THE EFFECTS OF WAR ON BIODIVERSITY IN TROPICAL FORESTS

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ABSTRACT

Tropical forests are one of the world's last remaining frontiers. And like all frontiers, they are sites of dynamic social, ecological, political, and economic changes. Such dynamism involves constantly changing advantages and disadvantages to different groups of people, which not surprisingly can lead to armed conflict, and all too frequently to war. Many governments have contributed to conflict by nationalizing their forests, so that traditional forest inhabitants have been disenfranchised while national governments sell trees to concessionaires to earn foreign exchange. Biodiversity-rich tropical forests in Papua New Guinea, Indonesia, Indochina, Myanmar, Sri Lanka, Central Africa, the Amazon, Colombia, Central America, and New Caledonia have all been the sites of armed conflict in recent years, sometimes involving international forces. While these conflicts have frequently, even invariably, caused negative impacts on biodiversity, peace is often even worse, as it enables forest exploitation to operate with impunity. Because many of the remaining tropical forests are along international borders, international cooperation is required for their conservation; as a response, the concept of international "peace parks" is being promoted in many parts of the world as a way of linking biodiversity conservation with national security. The Convention on Biological Diversity, which entered into force at the end of 1993 and now has 182 State Parties, offers a useful framework for such cooperation.

1. INTRODUCTION

The "peace dividend" expected from the end of the Cold War has not paid off in terms of reduced violent conflict and the recent events in New York, Washington, and Afghanistan demonstrate the growing potential for highly destructive war. Some tropical countries are facing generalized lawlessness and banditry, including by marauding ex-soldiers in several African nations and drug cartels in some parts of Latin America (Renner, 1996). Tension in various parts of Africa, Central America, Indonesia, Colombia, the Philippines, Sri Lanka and elsewhere are further indications of war as a fact of modern life in many tropical forest countries.

Despite these widespread threats to national sovereignty, governments are obliged under the 1992 Convention on Biological Diversity to conserve their own biodiversity (Article 1) and to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states (Article 3). Any negative impacts of war on biodiversity clearly are contrary to this international agreement. But what, specifically, are the impacts on biodiversity in tropical forest countries of war, preparations for war, and managing the aftermath of war? This paper attempts to identify some of the key issues to be considered in preparing a balanced assessment.

The issues are complicated and the available evidence does not provide simple answers. But it is hard to avoid the conclusion that modern means of communication, growing human populations and levels of resource consumption, increased vulnerabilities of inter-dependent, integrated civil societies, and the spread of modern instruments of war — including chemical and biological weapons – are likely to make future wars extremely destructive for both people and the rest of nature.

On the other hand, war is often seen as part of the way human societies adapt to changing conditions (see, for example, Harris, 1974; Keeley, 1996; and Vayda, 1974). The International Commission on Peace and Food (1994) concluded that: "Historically, all landmark changes in the international political and security system have been the result of armed conflicts, wars and revolutions". It appears that many, even most, societies have been defined by war, and that the organization of a society for the possibility of war has been its principal political stabilizer. The victors who emerged from the ashes of war have sown the seeds that would produce subsequent advances as well as tensions, disputes and conflicts. It often seems that an institutional lack of capacity to adapt to change, or the inertia of vested interests in the *status quo*, means that societies inevitably become maladapted over time, eventually requiring a shock such as war to set them on a different course (Edgerton, 1992).

A fundamental issue is how humans stay within the productive limits of their supporting ecosystem. While most would agree that such adaptation should be possible through the application of knowledge and wisdom, history does not support such a rational view, and in fact war is virtually universal in human societies as a means of resolving conflicts arising from various sources of maladaptation (Keeley, 1996). Underlying stress factors can produce or deepen rifts in societies, with disputes triggered by glaring social and economic disparities and exacerbated by the growing pressures of resource depletion, natural calamities, environmental degradation, and perceived excess population. Biodiversity-related problems like desertification, soil erosion, deforestation, and water scarcity reduce food-growing potential, worsen health effects, and diminish life-support capacity, which can lead to civil conflict and increase the likelihood of war. As Nietschmann (1990a) concludes, on the basis of experience from Nicaragua, "Degraded land and resources are as much a reason for taking up arms as are repression, invasion, and ideology".

