Gorillas in the midst: the impact of armed conflict on the conservation of protected areas in sub-Saharan Africa

L. Glew and M.D. Hudson

Abstract The frequently anecdotal nature of evidence concerning the impact of warfare on conservation poses numerous problems and there have been calls to apply a strict set of conditions to such data to improve the rigor of scientific analysis in this field. To illustrate the difficulties, however, of applying strict quantitative conditions on such data a deterministic model of conflict-linked deforestation in sub-Saharan Africa was constructed and the implications of the model discussed. Our model indicates that from 1990–2005 approximately 35,000 ha of timber have been used to support officially recorded UN refugees in this region: this is a continuing impact, albeit quantified using data with some potential error. An alternative semi-quantitative approach was also used, with reported environmental impacts of conflict assessed for reliability and severity using a number of empirical criteria. Data focusing on the Democratic Republic of Congo and Rwanda were subsequently analysed using this framework. Illegal resource exploitation was identified as the primary impact resulting from conflict and, in some instances, a driver of the hostilities. From the joint consideration of the conflict and post-conflict phases such exploitation is concluded to be the product of lawlessness and anarchy generated by violent uprisings rather than violence *per se*. As such, armed conflict does not pose a novel threat to protected areas but rather amplifies threats extant during peace, creating a need for appropriate responses by those involved in conservation management. With both the occurrence and violence of conflicts in sub-Saharan Africa increasing, the impacts of warfare are pertinent to both the immediate and long-term management of biological resources in the region.

Keywords Armed conflict, deforestation, ecological impact, protected areas, resource exploitation, sub-Saharan Africa, warfare.

This paper contains supplementary material that can only be found online at http://journals.cambridge.org

Introduction

Warfare inevitably has environmental impacts, whether intentional or accidental (Vanasselt, 2003). Conflict may trigger mass movement of human populations, the decline or near total collapse of state functions and consequently a forced reliance on wild resources, and uncontrolled natural resource exploitation (Dudley *et al.*, 2002; McNeely, 2003). Designated protected areas can become targets for belligerents as a strategic resource for exploitation or defence, a potential source of equipment, or a resource for the displaced (Jacobs & Schloeder, 2001; Kalpers, 2001a; Dudley *et al.*, 2002).

Because of the difficulties of engaging in scientific research in a war zone (Shambaugh *et al.*, 2000; Vanasselt, 2003) the availability of scientific or even pseudo-scientific data on the impact of warfare on conservation efforts is, at best, haphazard and, at worst, non-existent. In addition, the lack of clear spatial or temporal definition to conflict further hinders any rigorous assessment of its environmental impact.

Published analyses of warfare in an ecological context fall into two categories. The first reports specific events relating to a single conflict that are difficult to place into a wider context (Hatton *et al.*, 2001), and the second provides an overview of the type of impact that may be generated (Dudley *et al.*, 2002) and tends to be simultaneously too broad to apply in a specific context. Brauer (2001) condemned many existing reviews as anecdotal, grossly unreliable, incomplete, difficult and complex to assess, lacking a classification of impacts by severity, and edited to support the politically correct result. Although these criticisms are valid, the issue of scientific data collection from zones of armed conflict remains intractable, with many logistical and ethical barriers to negotiate. As Brauer himself conceded,

L. Glew and **M.D. Hudson** (Corresponding author) School of Civil Engineering and the Environment, Faraday Building, Highfield Campus, University of Southampton, Southampton, SO17 1BJ, UK. E-mail mdh@soton.ac.uk

Received 27 February 2006. Revision requested 2 August 2006. Accepted 20 December 2006.

© 2007 FFI, *Oryx*, **41**(2), 140–150 doi:10.1017/S0030605307001755 Printed in the United Kingdom

'ignorance is not bliss', and the nature of the evidence should not be used to prevent further examinations of the environmental consequences of warfare.

Here we attempt to find a way between these two approaches, examining multiple conflicts in a single biogeographic region (sub-Saharan Africa). Because of the insidious and lengthy nature of pre-conflict tensions we consider only periods of active hostilities and the immediate post-conflict environment, with the latter considered to extend either to the onset of the subsequent conflict or to the installation of an internationally recognized ruling authority, whichever is sooner. We first use a quantitative approach to examine whether the ecological consequences of warfare can be examined in the rigorous manner advocated by Brauer (2001), and we then use a semi-quantitative approach by examining the impacts of conflict in a case-study approach using a categorization of the severity of the effects and the reliability of the data.

We show that quantitative approaches, while limited by both lack of data and potential error, can demonstrate important and alarming trends in loss of natural resources. Our semi-quantitative approach identifies that warfare itself does not generally pose a novel threat to protected areas and endangered species, but rather amplifies threats which are ongoing during peace, or rather between periods of conflict. We discuss the challenges this brings to conservation management in one of the world's most important areas for biodiversity.

Armed conflict in sub-Saharan Africa, 1955–2001

One of the major failings of previous reviews of the effects of war on conservation efforts is the inadequate analysis of the characteristics of conflict. It is axiomatic that knowledge of the frequency, duration and nature of conflict experienced in a given locality is essential to comprehend the mechanisms by which the reported environmental impacts are produced. We therefore examined the history and distribution of conflict using the UN-supported public dataset that details warfare between 1955 and 2001 on a global scale (State Failure, 2001). By calculating 'conflict years' in each country we found that the average nation in sub-Saharan Africa experienced 6.55 years of conflict between 1955 and 2001 (Fig. 1) compared to the global average of 4.75 years, making it the most conflict-ridden continent. The temporal variation in the number of active conflicts in sub-Saharan Africa ranged from none in 1955 to >20 during the early 1990s. Conflict activity may be associated with major geopolitical events, such as decolonization during the late 1960s (Meredith, 2005). A decadal breakdown of conflicts highlights a general escalation in frequency since 1960, with 18 conflicts in 1960–1969 and 23 in 1990–1999. Conflict has also become increasingly severe, with the emergence of intense genocidal conflict in Sudan and Rwanda (Jennings, 2001).

The majority of wars in sub-Saharan Africa (e.g. 92% of those in 2000) have been civil conflicts fought within the boundaries of a single sovereign state (State Failure, 2001). However, internal wars are no less capable of having international consequences than transboundary conflict. A common feature of civil war is the mass displacement of people, and if this involves movement across an international border, a significant number of the ecological consequences of the conflict may be displaced into the recipient country, as seen in the Democratic Republic of Congo (DRC) after the Rwandan genocide of 1994 (Elongo, 2000). Equally, the unpredictable and unstructured nature of civil war, with the frequent emergence of new belligerent groups and shifting alliances, promotes frequent and repeated population displacements and a disparate security situation at anything above the immediately local level (Hart & Mwinyihali, 2001; Kalpers 2001a). Furthermore, many of the legal codes governing the conduct of belligerents during warfare are not applicable where hostilities do not cross international boundaries (Austin & Bruch, 2003). Thus, the international community has diminished capacity to censure the strategies and weaponry in use.

