

Effects of War and Civil Strife on Wildlife and Wildlife Habitats

JOSEPH P. DUDLEY,*§ JOSHUA R. GINSBERG,† ANDREW J. PLUMPTRE,†
JOHN A. HART,† AND LILIANA C. CAMPOS‡

*Institute of Arctic Biology, University of Alaska Fairbanks, AK 99775-7000, U.S.A.

†Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, NY 10460, U.S.A.

‡Tanana Chiefs Conference, Fairbanks, AK 99701, U.S.A.

Abstract: *Historically, the no-man's land created by human warfare often protected wildlife and habitats by limiting human incursions and human population densities within disputed territories. Relatively few examples of this phenomenon have been identified in conjunction with recent and ongoing wars in developing countries, however. Modern wars and civil strife are typically associated with detrimental effects on wildlife and wildlife habitats. Most cited instances of contemporary war-zone refuges refer to military security areas that are functionally and geographically distinct from actual battlefields or areas subject to armed civil conflicts. The disappearance of the war-zone refuge effect is attributable to modern trends in the scale, intensity, or technologies associated with military conflicts and violent civil strife. Munitions and chemical agents exert both immediate and residual effects, direct and indirect, on wildlife and habitats. Overharvesting of wildlife and vegetation in conflict zones exacerbates existing constraints on the access to natural resources, threatening both the resource base and the livelihoods of local communities dependent on these resources. Socioeconomic studies have identified causative linkages between environmental degradation and violent civil strife, with the scarcity of natural resources fostering the emergence of war and civil conflicts in developing countries. Wars and civil strife create positive feedback that reinforces and amplifies interactions between and among ecosystem vulnerability, resource availability, and violent conflict. Strong and flexible partnerships between local communities, nongovernmental organizations, and international institutions may be a critical factor in mitigating the effects of war on wildlife by helping to maintain continuity in conservation efforts during periods of political instability.*

Efectos de la Guerra y Conflictos Civiles Sobre la Vida Silvestre y Sus Hábitats

Resumen: *Históricamente, las tierras sin dueño creadas por la guerra a menudo protegían la vida silvestre y sus hábitats al limitar las incursiones de humanos y la densidad de poblaciones humanas dentro de los territorios en disputa. Sin embargo, se han identificado relativamente pocos ejemplos de este fenómeno en conjunción con guerras recientes y actuales en países en vías de desarrollo. Las guerras modernas y los conflictos civiles se asocian típicamente con efectos perjudiciales sobre la vida silvestre y sus hábitats. La mayoría de los casos citados de refugios en zonas de guerra contemporáneas se refieren a áreas de seguridad militar que son funcional y geográficamente distintas de campos de batalla o de áreas sujetas a conflictos civiles armados. La desaparición del efecto de un refugio de zona de guerra histórico es atribuible a las tendencias modernas en cuanto a la escala, intensidad o tecnologías asociadas con conflictos militares y civiles violentos. Munición y agentes químicos producen efectos tanto inmediatos como residuales, directos e indirectos, sobre la vida silvestre y sus hábitats. La sobreexplotación de la vida silvestre y la vegetación en zonas de conflicto exagera las limitaciones existentes al acceso a los recursos naturales, lo que amenaza tanto a la base de recursos como a la forma de vida de las comunidades locales que dependen de estos recursos. Estudios socioeconómicos han identificado relaciones causales entre la degradación ambiental y conflictos civiles violentos.*

§Current address: Bureau for Asia & the Near East, U. S. Agency for International Development, 1300 Pennsylvania Avenue NW, Washington, D.C., U.S.A., email fnjpd@aurora.alaska.edu

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tos; la escasez de recursos naturales fomenta el surgimiento de guerras y conflictos civiles violentos en países en vías de desarrollo. Las guerras y conflictos civiles crean relaciones de retroalimentación positiva que refuerzan y amplifican interacciones causales entre la vulnerabilidad de ecosistemas, la disponibilidad de recursos y conflictos civiles violentos. Asociaciones fuertes y flexibles entre comunidades locales, organizaciones no gubernamentales e instituciones internacionales pueden constituir un factor crítico en la mitigación de los efectos de la guerra sobre la vida silvestre al ayudar a mantener la continuidad de los esfuerzos de conservación durante períodos de inestabilidad política.

Introduction

Historically, the no man's land created by human warfare protected wildlife by limiting human incursions and settlements within disputed territories and preventing the overexploitation of wildlife and vegetation inhabiting these areas (Martin & Szuter 1999). Relatively few examples of Martin and Szuter's (1999) "war-zone/game source" phenomenon can be identified in conjunction with active wars and military conflicts during the latter half of the twentieth century, however, although military-controlled security areas along national frontiers sometimes perform similar functions (Kim 1997; Martin & Szuter 1999). Under present circumstances, we predict that any potential benefits of human warfare for wildlife populations will be transient at best and overwhelmed in the long term by the debilitating after-effects of war on environments, economies, and civil society.