Because environmental stress can be a fundamental cause of armed conflict, issues of conserving biodiversity, using biological resources sustainably, and sharing the benefits of such use in a fair and equitable manner — the three objectives of the Convention on Biological Diversity — are critical elements in discussions of national security in tropical forest countries. Investments in activities such as sustainable forestry, water conservation, land reform, and protected areas management, it can be argued, are vital contributions to peace.

This paper will begin by briefly assessing war as one of the traditional social means that human societies have used to adapt to changing environmental conditions, then assess some of the positive and negative impacts of war on tropical forest biodiversity before suggesting several issues that must be addressed if modern civilization is to meet the growing security challenges of the 21st century. It will conclude by showing how conserving biodiversity can contribute to peace, building on the preamble to the Convention on Biological Diversity, which states that, "Ultimately, the conservation and sustainable use of biological diversity will strengthen friendly relations among states and contribute to peace for humankind".

2. THE HISTORY OF WAR AND BIODIVERSITY

Today's biodiversity is to a considerable extent the result of long-term interactions between people and their environments reaching back at least as far as the origins of fire (see, for example, Flannery, 1994; McNeely, 1994; Martin and Klein, 1984; Ponting, 1992). The greatest diversity of terrestrial species today is found in forested areas inhabited by tribal and other indigenous peoples, where relatively large areas of "unoccupied" territory serve as a sort of buffer zone between communities that may be embroiled — at least historically — in virtually constant warfare, including sneak attacks, revenge killings, kidnappings, and raids on livestock (Keeley, 1996). It is instructive, therefore, to briefly examine the impact on biodiversity of warfare among traditional and indigenous societies, how modern armies relate to tropical forest-dwelling tribal peoples, and the influence such relations have had on biodiversity.

Ember and Ember (1992) found that higher frequencies of war in traditional societies can be forecast by a history of unpredictable natural disasters and severe food shortages, as people have tried to protect themselves by going to war to take resources from enemies. Raids often included plundering food stores and gardens of neighbouring groups in the Americas, Polynesia, New Guinea, and Africa, leaving an enemy facing starvation and rendering large areas of territory at least temporarily uninhabited. While this could

serve to provide larger areas of habitat to various species of wildlife, it could also lead to significant increases in the pressure of human population on the remaining wildlife populations. Losses and gains of territory were a very frequent result of warfare among pre-industrial societies, leading to dynamic tribal boundaries; and these frontiers often were places supporting great diversity of species. Keeley (1996) concludes, "Even in situations where no territory exchanges hands, active hostilities along a border can lead to development of a no-man's-land, as settlements nearest an enemy move or disperse to escape the effects of persistent raiding. Although such buffer zones could function ecologically as game and timber preserves, they were risky to use even for hunting and wood cutting because small isolated parties or individuals could easily be ambushed in them".

These buffer zones often are where biodiversity is richest, especially in terms of large mammals. As just one example, in South America at the time of the first contact with Europeans, large settled villages were found along the major rivers in various parts of the Amazon. The chieftains of these societies practised a type of warfare that often involved forces numbering in the hundreds of men drawn from multiple confederated villages who travelled by canoes and used sophisticated tactics to attack their enemies. The powerful chieftains often fought over territory, with large buffer zones separating them; these buffer zones often were refugia for wild game (Ferguson, 1989). In the first voyage up the Amazon's Ucayali river in 1577, Juan Salenas Deloyola contacted three principal groups, similar in culture but speaking different languages (an indication of linguistic separation). Each was separated from the next by a distance of about 250 kilometres about the same distance as was incorporated in the tribal territory. Myers (1979) considers this to be an example of a no-man's land, located between the defended territories of adjacent human groups. While the evidence available at present does not support any particular conclusions about the relationship between ecosystem productivity and war, competition for environmental resources very frequently is a factor in war between different communities in Amazonia at least (Ferguson, 1989). Vulnerability to attack may set a threshold on settlement size, or the threat of raids may encourage people to live together to maintain an adequate defensive force.