Quantitative assessment of the environmental impact of conflict

We constructed a deterministic model to demonstrate consequences of warfare for the environment and to highlight the severe curtailment of available knowledge inherent to the application of such a strict quantitative approach to data emerging from conflict zones. The model describes the only impact for which accurate data were available that could be directly linked to the armed conflict, namely timber usage by refugees in official UN refugee camps. Sources of data and potential errors are given in Table 1. Nations in the study area were classified into three environmental types: semi-desert/desert, savannah/grassland, and tropical forest. Using the average of timber consumption estimates during conflict in each of these categories, an average timber consumption value for each environmental type was calculated. This value was combined with annual estimates of the refugee population in each nation during 1990–2005 to yield an annual figure for national refugee-linked timber consumption. Using estimates of timber standing stock per ha for each nation, this figure was converted to the number of ha deforested per environmental type (Fig. 2). The model is described by

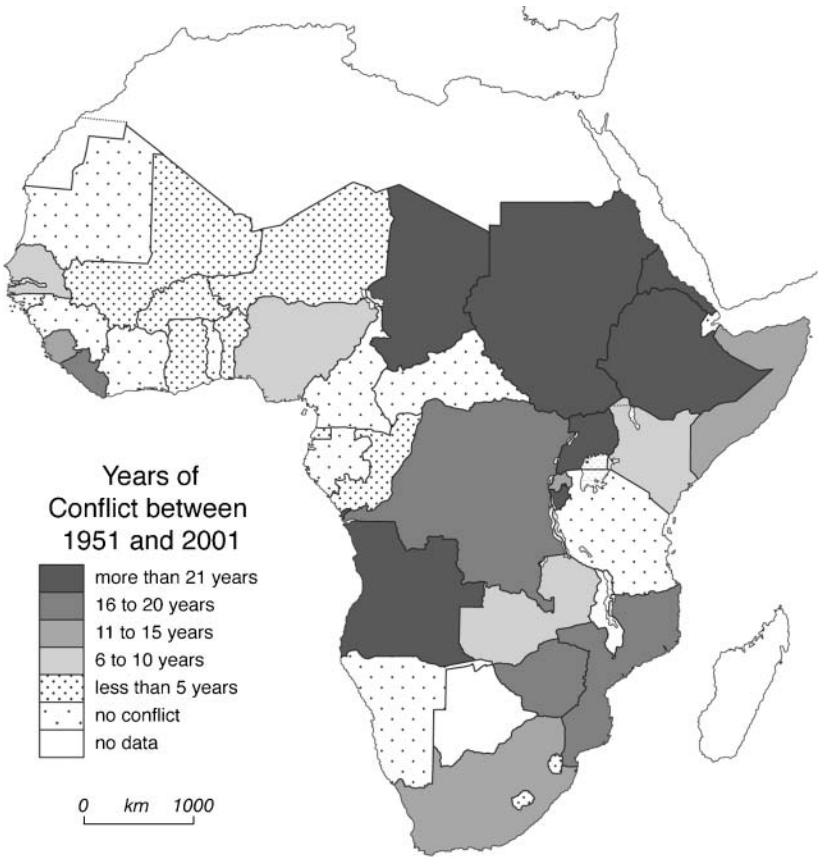

Fig. 1 The duration of armed conflict in sub-Saharan African nations during 1955–2001. The frequency of armed conflict or severe civil strife was determined via the calculation of conflict years (the number of months for which a nation was recorded as being at war in the dataset, converted to years) using conflicts reported within the State Failure Dataset (State Failure, 2001). Nations identified by this means as being particularly subject to prolonged warfare were Ethiopia, Eritrea, Chad, Somalia, DRC and Mozambique. The study included all mainland African nations whose southern boundary lies below that of true desert, excluding only Algeria, Egypt, Libya, Morocco, Tunisia and Western Sahara.

$$f_{ay1} = R_{ay1} * (W_{e1}/T_{n1})$$

where f_{ay1} is the area deforested (ha) in nation a in year 1 of the data set, R_{ay1} is number of refugees in year 1 in nation a, W_{e1} is wood used per capita in environment type $e1$, $e2$..., and T_{n1} is tonnage of timber per ha of nation a. The cumulative area of deforestation associated with UN refugees in the study nations during 1990–2005 (F) is given by

$$F = (f_{ay1} + f_{ay2} + f_{ay3} \ldots + f_{ayn}) + (f_{by1} + f_{by2} + f_{by3} \ldots + f_{byn}) + \ldots . (f_{zy1} + f_{zy2} + f_{zy3} \ldots + f_{zyn}),$$

where z is the last nation in the sample and yn is the last year.

There is an important caveat that must be attached to these calculations. Data on both the number of displaced persons and their timber consumption are estimates. For example, per capita timber consumption has been shown to vary widely according to the nature of the food rations and shelter provided by humanitarian organizations together with the cultural traditions and practices of the displaced population (Knudson, 2002; UNEP, 2005). Thus, our model can only provide an indication of the likely magnitude of refugee-linked deforestation, rather than an absolute estimate. However the importance of the model is twofold. Firstly, it quantitatively highlights the potential for severe ecological impact that arises from a single highly specific activity amongst the many impacts that warfare can generate. Our model indicates that the equivalent of 34,984 ha of timber would have been necessary to support the number of refugees generated by conflict in sub-Saharan Africa during 1990–2005, and this only accounts for those refugees officially recorded by the UN. Secondly, the implications of the model are perhaps of greater importance than its findings. Using a quantitative paradigm, as advocated by Brauer (2001), the substantial volume of data pertaining to the ecological consequences of warfare in sub-Saharan Africa (Appendix) is much reduced and has a margin of error that is probably large and is difficult to quantify (34,984 $\pm$ 5,143 ha, demonstrated by the diverging lines in Fig. 2). Notwithstanding the limitations of this approach, and the reduction of data that is inevitable, we have demonstrated the ongoing and increasing loss of a natural resource that, given a continuing trend for humanitarian crises in Africa, is unlikely to be reversed without considerable effort from the international community.

https://doi.org/10.1017/S0030605307001755 Published online by Cambridge University Press

Table 1 Model data sources and error calculations. The source and potential error for each type of data incorporated into the model (see text for details) is given. For refugee timber consumption per capita in each environment type (W_e), the model used estimates from several sources. In the standard run of the model the mean of those estimates was used to calculate deforestation. A second model run was conducted using the upper 95% confidence limit of the estimates for each environment type.