To evaluate this hypothesis, we reprise the war-zone/game-source hypothesis of Martin and Szuter (1999) and expand on previous discussions of war and wildlife issues by Fimbel and Fimbel (1997), Hall et al. (1997), Hart and Hall (1996), Hart and Hart (1997), and Martin and Szuter (1999). We review the effects of recent and current wars on large mammals and their habitats, with particular reference to tropical regions of Africa and Asia. We introduce sociopolitical models used for the analysis of interrelationships between environmental and political factors in the context of international security issues (Homer-Dixon et al. 1993; Homer-Dixon 1999; Lietzmann & Vest 1999) and identify self-reinforcing feedback between ecosystem vulnerability, natural-resource degradation, and violent civil conflict. We discuss the need for maintaining continuity in conservation projects during periods of political instability and identify strategies for maximizing the sustainability of conservation programs in areas subject to disruption by war or civil strife.

War Zones

Disputed territories and territorial frontiers have often functioned as de facto refuges for wildlife by limiting hu-

man disturbance and human settlements. The texts of the *Arthashastra*, a classical Indian work on statecraft (circa 300 B.C.), prescribed strict protection for wild elephants (*Elephas maximus*) living in forests along the boundaries of kingdoms and regulations for timber extraction (McNeely et al. 1995; Poffenberger 2000). Elephants and large carnivores may have been protected within frontier areas in part for their value as active deterrents to human incursion and settlement. Martin and Szuter (1999) have documented the importance of tribal warfare as a determinant of the distribution and abundance of ungulates and large carnivores in west-central North America, and use the terms "war zone" and "buffer zone" interchangeably with reference to the role of disputed territories as "game sources." The war-zone/buffer-zone of Martin and Szuter (1999) correlates the location of nineteenth-century population refugia for ungulates and carnivores with disputed areas (no-man's lands) within a landscape matrix of overharvested tribal territories. For the purposes of this analysis, we use the term *war-zone refugium* when referring to the war-zone/game-source phenomenon.

Martin and Szuter (1999) identified the demilitarized zone between North and South Korea as a modern example of a war-zone refugium. Despite the limitations imposed by land mines and razor-wire fencing, depopulated and fortified military security areas along national frontiers may provide useful and relatively secure refuges for some important species of both plants and animals (Kim 1997; Martin & Szuter 1999). Most such wildlife-friendly military security areas cited as modern examples of war-zone refugia are Iron Curtain artifacts of the Cold War that are of limited usefulness for understanding the scope and magnitude of environmental effects associated with most recent armed conflicts in Asia, Africa, Latin America, and elsewhere (Booth 1998). Although military conflict may indeed provide short-term benefits to wildlife and biodiversity in certain situations, most wars during the latter half of the twentieth century (1960-1999) have been associated with markedly negative effects on wildlife and wildlife habitats (Table 1).

An estimated 160 wars have been recorded since the end of World War II, with 52 active major conflicts in 42 countries reported for 1993, 34 for 1995, and 27 for

Table 1. Effects of war and civil strife on wildlife and wildlife habitats in Africa, Eurasia, and the Middle East (1960–1999).

