption Perceptions Index (Transparency International, 2014). The Ministry of Forestry is considered to be Indonesia's most corrupt ministry, according to the country's Corruption Eradication Commission (Amianti, 2014).

Photo: Mount Halimun Salak National Park harbors between 25% and 50% of the global silvery gibbon population. © Jaima Smith

Silvery Gibbons in Western Java

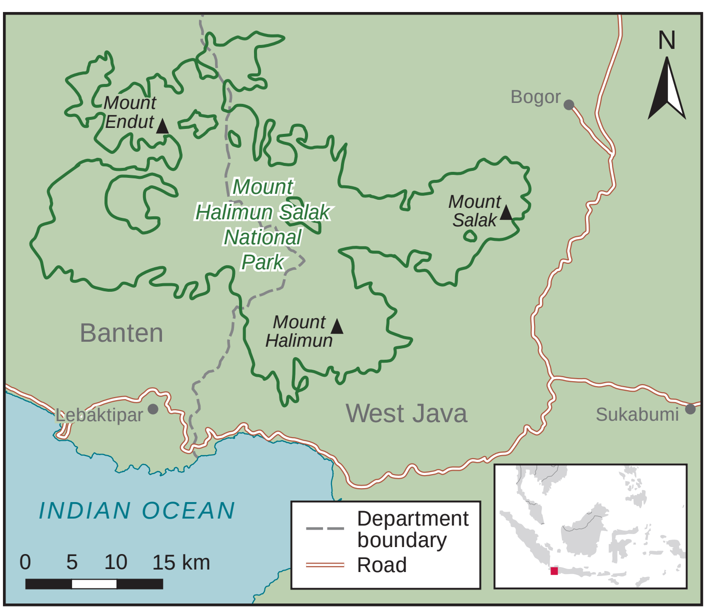
Since 1925, all species of gibbon have been protected under Indonesian law (Noerjito and Maryanti, 2001). The hunting of gibbons is not as prevalent in Java as elsewhere in Indonesia, since primate flesh is considered unfit for consumption under Islamic tenets and more than 95% of people in western Java are Muslim (BPS, n.d.). Moreover, the people of Java rely more on agriculture than their neighbors on the islands of Sumatra and Borneo, and few people are directly dependent on forest products for subsistence. Nevertheless, silvery gibbons are traded as pets on Java (Nijman, 2005).

The silvery gibbon is confined to lowland and lower montane rainforest, mostly below 1,600 m, but occasionally up to 2,000–2,400 m (Kappeler, 1984; Nijman, 2004). Most populations can be found in the provinces of Banten and West Java, however a few remain in Central Java (Kappeler, 1984); farther east the dry season is too long to support the evergreen tropical rainforest on which the species is dependent (Nijman, 1995, 2004).

Mount Halimun Salak National Park harbors between 25% and 50% of the global silvery gibbon population (Kappeler, 1984; Supriatna *et al.*, 1994; Djanubudiman *et al.*, 2004; Nijman, 2004). Situated about 100 km southwest of Jakarta, the park encompasses an area of 1,134 km² (113,400 ha) of forest from lowland to montane; Mount Halimun (1,929 m) and Mount Salak (2,211 m) dominate the area in the west and east, respectively (see Figure 7.10). The link between Halimun and Salak is formed by an 11-km, largely forested area known as “the corridor.” There are several large enclaves, such as plantations and villages, inside the park, including in the center the site of the Nirmala tea estate, which covers roughly 10 km² (1,000 ha) and has sharp boundaries with the adjacent forest. Agricultural land and villages border the park on all sides, and gibbon territories abut the agricultural fields.