Data type	Data source	Potential error/95% confidence limits
National environment type classification	Groombridge & Jenkins (2000)	Unknown
Timber standing stock per unit land area (T_n)	FAO (2005)	No data for Benin, Burundi, Eriteria, Lesotho, Sierra Leone & Togo
Number of refugees in nation per year of the dataset (R_{ay})	UNHCR (1995, 1996, 1997, 1999, 2005, 2006a,b)	No data for nations with <1,000 refugees
Refugee timber consumption per capita (W_e)		
Semi-desert/desert	Kimani (1995); UNHCR in Knudson (2002); Galitsky *et al.* (2005)	± 1.71 kg per capita yr^{-1}
Savannah/grassland	Owens in Knudson (2002); UNEP (2005)	± 5.47 kg per capita yr^{-1}
Tropical forest (wet/dry)	SCI in Knudson (2002); Henquin & Blondel in Kalpers (2001a); Knudson (2002)	± 2.29 kg per capita yr^{-1}

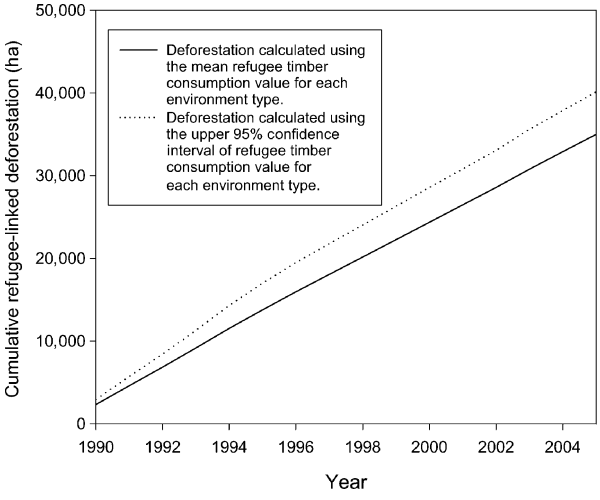

Fig. 2 Model (see text for details) of refugee-linked cumulative deforestation in sub-Saharan Africa between 1990 and 2005 (for data sources see Table 1).

Semi-quantitative assessment of the environmental impact of conflict

Given the limitations of a quantitative assessment of the environmental impact of conflict we explore the possibility of using a semi-quantitative assessment. We developed two criteria, Severity and Reliability (Table 2), to assess the impact of reported conflicts. Severity provides an indication of the magnitude, duration and ecological effects of the impact, and Reliability amalgamates data reliability, comprehensiveness and potential bias. In addition, data were classified according to the Lanier-Graham (1993) system, which categorizes the environmental impacts of warfare according to the intentions and status (civilian or military) of its perpetrators. The data are complex to assess, an inherent aspect of analysing reports from a politically unstable region in which long-term records and monitoring programmes are scarce.

We assessed 187 records of the environmental impact of warfare in 10 African nations published between 1 January 1990 and 31 December 2005 (Appendix). Illegal hunting of mammal species accounted for 57.8% of reported cases and the average Severity of this was scored as Major. Impacts resulting in deforestation, although numerically smaller than hunting-linked impacts, were of comparable severity. Thus, it appears that reviews of conflict in sub-Saharan Africa have focused on a subset of the total range of reported impacts. The reasons for this are unclear. The environmental impact of conflict in sub-Saharan Africa is seldom the product of direct or indirect military activity (Table 3). Rather, the majority of impacts are perpetrated by non-military personnel as a reaction to the changing socioeconomic conditions created by the conflict.

The environmental impact of warfare was not reported equally across the 10 nations, with the greatest proportion (75.4%) of information available for DRC and Rwanda. The environmental impact of conflicts in these two countries was comparable to the wider survey and we therefore confine further discussion to these two countries. The Rwandan Genocide of 1994 is estimated to have involved the murder of 800,000 civilians and the international displacement or impoverishment of a further 4 million (Kanyamibwa, 1998; Jennings, 2001). The relationship between the Rwandan crisis and the subsequent Congolese conflict is complex. The influx of refugees in 1994 remained as a displaced diaspora in DRC for several years, exacerbated the pre-existing civil unrest, and eventually propagated conflict that endured for nearly a decade and involved nine other nations (Biswas & Tortajada-Quiroz, 1996; Sato *et al.*, 2000; Hart & Mwinyihali, 2001; Lanjouw, 2001). The majority of

Table 2 Data significance assessment criteria. Severity constitutes a measure of the significance of the ecological impact of warfare-related alterations (whether beneficial or deleterious) to protected areas; overall severity was determined by the assessment of individual categories. If an impact scored mostly 1, the overall severity was scored as Minor, mostly 2 as Moderate, and mostly 3 as Major. Reliability is an indicator of the nature of the data source.

Category	Code	Criteria
Severity		
Size of impact	A1	MINOR: affecting <10% of total area & no ecologically sensitive areas
	A2	MODERATE: affecting 10–20% of total area & no ecologically sensitive areas
	A3	MAJOR: affecting >20% of the total area or any ecologically sensitive areas
Duration of impact	B1	MINOR: discernible impact for <1 year
	B2	MODERATE: discernible impact for >1 & <5 years
	B3	MAJOR: discernible impact considered permanent
Ecological uniqueness	C1	MINOR: many examples of similar or higher 'quality' at both local & national scales
	C2	MODERATE: one of a limited number of sites on a national scale or last example on a local scale
	C3	MAJOR: single national example or one of a limited number on an international scale
Recovery potential	D1	TOTAL: damage reversible & repairable with no lasting impact on ecological function
	D2	PARTIAL: damage partially reversible with minor alteration to ecological function
	D3	NONE: damage irreversible & irreparable, ecosystem function fundamentally altered
Vulnerability to other impacts	E1	NONE: threat from warfare-associated impacts is the only significant threat in operation
	E2	SOME: single other non-warfare associated threat in operation
	E3	MANY: many non-warfare associated impacts in operation
Potential for secondary impacts	F1	NONE: no discernible secondary impact
	F2	SOME: potential for secondary impacts but these do not threaten ecosystem integrity
	F3	MANY: potential for many & diverse secondary impacts that may threaten ecosystem integrity
Financial impacts	G1	MINOR: conservation of species/habitat/ecosystem has little direct financial benefit
	G2	MODERATE: conservation of species/habitat/ecosystem has direct local financial benefit
	G3	MAJOR: conservation of species/habitat/ecosystem has direct local & national financial benefit
Reliability		
Quantitative data	H1	QUALITATIVE: data provided are qualitative
	H2	SEMI-QUANTITATIVE: data provided are quantitative but not linked to baseline surveys
	H3	QUANTITATIVE: data provided are quantitative & linked to baseline surveys
Number of accounts	I1	SINGLE: only one account of specific impact
	I2	MULTIPLE: multiple, convergent accounts of a specific impact
Source	J1	UNKNOWN: no data
	J2	HEARSAY: based on local speculation or rumour
	J3	GOVERNMENT: Government report, potential for political editing
	J4	INDEPENDENT/SCIENTIFIC: reported by independent individuals, little potential for political editing

Table 3 Classification of the environmental impacts of warfare in 10 sub-Saharan African nations reviewed in the literature (Appendix) between 1 January 1990 and 31 December 2005. Classification follows the Lanier-Graham (1993) system.