Locality	Time period	Major impacts	Cause	Reference
Vietnam	1961–present	maimings and mortality of civilians and livestock	land mines, ordnance	Westing 1996
	1961–1969	estimated 20% of forested areas in South Vietnam chemically defoliated	herbicides	Westing 1996
	1961–1969	large-scale conversion of dense tropical forest to <i>Imperata</i> grasslands	herbicides	Dinh 1984
	1961–1969	herbicide-poisoning mortality of domesticated bovids \geq 96% in some localities	herbicides	Dang et al.
	1961–1969	herbicide-induced mortality of wildlife	herbicides	Dang et al.
Zimbabwe (formerly Southern Rhodesia)	post-war	24 spp. of birds in sprayed/converted areas; 145–170 spp. in unsprayed control sites	herbicides	Vo Quy et al. 1984
	1972–1980	5 spp. of mammals in sprayed/converted habitats; 30–55 spp. in control forests	herbicides	Vo Quy et al. 1984
	1979–1987	lower rates of elephant and rhino poaching due to presence of combatants	military and police	Hallagan 1981
Uganda		massive declines in populations of elephants and large ungulates;	armaments, civil strife	Eltringham & Malpas 1993
		encroachment and degradation of wildlife reserves	civilians	Eltringham & Malpas 1993
Afghanistan	1979–1994	decimation or extirpation of wild ungulate and carnivore populations;	armaments, lawlessness	Formoli 1995
		widespread environmental degradation and habitat destruction	refugee camps	Formoli 1995
Sri Lanka	1984–1999	illegal killing of elephants, disruption of elephant migratory patterns	army, guerrilla forces	Sukummar 1992
	1986	Wilpattu National Park attacked by rebels, 21 staff killed, facilities destroyed	guerrilla forces	McNeely 1998
Arabian Gulf	1991	severe pollution of aquatic and terrestrial habitats from oil spills, oil mist, and soot; extensive and locally severe oil-spill damage to coastal and littoral habitats;	burning oil wells	Gerges 1993
		severely degraded arid rangeland and desert habitats;	marine oil spills, soot, smoke	Price and Robinson, 1993
		severe surface erosion in arid range land desert habitats;	atmospheric oil and soot	Gerges 1993
		rinderpest epizootic among domesticated livestock	tanks, troop carriers	Alam 1993
Rwanda	1990–1997	lower rates of mammal poaching in eastern sector Parc National des Volcans;	refugee and livestock	Gerges 1993
		increased rates of poaching in western sector of Parc National des Volcans;	diaspora	
		known and suspected mortality of gorillas from land mines	minefields, guerrillas	Plumptre et al. 1997
		greatly increased rates of elephant poaching and habitat encroachment;	army, villagers	Plumptre et al. 1997
Republic of Congo (formerly Zaïre)	1990–1999	forest areas of Kahuzi Biega National Park burned to displace rebel forces;	land mines	Pech 1995
		bonobo and gorillas severely affected by intense poaching in conflict zones	army, guerrillas, refugees	Hall et al. 1997
Bosnia-Herzegovina	1992–1994	forests degraded by fuelwood overharvesting near cities and settlements;	army, guerrillas, army	W.C.S., unpublished report
		bark beetle outbreaks in forests	refugees	Vogel 2000
Iraq	1999–2000	large-scale drainage of Tigris-Euphrates marshlands to expose rebel sanctuaries	local inhabitants	Fell & Bader 1997
			artillery and bomb damage	Fell 1997
			Iraqi government	UNEP 2001

1999 (Kane 1995; Collier 2000). The frequency of wars around the world has risen substantially during the past 50 years. During the 1990s, there were more than three times as many ongoing wars than at any given time during the 1950s, and there were about twice as many as at any time during the 1960s (Kane 1995; Collier 2000). The majority of recent wars have involved internal conflicts among political factions or ethnic groups within countries rather than international military confrontations between different nation states. Refugee migrations caused by war or civil strife in one country often affect the political stability of neighboring countries, resulting in convoluted patterns of simultaneous and/or iterative wars and civil wars within affected regions (Kane 1995). This pattern of regional destabilization in conjunction with refugee migration has been evident in recent and ongoing armed conflicts in western and central Africa, the Balkans, Central America, and the Middle East.

One aspect of human warfare that has not changed appreciably over the past few millennia is the need for displaced human populations and isolated military and paramilitary forces to "live off the land" by foraging indiscriminately for food, shelter, and material goods. Displaced human populations undergoing food and fuel shortages in lawless landscapes exact heavy tolls on wildlife and habitats (Formoli 1995; Pech 1995). Military, paramilitary, and guerrilla forces lacking established or secure lines of supply often subsist partly or entirely on wild animals and plants. Large mammals, when available, are often an important source of food for isolated military or paramilitary groups operating within war zones and disputed territories (Plumptre et al. 1997; Martin & Szuter 1999). Military forces stationed in conflict areas often contribute to, rather than prevent, the overharvesting of wild animals within occupied territories. Opportunistic, accidental, and random shooting of animals by combatants in free-fire zones may be a significant cause of mortality among wildlife and livestock populations.

Africa

Modern instances of war-zone refugia have been reported from the 1972–1980 Southern Rhodesia/Zimbabwe civil war and the 1990–1994 Rwandan civil war (Hallagan 1981; Plumptre et al. 1997). In both these countries, lower rates of poaching within national parks and wildlife reserves adjoining international borders were attributed to the presence of military and guerrilla forces operating in these areas. The war-zone refugium observed in the Parc National des Volcans, Rwanda, was limited to the eastern portion of the study site, however, with increased rates of poaching recorded elsewhere within the study area (Plumptre et al. 1997).

The negative effects of war on wildlife are much more commonly observed. The 1979 war in Uganda precipi-

tated massive declines in populations of elephants (*Loxodonta africana*) and other large mammals (Malpas 1981; Eltringham and Malpas 1993). African elephants in the Democratic Republic of Congo (formerly Zaire), which once constituted perhaps 20% of the total continental population, are believed to have been severely affected by recent civil wars and migrations of refugees into protected areas (Said et al. 1995; Hart & Hall 1996; Hall et al. 1997; Plumptre et al. 2000). Poaching of bonobos (*Pan paniscus*) and gorillas also increased dramatically in the Democratic Republic of Congo as the result of ongoing civil wars in the region (Plumptre et al. 2000; Vogel 2000). Civil disturbances during and subsequent to the Rwandan civil war greatly increased poaching of mountain gorilla (*Gorilla gorilla beringei*), buffalo (*Synceiros caffer*), and antelopes (Plumptre et al. 1997).