FIGURE 7.10

Map of Mount Halimun Salak National Park, Java, Indonesia



Courtesy of Vincent Nijman

Population Surveys and Monitoring of Silvery Gibbons in Halimun Salak

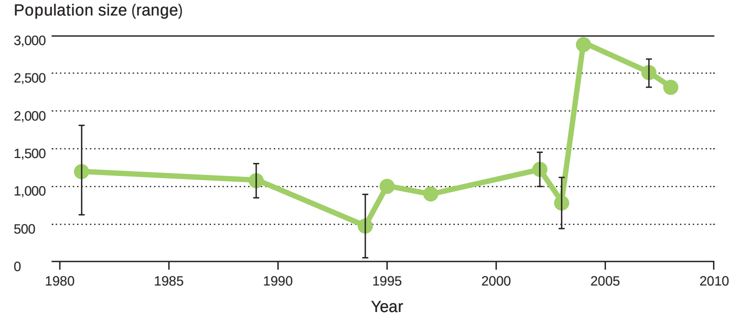
Population estimates for this species vary greatly, ranging from a few hundred in the late 1970s and again in the mid-1990s, to 2,000–5,000 gibbons at various times in the 1980s, 1990s and into the following decade. The IUCN Red List currently lists the silvery gibbon as endangered, having ranked it as critically endangered in 1996 and 2000, due to the small size of the remaining population fragments (Andayani *et al.*, 2008).

Over the past 30 years, Halimun Salak has seen at least ten attempts to estimate the number of silvery gibbons in the park, each with a distinct approach. The diverse findings are summarized in Figure 7.11; the differences in methodology, among other factors, preclude comparisons of these estimates over time, rendering analysis of the data difficult.

Estimates of group density in Halimun Salak show some variation, but between the elevations of 800 and 1,200 m, the range is 2–4 groups/km²; at higher elevations, up to 1,600 m, the density falls below 1 group/km² (Kool, 1992; Sugarjito and Sinaga, 1999; Sutomo, 2006; Iskandar, 2007). Average group sizes in Halimun Salak range from 2.1 to 4.0, without any apparent temporal or altitudinal pattern (Kool, 1992; Supriatna *et al.*, 1994; Sugarjito and Sinaga, 1999; Iskandar, 2007; Yumarni *et al.*, 2011). Much like the population size estimates, the density and group size estimates reflect different research teams' methodologies and assumptions.

FIGURE 7.11

Population Estimates of Silvery Gibbons in Mount Halimun Salak National Park



Notes: Error bars give minimum and maximum estimates. Estimates prior to 1992 do not include the Mount Salak part of the park as it was believed at the time that no gibbons were present there.

Data sources: Kappeler (1984); Kool (1992); Supriatna *et al*. (1994); Asquith, Martarinza and Sinaga (1995); Sugarjito and Sinaga (1999); Rinaldi (2003); Djanubudiman *et al*. (2004); Nijman (2004); Iskandar (2007); Campbell *et al.* (2008a)

Temporal Changes in Population and Habitat Estimates

As with the population figures, estimates of the amount of habitat available to silvery gibbons in the Halimun Salak area have varied over the years, partly due to changes in the amount of forest that remains, but also as a result of changes in methods used to estimate the proportion of the remaining forest that is actually used by silvery gibbons (see Table 7.1).

Using satellite imagery that covers 95% of the park, researchers established that in 2004 some 625 km² (62,500 ha) of the park's total (1,134 km² or 113,400 ha) was covered in natural forest (Prasetyo, Setiawan and Miuru, 2005). Estimates of forest available to silvery gibbons vary considerably—from about 280 km² to 470 km² (28,000–47,000 ha)—depending on factors such as whether areas >1,500 m above sea level or the first kilometer of the forest's periphery were included (Kappeler, 1984; Supriatna *et al.*, 1994; Campbell *et al.*, 2008a). Most of these estimates were derived from land use (forest) maps.