Lanier-Graham impact type	Definition	Report frequency (%)
Direct	The intentional targeting of ecological resources as a component of military strategy	9 (4.6)
Indirect	The unintentional & to some extent unavoidable outcome of military activity, typically resulting from troop movements & logistical support	16 (8.4)
Induced	Impacts that result from the actions of individuals not pursuant to a military outcome	162 (87.0)
Total		187

environmental impacts reported in Rwanda and DRC were the product of civilians exploiting, whether for need or greed, the breakdown of societal values and law enforcement (Kanyamibwa, 1998; Kanyamibwa & Chantereau, 2000; Kalpers, 2001b; Kalpers *et al.*, 2003) rather than a consequence of deliberate military strategy. Only 4.8 and 6.6% of all reported impacts could be attributed to direct military activity in DRC and Rwanda, respectively.

The military was, however, indirectly responsible for illegal resource exploitation in both nations, albeit on substantially different scales. Rwanda's Akagera

https://doi.org/10.1017/S0030605307001755 Published online by Cambridge University Press

National Park was used as a strategic base by the Rwandan Patriotic Front (Kanyamibwa, 1998; Plumptre *et al.*, 2001). Despite no evidence of direct strategy to target the park's resources, a number of environmental impacts occurred as a by-product of the military activity in the region. The proliferation of armed personnel with inadequate food rations caused an upsurge in hunting activity and by the end of 1990 a 60–90% loss of ungulates and other mammals from the Park was reported (ACNR in Kanyamibwa, 1998; William & Ntayomba, 1999 in Plumptre *et al.*, 2001).

The various rebel movements involved in the Congolese conflict engaged in illegal resource exploitation, in particular of columbo-tantalite, or coltan, to finance their campaign and acquire wealth. A marked increase in the global coltan price in late 2000 led to the widespread mining of the ore by the militias and their affiliates within the boundary of Kahuzi-Biega National Park and greatly increased pressure on scant local protein resources (Redmond, 2001). Civilians, and in particular refugees, were found to be responsible for the majority of reported environmental impacts in both Rwanda (87.0%) and DRC (87.4%). Large-scale humanitarian assistance camps for displaced Rwandans existed in the vicinity of two World Heritage Sites in eastern DRC during 1994–1995. These camps were found to account for 48% of all reported impacts in DRC, despite existing for less than a third of the study period.

Given the identity of those responsible it is unsurprising that impacts were focused on the exploitation of the two resources essential for survival, food and timber. In the DRC deforestation has been cited as the most frequent and significant environmental impact. We found, however, that illegal hunting had similar severity and a higher reporting frequency. This apparent disparity may be the product of a lower reporting threshold for those impacts that involve charismatic mammal species.

Arguably the most charismatic species to be affected by the conflicts in DRC and Rwanda is the gorilla *Gorilla* spp. which accounted for 10.2% of all 187 environmental impacts reported. Populations of both the eastern lowland gorilla *Gorilla berengei graueri* and the mountain gorilla *Gorilla berengei berengei* were affected in four protected areas. Within the DRC the reporting frequency of impacts was equal for the eastern lowland and mountain gorilla populations at 47.4% of the total each. The remaining reported impacts did not specify which subspecies was affected. Spatial disparities in the frequency of reported impacts were, however, apparent. As reported elsewhere (Yamagiwa, 2003) the gorilla population in Parc National des Virunga was relatively unscathed by the conflict, accounting for 26.3% of all reported impacts relating to gorillas. In contrast, the equivalent figure for Parc National du Kahuzi-Biega was 52.6%. This result is indicative of the high levels of spatial disparity in the impacts of conflict. There is evidence to suggest that protected areas may be compartmentalized with certain strategic areas seriously affected by conflict and others remaining comparatively undisturbed (Elongo, 2000).

While the Rwandan genocide was one of the most serious conflicts, in terms of civilian casualties, to have occurred in Africa (State Failure, 2001), no simultaneous escalation in the reported ecological impact is apparent, which would be anticipated if the level of violence in a fractious society was directly translated into ecological effects. Few impacts were reported during 1994 within the boundaries of Rwanda despite the majority of human casualties being recorded during April–May 1994. Evidence from DRC suggests this is not an isolated phenomenon but rather that the environmental impact of conflict is not a simple product of the gun. The propensity of civil conflicts to propagate mass civilian displacement, together with the documented importance of refugees in the environmental impact signature of such conflict, creates substantial spatial displacement of environmental impacts, frequently across international boundaries. For example, 54% of the impacts reported in DRC during 1994–1997 were linked to the presence of sizeable camps for Rwandan nationals in North and South Kivu. Similarly, the environmental impacts reported in Garamba National Park in northern DRC have been linked both to the Congolese civil conflict and those in both Sudan and Uganda. Mercenaries from Sudan and Uganda have been implicated in the illegal exploitation of the last remaining wild population of northern white rhino *Ceratotherium simum cottoni*, with revenues from the sale of horn used to fund activities in their home countries (IUCN, 2004; Anon., 2005; Anthony, 2006). The Garamba population was stable, albeit small, between 1998 (the outbreak of the second Congolese civil war) and June 2003 (IUCN, 2004). However, the population had declined by 50–74% by 2004, with only 5–10 individuals remaining in the wild (IUCN, 2004; Anon., 2005). The most recent census data indicate that the current population comprises no more than four individuals (Anthony, 2006). The recent upsurge in hunting serves to highlight the potential for the temporal displacement of the environmental impacts of conflict.

During 2004 and 2005 peace talks were underway in both DRC and Sudan. The hiatus in conflict led to large numbers of mercenaries in the vicinity of Garamba with little other occupation (IUCN, 2004). Unsurprisingly, illegal hunting for commercial profit commenced, exploiting the trading routes to the Arab peninsula

and northern Africa that had previously been blocked by armed conflict (Anthony, 2006).