Warfare between modern and traditional societies has often involved what might be termed "ecological attacks". As one of the most obvious examples of this, the final destruction of the great herds of American bison (*Bison bison),* the foundation of Plains Indian life in the USA, closely coincided with the defeat of the Sioux and Cheyenne in the 1870s. Biological warfare was also used, either accidentally or intentionally. Diseases such as smallpox, measles, and influenza had a major impact on the native populations of the Americas, Australia, and the Pacific Islands because they lacked immunity to the "new" diseases. Perhaps more important, the Europeans also brought ecological transformations that disrupted traditional economies and replaced native ecosystems with new agricultural systems that produced more of the goods required by colonists (Crosby, 1986), leading to fundamental — and perhaps permanent — changes in biodiversity.

One of the world's biologically-richest areas is in the upper Amazon, including Venezuela, Colombia, and Brazil: a true "biodiversity hotspot" (McNeely, *et al.*, 1990), where borders are not well demarcated. Perhaps not coincidentally, this is also an area that is occupied by a large number of culturally-distinct Indian groups which have formed long-term relationships with their environment, including elements such as warfare, infanticide, and raiding, that are unacceptable in modern society (except, of course, where they are sanctioned by the government as part of modern warfare). For example, Chagnon (1988) has found that among the Yanomamo Indians, the largest Indian group in the Amazon rainforest, 44 percent of males 25 or older have participated in the killing of someone, about 30 percent of adult male deaths are due to violence, and nearly 70 percent of all adults over 40 have lost a close genetic relative due to violence. The relationship between indigenous peoples, biodiversity, colonists, and the modern military in this frontier region is a complex and fascinating one that contains several important lessons for those seeking better understanding of the relationship between biodiversity, conflict, and national security in tropical forest countries.

In November 1981, Brazil's President Fernando Color de Melo issued a decree to give the Yanomamo partial control of their traditional lands. The decree was opposed by the Brazilian military, because the Yanomamo lands extend across the borders with Venezuela and Colombia, a militarily sensitive area. The decree was part of a zoning process which involved dividing the forest into protected areas, land for traditional Indian farming and hunting, and areas permitting environmentally destructive development such as logging, roads, mines, and dams.

However, the Brazilian military has continued to impede full legalization of Indian land rights near its international borders, branding as subversives those scientists who are working internationally to save the Amazonian forest habitats of the indigenous peoples. Lewis (1990) reported on a secret document prepared by the Brazilian High War College proposing that war could be used against indigenous or environmental organizations in the Amazon. Conklin and Graham (1995) observe that "The idea that the Amazon might be invaded by foreign armies aiming to stop the deforestation may appear ludicrous to foreigners, but it is taken seriously in South America and has been used to justify the Brazilian military's tight control of Amazonian policy".

CIMI (1987) concludes that the Brazilian military sees the preservation of the rainforest and its peoples as a threat to national security, considering it necessary to "clean" the frontier strip of obstacles to the implantation of more permanent investments, which spells disaster for the Indians and for biodiversity. This perception perpetuates the conflict among the military, indigenous peoples, and conservation interests.

This military mind-set is not confined to Brazil. In Venezuela, a proposal to create a Yanomamo Biosphere Reserve along the border with Brazil was rejected by the Ministry of External Relations, concerned that national and international public opinion would be mobilized to advance the human rights of the indigenous groups and to promote eventual self-development and self-determination. They singled out a group of Venezuelan ecologists and anthropologists as the core of an international conspiracy to undermine the ability of the government to control the Amazon territory and its native inhabitants (Hill, 1994); the anti-western ideology of the current Venezuelan government may be at least partly a reflection of this concern. And the high-level Congress of the Armies of the Americas (CAA) used a number of distortions to reduce complex social problems into a black and white opposition between "national security" and "terrorist subversion", with those advocating Indian rights being linked to subversive organizations (a group that also included feminists and environmentalists). In essence, the CAA created a mythological history of the relationships between indigenous peoples and their land, defining the problems in terms that required military solutions (Hill, 1994) and ignoring the role of indigenous ways of life in maintaining the rich biodiversity of the upper Amazon, and the dependence of the forest-dwelling people on the biological resources of the forest. Such mythologies are not confined to the Amazon.