More recently, two studies combined field observations with GIS and habitat suitability analysis to estimate how much suitable habitat is available to silvery gibbons in Halimun Salak. One of them covered the park using satellite imagery from 2001 and field data from 2003; it finds that some 246 km² (24,600 ha) of forest was highly to moderately suitable for silvery gibbons and that an additional 123 km² (12,300 ha) of forest was deemed suitable (Dewi, Prasetyo and Rinaldi, 2007). The other study, covering just Salak, used satellite imagery from 2003 and field data from 2006; it concludes that 78 km² (7,800 ha) was highly to moderately suitable and 33 km² (3,300 ha) was suitable (Ikbal, Prasetyo and Idung, 2006).

The main difficulty in comparing estimates of available habitat is that some researchers only considered forest inside the reserve—be it Halimun or Halimun Salak—as available to silvery gibbons, whereas others included continuous forest outside the reserve as well. Various studies set the altitudinal limit at 1,400 m, 1,500 m and 1,900 m (Kappeler, 1984; Kool, 1992; Sugarjito and Sinaga, 1999); meanwhile, one study excluded some of the best lowland forest as the researchers mistakenly assumed that silvery gibbons did not inhabit the forest periphery (Supriatna *et al.*, 1994).

TABLE 7.1

Estimates of the Forest and Available Habitat for Silvery Gibbons in Mount Halimun Salak National Park

Year	Forest area (km²)	Area available to gibbons (km²)			Method	Source
		H	S	HS		
1981	400 (H)	380	0	380	Satellite imagery	Kappeler (1984)
1994	470 (HS)	235–96	50–70	305–46	Not specified	Supriatna *et al.* (1994)
1999	360 (H)	240–300	–	–	Land use maps	Sugarjito and Sinaga (1999)
2002	–	270	70	340	Land use maps	Nijman (2004)
2003	379 (HS)	–	–	369	GIS modeling	Dewi, Prasetyo and Rinaldi (2007)
2004	625 (HS)	–	–	–	Satellite imagery	Prasetyo, Setiawan and Miuru (2005)
2006	135 (S)	–	111	–	GIS modeling	Ikbal, Prasetyo and Idung (2006)
2008	–	–	–	283	Not specified	Campbell *et al.* (2008a)

Notes: HS = entire area; H = only Halimun; S = only Salak; — = not assessed or not found. Varying research methods were applied.

Some data are available on deforestation rates in Halimun Salak; not all of the monitored areas were inhabited by gibbons, however. One study used Landsat data to estimate deforestation rates for an initial forest area of 841 km² (84,100 ha) over the period 1989 to 2004; the results show an average rate of around 1.9% per year. The study observed significantly higher levels of deforestation during the height of the Asian economic crisis in 1998 (3.3%) and in 2001–3 (3.4%), just before the transfer of State Forestry production forest into Mount Halimun Salak National Park. Overall, the park lost some 200 km² (20,000 ha) of forest over the 15 years covered by the study (Prasetyo *et al.*, 2005). While that research clearly demonstrates land use changes within the boundaries of what is now Halimun Salak, including the loss of natural forest, it is not possible to extrapolate the findings directly to the loss of silvery gibbon.

Challenges Associated with Long-term Monitoring

As is clear from the data presented above, no long-term, consistent monitoring of the silvery gibbons has taken place in Halimun Salak. Many of the studies that have been undertaken were of short duration or covered only a section of the reserve, or both (Kool, 1992; Indrawan *et al.*, 1996; Geissmann and Nijman, 2006; Kim *et al.*, 2011, 2012; Yumarni *et al.*, 2011). At best, the different population estimates can be compared with one another, but given that they differ in vital aspects—such as methodology, survey sites, area included and duration—no firm conclusions can be drawn.

While Jakarta's Biological Science Club has maintained a research station in the eastern part of Halimun Salak since the 1980s, and the Cikaniki field station in the center of the park has been operational since the early 1990s, there is no comprehensive trail system in place that allows for monitoring of the park as a whole. The steep terrain is difficult to work in and the amount of rainfall during the rainy season hampers fieldwork, which may explain, at least in part, the absence of permanent research teams.