Temporal displacement of environmental impacts into the immediate post-conflict period is a consistent feature of African conflicts. The lawlessness that permits induced environmental impacts during conflict does not evaporate upon the declaration of peace but rather recedes gradually as state and civil society are reconstructed (Kayanja & Douglas-Hamilton, 1984; Hatton *et al.*, 2001). In many of the protected areas of DRC reports of illegal exploitation and adverse environmental impacts increased after peace negotiations, and in Rwanda impacts were reported long after the official cessation of conflict (Fig. 3). The presence of the French military in Nyungwe Forest Reserve prevented much ecological impact from the genocide and civil war (Jennings, 2001; Plumptre *et al.*, 2002) but during the post-war period this immunity ceased, with increasing resource pressure exerted by the local community (Plumptre, 2003), and the incidence of poaching increased markedly with 300–400 snares removed from the reserve per month (Plumptre *et al.*, 2001). Similarly, few deaths of the flagship mountain gorilla can be directly attributed to the Rwandan civil war but rather to reduced likelihood of legal consequences during the reconstruction period (Plumptre *et al.*, 1997). In DRC the year-long ceasefire between conflicts had a significantly higher frequency of reported environmental impacts than the average year of the conflict that followed (U = 66, P <0.01; Mann-Whitney U Test) but this could be due to better communications and access for the media.

The increase in illegal resource exploitation in protected areas during both conflict and its immediate aftermath is the product of a breakdown of government infrastructure and, in particular, the inability of conservation staff to act in protected areas. The continued active management of protected areas by conservation staff has been suggested as a means by which the adverse impacts of conflict may be reduced (Kayanja & Douglas-Hamilton, 1984; Lanjouw, 2001; Plumptre, 2003). In both DRC and Rwanda conservation activity is heavily dependent upon international funding, whether from donors or tourists, both of whom are highly sensitive to the emergence of armed conflict (Shambaugh *et al.*, 2000).

Donors frequently categorize conservation-related activities as non-essential or low priority projects (Wabbes-Candotti, 2000). Prior to conflict, the withdrawal or suspension of expedient conservation initiatives may be employed as a warning of greater sanctions to come. Similarly, post-conflict funding is frequently directed toward humanitarian and infrastructure repair projects prior to being directed at conservation. Thus, conservation activities may feel the effects of the conflict for considerably longer than other economic sectors, lengthening the period during which illegal resource exploitation is difficult to curb. In both Rwanda and DRC a number of major donors suspended their conservation support in the early 1990s as tensions in the region increased (Wabbes-Candotti, 2000; Plumptre *et al.*, 2001). Despite the short-lived nature of the Rwandan conflict, which ceased in 1995, only the German Technical Development Agency had reinstated funds by 2001 (Plumptre *et al.*, 2001). Similarly, this was the only bilateral donor to maintain funding during the Congolese conflict. A pilot project by the UN and Fauna & Flora International to provide emergency funds for protected area management during conflict may provide a means by which some of the environmental impacts of conflict could be curtailed (FFI, 2006).

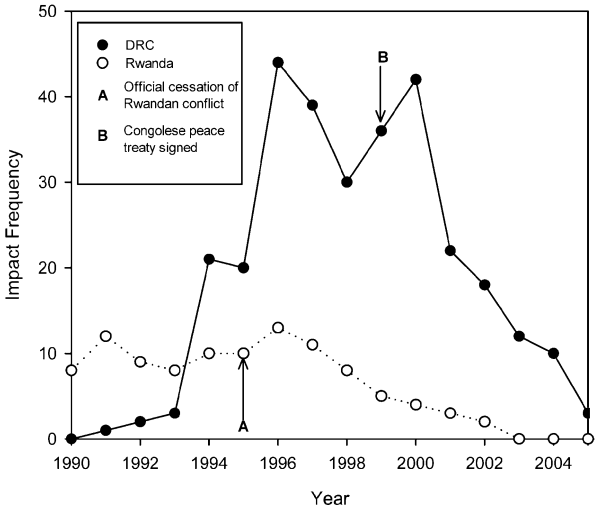

Fig. 3 The incidence of environmental impacts of the Rwandan and DRC conflicts as reported in the literature between 1 January 1990 and 31 December 2005 (see Appendix).

Discussion

The study of the ecological consequences of warfare becomes reliant on a much reduced data set if only strictly quantitative data are considered. As illustrated in our initial quantitative analysis, all data emerging from war zones would have to fulfill three criteria to meet Brauer's (2001) requirements for quantitative analysis. Firstly, the data should consist of a pre-war baseline and a post-war survey as a minimum, with regular in-conflict surveys preferable. Secondly, the data should be related directly to the conflict, either presenting a novel impact not present during times of political stability, or create a measurable change in existing threats that is directly attributable to the conflict. Thirdly, the data need to be correlated directly to some

https://doi.org/10.1017/S0030605307001755 Published online by Cambridge University Press

reliable quantitative characteristic of the conflict, such as the number of casualties or the number of refugees. As we have illustrated, fulfillment of all three criteria is a formidable, if not impossible, task.

If African nations experiencing conflict in 2005 alone are considered, the environmental protection and conservation capacity of nine nations was directly affected by conflict (Marshall & Gurr, 2005). The impacts of a conflict may overspill its defined boundaries, affecting both a nation and its neighbours for substantial lengths of time (Commission for Africa, 2005). Assuming that each of those nine conflicts has created refugee flows into at least one of its neighbours, 30% of nations in sub-Saharan Africa were subject to conflict-linked environmental degradation in 2005 alone. Thus, while war zones are an abnormal environment in which to conduct scientific research, conflict and upheaval is becoming a normal circumstance for an increasing number of nations. The importance of understanding the impacts of conflict upon the environment is such that it may be necessary to knowingly sacrifice normally accepted standards of data quality, with appropriate caveats, in return for an increased ability to evaluate the impacts of, and our responses to, each crisis as it develops. However, creating a systematic assessment framework to satisfy Brauer's criteria was a valuable exercise, highlighting a number of the characteristics of the environmental impact of conflict in sub-Saharan Africa that may be used to improve the response of the international conservation community.

The impacts of warfare are many and varied, mirroring the nature of the conflicts themselves (Hart & Mwinyihali, 2001; Draulans & van Krunkelsven, 2002; Dudley *et al.*, 2002). Modern armed conflict in sub-Saharan Africa does not usually directly target ecological resources in pursuit of a military outcome but rather those impacts are a by-product of its occurrence (Biswas & Tortajada-Quiroz, 1996; Kalpers, 2001a; Draulans & van Krunkelsven, 2002; Dudley *et al.*, 2002). The typical impacts of warfare in the region are those of illegal resource exploitation (Elongo, 2000; Redmond, 2001; UNOCHA, 2004), which are not directly linked to military activity itself but to the emergent properties of conflict, lawlessness and anarchy. The environmental impact of contemporary conflict in the region may be viewed as a dichotomy, linked either to the provision of finance for military operations or the humanitarian needs of the disrupted civilian population. During intense conflict, however, the opportunities for resource exploitation may be limited, with trading routes inaccessible and the risk of personal injury high. In both Rwanda and DRC adverse environmental impacts were greatest in relatively calm but lawless periods and locations. It is therefore important to minimize the period of lawlessness in protected areas and in so doing reduce the opportunity for illegal resource exploitation.