Wildlife products are often sold or bartered for food, arms, ammunition, other goods, or services. Elephants and rhinos are often killed solely for ivory or horns, whereas ungulates, primates, and carnivores may be killed for meat, furs, ornaments, or body parts for ritual or medicinal purposes (Malpas 1981; Cumming et al. 1990). The presence of military forces may alleviate or aggravate the illegal harvesting of plants and animals within reserve areas (Plumptre et al. 1997). Military combatants and foreign "peacekeeping" forces may be both suppliers and consumers of wildlife products. Over the past several years, the wildlife populations of reserves in the eastern districts of the Democratic Republic of Congo (i.e., Garamba National Park, Kahuzi-Biega National Park, Okapi Wildlife Reserve) have been severely depleted as the result of poaching by refugees, guerrillas, and army forces (Plumptre et al. 2000). Similar circumstances are believed to have contributed to the decimation and extirpation of many if not most populations of African elephants in Angola, Mozambique, Sudan, Somalia, and Uganda over the past two decades (Said et al. 1995).

Asia

The Second Indochina War ("Vietnam War") and Afghan-Soviet War were accompanied by a broad spectrum of negative environmental effects (Formoli 1995). Chemical and conventional weapons were used by the United States during the Second Indochina War, by Soviet forces in Afghanistan, and by Iraq during the 1982–1983 Iran-Iraq War (Westing 1984; Henderson 1999). Despite its brevity, the 1991 Arabian Gulf War was accompanied by landscape-scale detrimental effects on terrestrial, coastal, and marine ecosystems (Price & Robinson 1993; Table 1).

Asian elephants (*Elephas maximus*) were routinely strafed and bombed by U.S. military aircraft during the Second Indochina War, on the assumption that they might be captives used by opposition forces for trans-

port of military supplies (Chadwick 1992; M. Bengé, personal communication). United States military aircraft sprayed an estimated 100,000 tons of highly concentrated defoliant herbicides over large areas of Vietnam, Laos, and Kampuchea from 1961 to 1969 (Westing 1984). Mortality and habitat alteration associated with herbicides have been implicated in marked declines or local extirpations of wild carnivores, ungulates, rhinoceros, and elephants in central Vietnam (Dang et al. 1984). Herbicide defoliation has facilitated the large-scale invasion and replacement of species-rich tropical forests by species-poor *Imperata cylindrica* grasslands (Dinh 1984). Acute and chronic exposure to sublethal doses of defoliant herbicides has been identified as a possible cause of birth defects and illness in humans and livestock in heavily sprayed areas (Westing 1984).

Wildlife populations in Afghanistan and Sri Lanka are believed to have declined significantly as the result of long-term armed conflicts within these countries. Military and civil conflicts in Afghanistan during and subsequent to the 1979–1991 Afghan-Soviet War severely affected wildlife populations by promoting the overharvest of carnivores and ungulates for meat, furs, and other consumable or marketable byproducts (Formoli 1995). Asian elephants in northern Sri Lanka have been subject to disruption and illicit killing by military and guerrilla forces since 1984 as the result of armed conflict between Tamil separatists and government forces, and 49% of the “protected” range of elephants in Sri Lanka is currently inaccessible to scientists and wildlife officers as the result of the ongoing guerrilla war (Sukumar 1992; Santiapillai and Jayewardene 1999).

Land Mines and Munitions

Explosives, firearms, and most other weapons employed in modern warfare may be sources of immediate and long-term damage to humans, livestock, and wildlife. The problem of land mines and residual munitions (e.g., bombs, artillery shells, hand grenades, etc.) within active and former war zones is immense and increasing steadily. The proliferation and persistence of land mines, unexploded ordnance, and explosive residues in war zones and disputed territories is a major impediment to the potential function of these areas as refuges for endangered large-mammal species (cf. Westing 1996). Land mines are routinely deployed in military security areas and combat zones in most countries, and the exact location and extent of minefields in combat zones and the frontier areas of developing countries are often poorly documented. White phosphorus residues from exploded munitions have been identified as a significant cause of mortality among waterfowl populations inhabiting U.S. military training ranges (Sparling et al. 1998; Vann et al. 2000).

The majority of the >100,000,000 land mines deployed in countries around the globe are not triggered by combatants and can remain in place and ready to explode for decades (Westing 1996). Cambodia alone has more than 2000 known minefields containing an estimated 6–10 million land mines; minefields currently occupy some 1.8% of Cambodia’s national territory (Royal Government of Cambodia and United Nations Environmental Program 1994). Although the presence of land mines may limit human intrusions to some degree, mine triggers do not differentiate between humans and non-target species of sufficient mass to activate them (≥ 10 kg) (Westing 1996). We believe that heavily mined military security areas probably do not constitute viable long-term refuges for endangered large-mammal species such as apes, elephants, buffalo, tigers and bears.