One of the challenges facing silvery gibbon conservation in Halimun Salak is that no single organization or park has "adopted" the ape as its responsibility or project; rather, many organizations have been making small contributions once in a while. These include the Japanese International Cooperation Agency, which began to work in Halimun in the 1990s, but much of its work focused on the area around the Cikaniki field station. Cikaniki was also the site of a one-year ecological study on three habituated groups (Kim *et al.,* 2011, 2012). One organization, the Silvery Gibbon Project, based out of Perth Zoo, works with the Javan Gibbon Rescue and Rehabilitation Center to support the Javan Gibbon Center at the Bodogol Resort in Mount Gede Pangrango National Park. The project is focused on rescue and rehabilitation, and has little direct effect on the conservation of silvery gibbons in Halimun Salak.

Recommendations and Opportunities

The potential for proper long-term monitoring of the silvery gibbons in Halimun Salak is high: major universities, the Indonesian Institute of Sciences and the Ministry of Forestry, and several major conservation NGOs are situated in the nearby cities of Bandung, Bogor and Jakarta. It is important for monitoring programs to emphasize the use of consistent methods and to share findings, including raw survey data, if possible.

The various studies over the past three decades have shown that the population of silvery gibbons in Halimun Salak is indeed the largest remaining in Java; the amount of

Photo: The engagement of governments, industry, communities and other stakeholders is vital to the success of long-term conservation projects. © HUTAN -Kinabatangan Orang-utan Conservation Project

gibbon habitat included in the protected area network has increased substantially over this period, as has our understanding of the distribution of gibbons in the area. Increased protection and effective monitoring and management of this population are critical. Such conservation efforts could eventually be expanded to include populations in more remote locations, such as Ujung Kulon National Park and Mts Dieng.

Final Thoughts

> "The need for effective land use planning cannot be overstated. At the local, national and regional levels, such planning can benefit biodiversity, natural resources and human livelihoods."

Although the case studies presented in this chapter cover distinct species in different locations, they illustrate at least five cross-cutting themes that are key to conservation work across the board.

First, they underscore the urgent need for sustainable ways to meet the often-incompatible requirements of a growing human population on the one hand, and of the world's wildlife and its habitat on the other. Striking that balance means securing improvements in human health, education and communication to promote social and economic development—a complex process that relies on creative and effective partnerships between government agencies, NGOs and local communities. At the same time, it calls for the engagement of local actors in conservation strategies, transparent and equitable approaches to the sharing of benefits with local communities, and effective enforcement of forest and wildlife protection legislation.

The second point relates to the growing use of technological tools—from satellites and drones to shareware and handheld devices—to record geo-referenced data, monitor forests and wildlife, produce real-time reports and compare environmental conditions over time. Today's low-cost, user-friendly technology can serve as a valuable addition to more sophisticated and expensive satellite technology in the monitoring of forest areas.

The third theme concerns the value of long-term research. Only when data are gathered using a consistent approach and method, with set survey sites and fixed geographical areas, can researchers hope to identify trends such as population decline, the shrinking of habitats and patterns of deforestation over long periods of time. In conjunction with a solid understanding of the local history and context, analyzing trends can also help to reveal what external factors—such as war or disease—might be at play in the environment under review. Moreover, such quantifiable evidence can inform effective policies to counter adverse effects on biodiversity and human development alike.

A fourth theme revolves around the effective management of protected areas. As the case studies stress, the engagement of governments, communities and other stakeholders is vital to the success of long-term conservation projects. Such engagement can promote the enforcement of laws and the prosecution of illegal activities; similarly, it can encourage local communities to take ownership of conservation goals. During times of political instability or conflict, it is particularly important for local communities to be able to protect the resources and land on which they depend.

Finally, the need for effective land use planning cannot be overstated. At the local, national and regional levels, such planning can benefit biodiversity, natural resources and human livelihoods—while allowing stakeholders to avoid repeating the errors of the past. In this context, partnerships based on shared goals, cooperation and understanding are also central.

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