The eruption of armed conflict in the midst of internationally backed conservation projects almost inevitably leads to the immediate partial or, in many cases, total withdrawal of support (Wabbes-Candotti, 2000; Wit, 2000). The actions of donors, not only in withdrawing support but also in failing to reinstate it as soon as active hostilities cease, is a substantial component in propagating the damage to the protected areas of the region. International donors must respond more effectively and strategically to the relationship between conflict and biodiversity conservation in sub-Saharan Africa (Wabbes-Candotti, 2000).

Acknowledgements

Grateful thanks to Dr Michael Fenner for the original inspiration, Dr Simon Bray for much needed advice, and the University of Southampton Cartographic Unit for preparing Fig. 1. Much of the work presented would have been impossible without the contributions of Jamison Suter of Fauna & Flora International, Robert Muir of the German Technical Development Agency, Dr Andrew Plumptre of the Wildlife Conservation Society, Christian Oxenball of the UN High Commission for Refugees, and the many compilers of the State Failure dataset.

References

Anderson, T.A. (2002) *Wildlife, Too, Under Siege in Zimbabwe.* Hoover Institution, Stanford, USA [http://www.hoover.org/pubaffairs/we/2002/anderson_0402.html, accessed 18 November 2005].

Anon (2005) No rhino rescue. *New Scientist*, **185**, 7.

Anthony, D. (2006) *Ugandan Rebel Army Pledges to Save Highly Endangered Rhinos.* Http://www.earthorganization.org/News.aspx?tid=33 [accessed 14 September 2006].

Appleton, M. & Morris, J. (1997) Conservation in a conflict area. *Oryx*, **31**, 153–155.

Austin, J.E. & Bruch, C.E. (2003) Legal mechanisms for addressing wartime damage to tropical forests. In *War and Tropical Forests: Conservation in Areas of Armed Conflict* (ed. S.V. Price), pp. 167–199. Haworth Press, New York, USA.

Aviram, R., Bass, M. & Parker, K. (2003) Extracting hope for bushmeat: case studies of oil, gas, mining and logging industry efforts for improved wildlife management. In *Uncertain Future: The Bushmeat Crisis in Africa.* Reports prepared for the Bushmeat Crisis Task Force by the Problem Solving team of the Fall 2002 Conservation and Development Course (CONS 680). Sustainable Development and Conservation Biology Graduate Program, University of Maryland: College Park, USA [http://www.bushmeat.org/pdf/PS_Private.pdf, accessed 15 November 2005].

Biswas, A.K. & Tortajada-Quiroz, H.C. (1996) Environmental impacts of the Rwandan refugees on Zaire. *Ambio*, **25**, 403–408.

Black, R. (2004) *Congo Poachers Leave Bonobo at Risk.* Http://news.bbc.co.uk/go/pr/fr/-/1/hi/sci/tech/4080807.htm [accessed 12 September 2004].

Blom, A. & Yamidou, J. (2001) *A Brief History of Armed Conflict and its Impact on Biodiversity in the Central African Republic*. Biodiversity Support Program, Washington, DC, USA.

Brauer, J. (2001) *War and Nature: The Problem of Data and Data Collection.* Paper presented to a conference on *Identifying Wars: Systematic Conflict Research and its Utility in Conflict Resolution and Prevention*, 8–9 June 2001, PRIO/Uppsala University/DECRG, Uppsala, Sweden [http://www.per.uu.se/conferences/Euroconference/brauer_data.pdf, accessed 5 April 2005].

CARPE (Central African Regional Program for the Environment) (2005) *The Forests of the Congo Basin, A Preliminary Assessment.* Http://carpe.umd.edu/products/PDF_Files?FOCB_APrelimAssess.pdf [accessed 29 October 2005].

Commission for Africa (2005) *Commission for Africa: Report of the Commission for Africa*. Commission for Africa, London, UK.

Cooper, J. & Cooper, M. (1996) Mountain gorillas – a 1995 update. *African Primates*, **2**, 30–31.

de Merode, E., Bila, I., Teid, J. & Panziama, G. (2005) *An Aerial Reconnaissance of Garamba National Park with a Focus on Northern White Rhinoceros. August 2004.* Http://www.rhinos-irf.org/news/african/garamba/Garambasurveyreport28.8.05.pdf [accessed 25 August 2005].

Debonnet, G. & Hillman-Smith, K. (2004) Supporting protected areas in a time of political turmoil: the case of World Heritage Sites in the Democratic Republic of Congo. *Parks*, **14**, 11–18.

Draulans, D. & van Krunkelsven, E. (2002) The impact of war on forest areas in the Democratic Republic of Congo. *Oryx*, **36**, 35–40.

Dudley, J.P., Ginsberg, J.R., Plumptre, A.J., Hart, J.A. & Campos, L.C. (2002) Effects of war and civil strife on wildlife and wildlife habitats. *Conservation Biology*, **16**, 319.

Elongo, S. (2000) The conservation of nature in periods of war in the Democratic Republic of Congo. In *Nature in War: Biodiversity Conservation During Conflict* (eds E. Blom, W. Bergmans, J. Dankelman, P. Verweij, M. Voeten & P. Wit), pp. 39–44. Netherlands Commission for International Nature Protection, Leiden, The Netherlands.

Enckoto, M. (2003) *Conservation in the Face of Armed Conflict: The Effects of Political Instability on the Management of the Okapi Wildlife Reserve*. Gilman International Conservation, Epulu, Democratic Republic of Congo [http://www.giconline.org/armedconflict.pdf, accessed 12 November 2005].

FAO (2005) *Global Forest Resources Assessment 2005. Progress Towards Sustainable Forest Management*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FFI (2006) *Rapid Response Facility.* Http://www.fauna-flora.org/rrf/index.html [accessed 1 April 2006].

Galitsky, C., Gadgil, A., Jacobs, M. & Lee, Y.M. (2005) *Fuel Efficient Stoves for Darfur Camps of Internally Displaced Persons*. Field Report, University of Berkeley, California, USA.

Global Witness (2004a) *Dangerous Liaisons: The Continued Relationship between Liberia's Natural Resource Industries, Arms Trafficking and Regional Insecurity. A Briefing Document submitted by Global Witness to the United Nations Security Council*. Global Witness, London, UK.

Global Witness (2004b) *Liberia. Back to the Future: What is the Future of Liberia's Forests and its Effects on Regional Peace?* Global Witness, London, UK.

Global Witness (2005) *Timber, Taylor, Soldier, Spy: How Liberia's Uncontrolled Resource Exploitation, Charles Taylor's Manipulation and the Re-recruitment of Ex-combatants are Regional Peace*. A Report Submitted to the UN Security Council. Global Witness, London, UK.

Groombridge, B. & Jenkins, M.D. (2000) *Global Biodiversity: Earth's Living Resources in the 21st Century*. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Hall, J.S., Saltonstall, K., Inogwabini, B.I. & Omari, I. (1998) Distribution, abundance and conservation status of the Grauer's gorilla. *Oryx*, **32**, 122–130.