Sociopolitical and Economic Models

Wars result in the disruption of government services and functions, destruction of physical resources and infrastructure, depletion of human and economic capital, and diversion of public expenditures into support of military and police sectors (Collier 1999). The alienation of foreign investment capital and international development aid typically associated with political instability, war, or civil strife in developing countries may forestall the deforestation and environmental degradation often associated with rapid industrialization and large-scale, externally funded infrastructure projects. Nonetheless, the potential short-term benefits of isolation from economic development are probably outweighed by the long-term effects of a concurrent breakdown in the local institutional capacity for the sustainable management of natural resources (Goldstone 1996).

Political destabilization often leaves developing countries subject to the ministrations of high-risk venture capitalists and multinational pirate corporations that have no vested political or economic interests in economic sustainability or the mitigation of the environmental and social effects of unrestrained exploitation of natural resources. Control of mining areas and marketing monopolies for diamonds, gold, or strategic minerals has been an important factor in ongoing, long-term civil conflicts in the Republic of Congo, Angola, and Sierra Leone (United Nations General Assembly 2000; United Nations Security Council 2000). The mining resources of the Republic of Congo are being contested by an array of opportunistic corporate and political entities that has included (as of March 2001) Congolian government forces, civilian militias, guerrilla groups, and armies from at least five other African countries (Angola, Namibia, Zimbabwe, Uganda, and Rwanda) (Global Witness 2000).

The likelihood of civil war in developing countries is positively correlated with the importance of natural-

resource commodities in the national economy (Collier & Hoeffler 1998). Homer-Dixon et al. (1993) identified causative linkages between environmental degradation and civil conflict, with natural or human-induced scarcities of renewable natural resources (e.g., croplands, forest products, fisheries stocks, fresh water) fostering the development of violent civil strife in developing countries (see also Homer-Dixon 1999). Lietzmann and Vest (1999) provided alternative models of the relationship between environmental factors and political violence. We suggest that the ecological degradation of landscapes associated with war and civil strife creates positive, self-reinforcing feedback loops between those environmental and socioeconomic factors that may foster or contribute to the development of war and violent civil conflict (Figs. 1 & 2).

The countries hardest hit by the Second Indochina war—Vietnam, Cambodia, and Laos—have similar per capita gross national products (\$300–400), but their forest cover and human population densities are immensely different. Forest loss and wildlife depletion within Indochina during the past two decades have been driven by a complex interplay between economics, politics, and human population density (Kerr and Currie 1995). The absence of external investment in infrastructure development and lack of access to international markets appears to have inhibited deforestation in Cambodia, Laos, and Myanmar from 1975 to 1990. Subsequent to the Second Indochina War, population pressure and destruction of open-access resources have

caused the degradation of wildlife and forestry resources in Indochina, particularly Vietnam, with most remaining forest cover being heavily degraded secondary forest (Bryant et al. 1997; Duckworth & Hedges 1998).

The status of forests and wildlife in densely populated Vietnam (243 people/km², 25% forest cover), the country most heavily affected by the war, most closely resembles that of industrialized Thailand (121 people/km², 25% forest cover), which served as a staging area for U.S. military campaigns during the Second Indochina War. Laos (22 people/km², 55% forest cover) and Cambodia (66 people/km², 68% forest cover), both heavily affected during the war, are more similar in current status to neutral, isolationist Myanmar (72 people/km², 43% forest cover). The opening up of Myanmar to international markets and foreign investment subsequent to a 1988 military coup d'état has resulted in greatly increased stress on natural resources (depletion of forest cover by logging has been estimated at 6000 km² per year).

The Plagues of War

The inability of governments to maintain sanitation, medical, and veterinary support systems during periods of political instability may result in epidemic disease outbreaks within and among human, livestock, and wildlife populations (Lawrence et al. 1980; Kobuch et al. 1990; United Nations Department of Humanitarian Affairs [UNDHA] & Integrated Regional Information Network [IRIN] 1997). Epidemic outbreaks of anthrax and rabies among wild and domesticated animals were attributed to the disruption of government veterinary services during the Southern Rhodesia–Zimbabwe Civil War (Lawrence et al. 1980; Kobuch et al. 1990). Anthrax ultimately spread through livestock populations within six of Zimbabwe's eight provinces, with >10,000 recorded secondary infections in humans before effective control of the disease was reestablished 7 years following the war's end (Pugh & Davies 1990). The Iran–Iraq War and the Arabian Gulf War precipitated rinderpest epidemics among livestock populations, which may have been caused or aggravated by war-related displacement of pastoralists and their flocks (Gerges 1993). Recent outbreaks of human monkeypox and bubonic plague in the Democratic Republic of Congo have been linked to the disruptive effects of the ongoing civil strife (Fenner 1993; UNDHA and IRIN 1997; IRIN 2000). As demonstrated by the recent outbreak of foot-and-mouth disease in Great Britain and Europe, local or regional quarantines resulting from infectious disease outbreaks in humans or livestock can severely affect the economic stability of countries dependent on the export of livestock products and income from international tourism.

Disease outbreaks can be both an artifact and artifice of war. Cultivated and genetically engineered disease or-

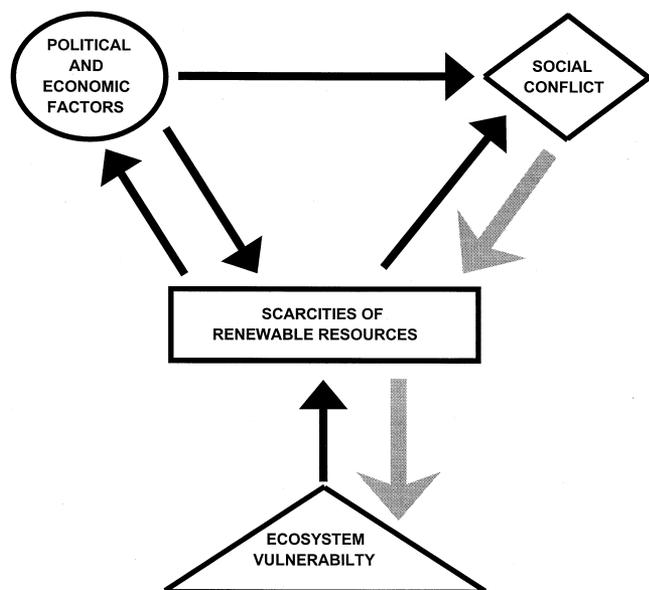


Figure 1. Model of causal relationships between ecosystem sensitivity, availability of renewable resources, political and economic factors, and violent civil strife Homer-Dixon et al. 1993. Gray arrows show positive feedback linkages identified in this analysis.

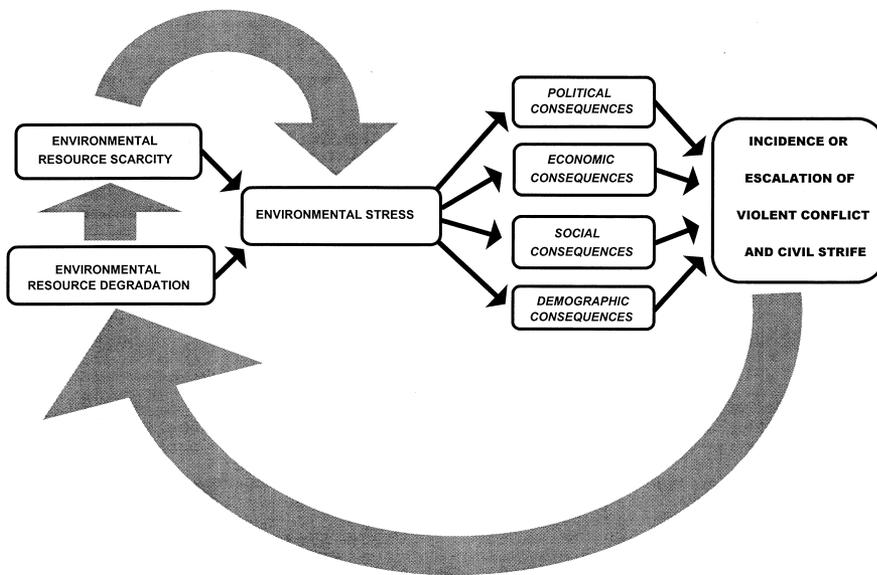


Figure 2. Alternative model of relationships between environmental and sociopolitical factors and the incidence or escalation of violent conflict (after Lietzmann & Vest 1999). Gray arrows show positive-feedback linkages identified in this analysis.

ganisms are considered by some to constitute the most potentially dangerous of all currently available weapon technologies, fusion nuclear devices notwithstanding (Bozheyeva et al. 1999; Henderson 1999). Military and terrorist applications of bioweapons technologies are threats to more than just human lives and livelihoods: some diseases associated with bioweapons may present a real danger to wildlife and floral biodiversity. Plant diseases developed for military use against agricultural crops might infect and proliferate among nontarget species of both wild and domesticated plants (Alibek 2000). Genetically modified diseases of both humans and animals (e.g., bubonic plague, tularemia, anthrax) and weapons-grade strains of livestock diseases (rinderpest, glanders) may be potentially serious threats to populations of both wild and domesticated animals. Diseases cultivated and tested for military applications include numerous zoonotic and epizootic diseases that can infect both wild and domesticated animals, including anthrax, brucellosis, tularemia, glanders, melioidosis, rinderpest, psittacosis, and Venezuelan equine encephalitis (Bozheyeva et al. 1999; Alibek 2000; Kortepeter et al. 2000).