Hanyona, S. (2003) *Man-Animal Conflict Continues in Hwange.* Http://www.zimbabwesituation.com/jul31_2003.html#link12 [accessed 24 January 2006].

Hart, T. & Mwinyihali, R. (2001) *Armed Conflict and Biodiversity in Sub-Saharan Africa: The Case of the Democratic Republic of Congo*. Biodiversity Support Program, Washington, DC, USA.

Hart, T.B., Hart, J.A. & Hall, J.S. (1996) Conservation in the declining nation state. *Conservation Biology*, **10**, 685–686.

Hatton, J., Couto, M. & Oglethorpe, J. (2001) *Biodiversity and War: A Case Study of Mozambique*. Biodiversity Support Program, Washington, DC, USA.

Hayes, K.T. (2002) *Coltan Mining in the Democratic Republic of Congo: The Implications and Opportunities for the Telecommunications Industry*. Unpublished Report, Fauna & Flora International, Cambridge, UK.

Inogwabini, B.I., Hall, J.S., Vedder, A., Curran, B., Yamagiwa, J. & Basabose, K. (2000) Status of large mammals in the mountain sector of Kahiezi-Biega National Park, Democratic Republic of Congo in 1996. *African Journal of Ecology*, **38**, 269–276.

Inogwabini, B.I., Ilambu, O. & Gbanbi, M.A. (2005) Protected Areas in the Democratic Republic of Congo. *Conservation Biology*, **19**, 15–22.

IUCN (2004) *Reprieve Planned for Garamba's Rhinos: Extra Efforts Promised to Safeguard their Homeland*. IUCN press release, Gland, Switzerland, 21 January 2004.

Jacobs, M.J. & Schloeder, C.A. (2001) *Impacts of Conflict on Biodiversity and Protected Areas in Ethiopia*. Biodiversity Support Program, Washington, DC, USA.

Jennings, C. (2001) *Across the Red River: Rwanda, Burundi and the Heart of Darkness*. Orion Books Limited, London, UK.

Kalpers, J. (2001a) *Overview of Armed Conflict and Biodiversity in Sub-Saharan Africa: Impacts, Mechanisms and Responses*. Biodiversity Support Program, Washington, DC, USA.

Kalpers, J. (2001b) *Volcanoes Under Siege: Impact of a Decade of Armed Conflict in the Virungas*. Biodiversity Support Program, Washington, DC, USA.

Kalpers, J., Williamson, E.A., Robbins, M.A., McNeilage, A., Nzamurambaho, A., Lola, N. & Mugiri, G. (2003) Gorillas in the crossfire: population dynamics of the Virunga Mountain gorillas over the past three decades. *Oryx*, **37**, 326–337.

Kanyamibwa, S. (1998) Impact of war on conservation: Rwandan environment and wildlife in agony. *Biodiversity Conservation*, **7**, 1399–1406.

Kanyamibwa, S. & Chantereau, O. (2000) Building regional linkages and supporting stakeholders in areas affected by conflict: experience from the Albertine Rift Region. In *Nature in War: Biodiversity Conservation During Conflict* (eds E. Blom, W. Bergmans, J. Dankelman, P. Verweij, M. Voeten & P. Wit), pp. 45–58. Netherlands Commission for International Nature Protection, Leiden, The Netherlands.

Kayanja, F. & Douglas-Hamilton, I. (1984) The impact of the unexpected on the Ugandan National Park. In *National Parks, Conservation and Development. The Role of Protected Areas in Sustaining Society* (eds J.A. McNeely & K.R. Miller), pp. 87–92. IUCN/Smithsonian Institution Press, Washington, DC, USA.

Kimani, M. (1995) *Meeting Energy Requirements in Refugee Situations: A Case Study in Household and Institutional Energy Interventions in Goma, Zaire and Dadaab, Kenya*. GTZ, Berlin, Germany.

Knudson, B. (2002) *Deforestation and Fuelwood Supply Tightly Linked, Analysis Suggests.* Http://www.she-inc.org/art.php?id=5 [accessed 30 September 2006].

Lanier-Graham, S.D. (1993) *The Ecology of War: Environmental Impacts of Weaponry and Warfare*. Walker, New York, USA.

Lanjouw, A. (2001) Building partnerships in the face of political and armed crisis. In *War and Tropical Forests: Conservation in Areas of Armed Conflict* (ed. S.V. Price), pp. 93–114. Haworth Press, New York, USA.

Marshall, M.G. & Gurr, T.R. (2005) *Peace and Conflict 2005: A Global Survey of Armed Conflict, Self-Determination Movements and Democracy.* Http://www.cidcm.umd.edu/peace_and_conflict.asp [accessed 15 March 2006].

McNeely, J.A. (2003) Conserving forest biodiversity in times of violent conflict. *Oryx*, **37**, 141–152.

Meredith, M. (2005) *The State of Africa: A History of Fifty Years of Independence*. Free Press, London, UK.

Muir, R. (2004) *Democratic Republic of Congo: Crisis in the PNVi, Encroachment of the Mikeno Sector.* Http://www.zaf.de/presse/hintergrund/DRCcrisis.pdf [accessed 16 June 2004].

Omari, I. (2004) *Ecology of the Eastern Lowland Gorilla: Is there Enough Scientific Knowledge to Mitigate Conservation Threats Associated with Extreme Disturbances in Its Distribution Range?* Http://www.brookfieldzoo.org/pagegen/inc/ACLlambu.pdf [accessed 25 January 2006].

Plumptre, A.J. (1996) Modelling the impact of large herbivores on the food supply of mountain gorillas and implications for management. *Biological Conservation*, **75**, 147–155.

Plumptre, A.J. (2003) Lessons learned from on-the-ground conservation in Rwanda and the Democratic Republic of Congo. In *War and Tropical Forests: Conservation in Areas of Armed Conflict* (ed. S.V. Price), pp. 71–92. Haworth Press, New York, USA.

Plumptre, A.J., Bizumuremyi, J.B., Uwimana, F. & Noaruhebeye, J.D. (1997) The effects of the Rwandan Civil War on the poaching of ungulates in the PNdV. *Oryx*, **31**, 265–273.

Plumptre, A.J., Masozera, M., Fashing, P.J., McNeilage, A., Ewango, C., Kaplin, B.A. & Liengola, I. (2002) *Biodiversity Surveys of Nyungwe Forest Reserve in SW Rwanda*. WCS Working Papers No. 18, WCS, New York, USA.

Plumptre, A.J., Masozera, M. & Vedder, A. (2001) *The Impact of Civil War on the Conservation of Protected Areas in Rwanda*. Biodiversity Support Program, Washington, DC, USA.