The greatest potential threat of bioweapons to biological diversity is from the proliferation of broad-spectrum diseases of domesticated livestock and crops among naive, susceptible populations of wild plants and animals. Wild species that are naturally rare and species that have been severely depleted in numbers due to overharvesting or habitat degradation are particularly at risk of extinction from introduced diseases of domesticated animals. The traditional livestock breeds and varieties that constitute our most critical reservoirs of genetic diversity for domesticated animal species are also highly susceptible to decimation or extinction from even highly localized disease outbreaks (Ruane 2000; Toro et al. 2000). The effects of canine distemper on the North

American black-footed ferret (*Mustela nigripes*) and the African wild dog (*Lycaon pictus*) is a case in point. Canine distemper is a common viral disease of domesticated dogs and cats that can spread to wildlife. During the past decade, outbreaks of canine distemper have resulted in the extinction of the last known wild population of the North American black-footed ferret and the extirpation of the African wild dog population of Serengeti National Park, Tanzania (Ginsberg et al. 1995; Woodroffe & Ginsberg 1997; Daszak et al. 2000).

The African rinderpest epidemic of a century ago provides a useful heuristic model for evaluating the potential regional effects of disease outbreaks on susceptible wildlife and livestock populations (Daszak et al. 2000). An 1889 rinderpest outbreak in Ethiopia spread from the Horn of Africa to the southern Cape in less than a decade, causing up to 95% mortality among populations of cattle, Cape buffalo (*Synceros caffer*), and wildebeest (*Connochaetes taurinus*) (Sinclair 1979; Smithers 1983). Despite intensive control efforts, rinderpest is now endemic in East Africa, with periodic outbreaks still affecting both livestock and wildlife populations in the region (Dobson 1994). Disease epidemics caused by bioweapons might proliferate more rapidly than natural outbreaks, given the exceptional virulence and enhanced resilience of cultivated disease strains (Bozheyeva et al. 1999; Alibek 2000) and accelerated rates of long-distance transport of disease vectors and infectious materials by motor vehicles, aircraft, and tourists (Daszak et al. 2000).

Environmental Degradation and Civil Strife

National parks and wildlife reserves are increasingly subject to human occupation by guerrillas, military forces,

and refugees during and subsequent to periods of war and civil conflict. Refugees of war and civil strife in east-central Africa dispersed en masse into remote areas along national frontiers, many of which were designated protected areas, in the attempt to escape from civil and ethnic conflicts. Approximately 50% of Rwanda's civilian population was displaced during the Rwandan civil war into camps within the eastern regions of the Republic of Congo (about 3.5 of 7 million people; Prunier 1995). Of these, approximately 860,000 refugees were concentrated in the vicinity of Virunga National Park, with another 332,000 encamped in the Democratic Republic of Congo near Kahuzi Biega National Park (Prunier 1995).

Refugee encampments are often associated with severe environmental degradation. Slash-and-burn agriculture and overharvesting of vegetation for fuel, forage, and construction materials may result in widespread deforestation and erosion. The looting of crops and livestock by combatants and refugees may leave local inhabitants with no practical alternatives to the subsistence and commercial harvesting of bushmeat and wild food plants during periods of civil disruption (Plumptre et al. 1997). Breakdowns in food production and looting of livestock by transients may result in the indiscriminate slaughter of wildlife for food and marketable byproducts such as meat, horn, hides, and ivory (Formoli 1995; Pech 1995; Vogel 2000).

The ecological degradation and environmental changes often associated with war and civil strife threaten the stability and security of national governments in many regions of the developing world (Homer-Dixon 1999; Lietzmann & Vest 1999; North Atlantic Treaty Organization [NATO] 1999). Increased rates of deforestation and conversion of tropical forest habitats in the Andean region of Columbia are attributable in part to instability in land-use patterns and uncertainty of land tenure associated with violent civil conflict in this region (Dávalos 2001). Political instability in the northern Andean region of South America is fueled by a complex array of social, political, economic, and resource pressures related to land use, land tenure, cocaine production and processing, gold mining, oil prospecting, and oil production. Major actors in the so-called Andean "drug wars" include national military and police forces, international drug cartels, peasant farmers, cattle barons, leftist guerrillas, rightist paramilitaries, multinational corporations, and the U.S. government (Dávalos 2001).

Peace Dividends

Despite the severe negative effects of civil war on environments and national economies, the restoration of peace does not necessarily result in improved economic conditions (Collier 1999). The proliferation of vehicles,

roads, and weapons in remote areas during conflicts may facilitate greater rates of resource extraction and wildlife harvesting during and following periods of conflict. The culture of lawlessness engendered by protracted periods of war and civil strife may spill over into peace time, with devastating effects on forests, fisheries, and other marketable forms of natural resources (Eltringham & Malpas 1993; Global Witness 1996, 1998). Peace dividends sometimes come in the form of dangerously increased rates of depletion of renewable natural resources and accelerated rates of destruction of non-renewable natural resources (Eltringham & Malpas 1993).