Redmond, I. (2001) *Coltan Boom and Gorilla Bust. The Impact of Coltan Mining on Gorillas and other Wildlife in the Eastern Democratic Republic of Congo*. Report, Dian Fossey Gorilla Fund, Atlanta, USA and Born Free Foundation, Horsham, UK.

Reinartz, G. & Inogwabini, B.I. (2001) Bonobo survival and a wartime conservation Mandate. In *The Great Apes – Challenges for the 21st Century, Conference Proceedings*, pp. 52–55. Chicago Zoological Society, Chicago, USA.

Saegusa, A. (2000) Congo war increases threat to Bonobo research. *Nature*, **405**, 262.

Sato, H., Yasui, K. & Byamana, K. (2000) Follow-up survey of the environmental impacts of the Rwandan refugees on eastern D.R. Congo. *Ambio*, **29**, 122–123.

Schoene, C. (2003) *Rwanda: Conservation in a Haunted Country.* Http://jounrals.sabinet.co.za/images/ejour/wild/wildnews_2003_a23.pdf [accessed 25 January 2005].

Shambaugh, J., Oglethorpe, J. & Ham, R. (2000) *The Trampled Grass: Mitigating the Impact of Armed Conflict on the Environment*. Biodiversity Support Program, Washington, DC, USA.

Sharman, J. (2001) *Zanu PF's Legacy to Zimbabwe.* Http://www.africantears.netfirms.com/intro.htm [accessed 21 January 2006].

Sokanele-Zvakwana (2005) *Zimbabwe: Transfrontier Park and Heritage Site under Threat.* Http://www.sokanele.com/article/sokanele/informationaboutillegalhunting_august2003.html [accessed 15 November 2005].

State Failure (2001) *Internal Wars and Failures of Governance 1955–2002. Political Instability Task Force.* Http://www.cidcm.umd.edu/inscr.stfail/ [accessed 7 October 2005].

Stephenson, P.J. & Newby, J.E. (1997) Conservation of the Okapi Wildlife Reserve, Zaire. *Oryx*, **31**, 49–58.

Tshombe, R., Hart, T. & Amboya, C. (2005) Impacts of conflicts on forests and people in Democratic Republic of Congo. *ETFRN News*, **43–45/05**, 45–47.

UN (2001) *Report of the Panel of Experts on the Illegal Exploitation of Natural Resources and Other Forms of Wealth of the Democratic Republic of Congo*. United Nations, New York, USA.

UNEP (United Nations Environment Programme) (2005) The impact of refugees and internally displaced persons on local environmental resources. *Environmental Emergencies News*, **5**.

UNEP-WCMC (2002a) *Garamba National Park, Democratic Republic of Congo.* Http://www.unep-wcmc.org/sites/wh/garamba.html [accessed 15 April 2005].

UNEP-WCMC (2003) *Kahuzi-Biega National Park, Democratic Republic of Congo.* Http://www.unep-wcmc.org/site/wh/kahuzi-b.html [accessed 15 April 2005].

UNHCR (UN High Commission for Refugees) (1995) *Populations of Concern to UNHCR: A Statistical Overview (1994)*. UNHCR, Geneva, Switzerland.

UNHCR (UN High Commission for Refugees) (1996) *Populations of Concern to UNHCR: A Statistical Overview (1995)*. UNHCR, Geneva, Switzerland.

UNHCR (UN High Commission for Refugees) (1997) *Populations of Concern to UNHCR: A Statistical Overview (1996)*. UNHCR, Geneva, Switzerland.

UNHCR (UN High Commission for Refugees) (1999) *Refugees and Others of Concern to UNHCR - 1998 Statistical Overview.* UNHCR, Geneva, Switzerland.

UNHCR (UN High Commission for Refugees) (2005) *Statistical Yearbook 2003: Trends in Displacement, Protection and Solutions.* UNHCR, Geneva, Switzerland.

UNHCR (UN High Commission for Refugees) (2006a) *Statistical Yearbook 2004: Trends in Displacement, Protection and Solutions.* UNHCR, Geneva, Switzerland.

UNHCR (UN High Commission for Refugees) (2006b) *2005 Global Refugee Trends: Statistical Overview of Populations of Refugees, Asylum-seekers, Internally Displaced Persons, and Other Persons of Concern*. UNHCR, Geneva, Switzerland.

UNOCHA (UN Office for the Coordination of Humanitarian Affairs) (2004) *Cote D'Ivore: Civil War Allows Rampant Illegal Logging*. Http://www.irinnews.org/report.asp?ReportID=44801 [accessed 9 February 2005].

Vanasselt, W. (2003) Armed conflict, refugees and the environment. *World Resources*, **2002–2004**, 25–27.
Van Krunkelsven, E., Bila-Isia, I. & Draulans, D. (2000) A survey of bonobos and other large mammals in the Salonga National Park, Democratic Republic of Congo. *Oryx*, **34**, 181–187.
Vogel, G. (2000) Conflict in Congo threatens bonobos and rare gorillas. *Science*, **287**, 2386–2387.
Wabbes-Candotti, S. (2000) The evolving role of an international conservation organization in times of war: the WWF in the Democratic Republic of Congo. In *Nature in War: Biodiversity Conservation During Conflict* (eds E. Blom, W. Bergmans, J. Dankelman, P. Verweij, M. Voeten & P. Wit), pp. 21–38. Netherlands Commission for International Nature Protection, Leiden, The Netherlands.
Westing, A.H. (1992) Protected natural areas and the military. *Environmental Conservation*, **19**, 343–348.
Wilson, D. (1991) The conflict in Rwanda and its impact on mountain gorillas. *Oryx*, **25**, 119–120.
Wit, P. (2000) The impacts of conflict on nature and the environment. In *Nature in War: Biodiversity Conservation During Conflict* (eds E. Blom, W. Bergmans, J. Dankelman, P. Verweij, M. Voeten & P. Wit), pp. 9–20. Netherlands Commission for International Nature Protection, Leiden, The Netherlands.
Yamagiwa, J. (2003) Bushmeat poaching and the conservation crisis in Kahiezi-Biega National Park, Democratic Republic of Congo. In *War and Tropical Forests: Conservation in Areas of Armed Conflict* (ed. S.V. Price), pp. 115–136. Haworth Press, New York, USA.
ZCTF (2006) *Zimbabwe's Tragedy*. Http://www.zctf.mweb.co.zw [accessed 13 January 2006].

Appendix

The Appendix for this article is available online at http://journals.cambridge.org

Biographical sketches

Louise Glew has a particular interest in conservation in developed countries and the ecology of predators in Africa. She is currently involved in developing ecological sensitivity maps for marine ecosystems in eastern Africa.

Malcolm Hudson's research interests include managing human impacts on natural environments, both terrestrial and coastal, and environmental impact assessment.

https://doi.org/10.1017/S0030605307001755 Published online by Cambridge University Press