The effects of postwar ecological and social disruption are at least as significant a threat to wildlife and ecosystems as war itself. Breakdowns in transportation infrastructure and food-marketing networks during and subsequent to wars may prove more devastating to wildlife and habitats than armed conflict, because they force local inhabitants to rely on locally available wildlife and wild plants as their primary sources of food and trade goods (Eltringham & Malpas 1993; Formoli 1995; Plumptre et al. 1997). The looting of landscapes begun during wars can continue unabated into peacetime and may even increase, given circumstances that ensure a lack of military preoccupation with combat activities and a concurrent absence of effective civilian government authority. Rates of deforestation in Cambodia increased exponentially following the end of the Cambodian civil war as the result of large-scale commercial logging controlled and orchestrated by military field commanders and corrupt forestry officials. This situation is compounded by a systemic breakdown in Cambodia's management systems for the regulation of timber harvesting, resulting in large-scale illegal logging and timber exports (Global Witness 2001).

Conservation and Conflict

Recent experiences in central Africa have demonstrated the importance of robust, strong, and flexible partnerships between indigenous field personnel and international organizations for the conservation of endangered wildlife in war zones (Fimbel & Fimbel 1997; Hart & Hart 1997; Plumptre et al. 2000). International and multilateral aid agencies often withdraw management personnel and funds during outbreaks of political or social violence, even when their host-country counterparts are willing to put their own lives at risk to maintain the continuity of projects and conserve their sites. It is local conservationists and field staff who must maintain continuity of presence during periods of political instability, establish lines of communication with local government officials and military administrators in rapidly shifting political landscapes, and provide much-needed material and moral support to besieged reserve personnel in re-

gions beset by war and civil conflict. In instances where government institutions have been overthrown or ceased to function, local nongovernmental organizations and conservationists can help maintain continuity in conservation programs in the absence of support from central government or international organizations. The direct involvement of local residents and communities in forest conservation and protected-areas management has proved a key factor in maintaining conservation efforts in politically unstable regions (Hamilton et al. 2000).

Institutional capacity building and professional training for indigenous professionals and institutions, at both the national and local levels, may be crucial for sustaining conservation efforts within areas subject to war and civil strife. It is especially important to provide training to junior government officers and local field staff, because it is these individuals who typically must bear the burden of maintaining management continuity during periods of political unrest. Capacity building and training are necessary but not sufficient criteria for the sustainable conservation of biodiversity in politically unstable developing countries, however. Institutional commitments to people and places are necessary adjuncts to training and logistical support for sustaining long-term conservation efforts within areas subject to the disruptive effects of war and civil strife. The belief that conservation support will resume when calm returns is essential for maintaining the morale of the local field staff in crisis situations. Commitment, continuity, in-country staff training, and community participation provide a stable foundation that can support conservation efforts even when sites and projects are engulfed by violence during periods of war and political instability.

Conclusions

Modern wars and civil strife are typically associated with markedly negative effects on wildlife and wildlife habitats. The majority of available evidence indicates that most war zones currently function as population sinks rather than refuges for most wildlife species. The disappearance of the historical "war-zone/buffer-zone" effect of Martin and Szuter (1999) is attributable to modern trends in the scale, intensity, and technology of warfare. The Korean Demilitarized Zone and similar military security areas should be considered functionally independent of, and qualitatively distinct from, battlefield zones and areas subject to armed political conflicts. We believe that the loss of the war-zone refugium effect has become a critically important issue because the protected areas that now constitute the principal remaining habitat for endangered species in many developing countries are increasingly subject to invasion by refugees and guerrillas during insurgencies and military conflicts (Plumptre et al. 2000; Vogel 2000; Dávalos 2001).

Intensive subsistence or commercial harvesting of wildlife and vegetation by refugees, combatants, and local residents during periods of civil strife exacerbates the effects of preexisting scarcities of natural resources on local communities and increases the vulnerability of tropical-forest ecosystems to further systemic human degradation. Even in the absence of tactical nuclear warfare (perhaps the ultimate "human-overkill" scenario), the environmental and social effects of war and political violence represent an increasingly serious threat to the viability of conservation and economic development programs within many regions of the globe. Strong and flexible partnerships among indigenous researchers, local communities, and international institutions can be of critical importance to sustaining wildlife conservation efforts during periods of war and violent social conflict. Capacity building for local professionals, community-based organizations, and junior field staff are essential elements of biodiversity conservation strategies in countries that may be subject to disruption by war or violent civil conflict. Based on recent experiences in central Africa, the best preparation for conservation in politically unstable areas is to ensure local involvement and community support for the management of strong, site-based conservation programs.

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