New Guinea is a tropical forest-covered island that has been a particularly fertile ground for the study of war, as warfare has been frequent, deadly, and a defining factor in the life of most tribal peoples of the island during the 100 years or so that anthropologists were available to study its highly diverse societies (over 700 languages are known from New Guinea). For example, warfare among the Maring, a people of the New Guinea Highlands, facilitated demographic shifts, adjusted relationships between population and land, and alternated the build up of pig herds with slaughter for pig feasts that played an important role in warfare. Rappaport (1984) saw warfare as part of a self-regulating ecological system which maintained the population of both people and pigs below the carrying capacity of the land. Some of the New Guinea highland cultures have particularly bloody histories. For example, the Mae Enga fought 41 wars for land between 1900 and 1950, of which six resulted in complete routs of the enemy that led to acquisition of new territory from the defeated clan (Meggitt, 1977). Among the Dani people of the New Guinea Highlands, warfare is responsible for almost 30 percent of mortality (Heider, 1970). Warfare in association with hunting has been well documented among a number of other New Guinea groups, including the Purari, the Kiwai, the Trans-Fly peoples, the Marind-Anim, the Kolopom, the Jacquia, and the Asmat.

Generally speaking, the New Guinea tribes engage in two rather different kinds of warfare. One is highly ritualistic, involving hundreds of men who meet on a designated public battleground and shoot arrows at each other; these battles tend to be generally inconclusive and casualties are low. The other kind of warfare is more secular, brief, and infrequent. It often involves a large-scale clandestine attack which kills large numbers of people and destroys property (Shankman, 1991). Some battles lead to massacres of over 100 people in an hour or so (Blick, 1988), which can amount to over 5 percent of the group's population (an impact equivalent to 6 million Japanese dying). Heider (1979) sees New Guinea warfare as a cycle of battles and raids over many years that constantly splits alliances and rearranges confederations, thus setting the stage for subsequent battles. The result of such fighting is that fields and home sites are abandoned, thereby redistributing land and other resources and creating buffer zones that provide sanctuary to at least some components of biodiversity.

Indigenous warfare was prevalent throughout Melanesia, and anthropological accounts of pre-colonial warfare come from the Admiralty Islands, New Ireland, New Britain, Bougainville, Choiseul Island, New Georgia, Malaita, San Cristoval, New Hebrides (now Vanuatu) and New Caledonia, and both coastal and interior New Guinea (summarized in Knauft, 1990).

While the existence or intensity of warfare in pre-state societies is not a simple linear function of population density, population pressure on the land, or protein scarcity, all of these factors are important contributors, and it seems reasonable to conclude that ecological pressure works together with cultural and political dispositions toward warfare. The perception of individual or group land scarcity is a function of socio-cultural as well as ecological organization; perceptions of scarcity are often as important as the pattern of rainfall, the numbers of pigs, or the game animals in the forest (Knauft, 1990). Thus the actual warfare carried out by the indigenous peoples of the tropical forests have involved numerous factors reinforcing each other, including increasing human population density, related clearance of forests to increase domestic food production, and declining wild food resources at the same time that demand for resources is increasing, leading to increased opportunities for conflict. The subsequent population redistribution certainly had profound implications for biodiversity.

To conclude this section, it appears that various forms of war have been part of the way traditional societies adapted to changing conditions, and — at least coincidentally — helped contribute to the rich biodiversity found today in many tropical forest areas occupied by traditional and indigenous peoples. Bringing peace to these regions will remove this means of adaptation, requiring other ways to conserve biodiversity and maintain the capacity to adapt to changing conditions. And what happens when modern war comes to the tropical forests?

3. THE IMPACTS OF WAR ON BIODIVERSITY IN TROPICAL FORESTS

3.1. Negative impacts of war on biodiversity

The negative impacts of war on biodiversity in tropical forests result from the collective actions of large numbers of people (mostly male) for whom war is a dispensation to ignore normal restraints on activities that cause environmental damage. War, and preparations for it, has negative impacts on all levels of biodiversity, from genes to ecosystems. These impacts can be direct — such as hunting and habitat destruction by armies — or indirect, for example through the activities of refugees.

Sometimes these impacts can be deliberate, and a new word has been added to the military vocabulary: "ecocide", the destruction of the environment for military purposes, clearly deriving from the "scorched earth" approach of earlier times. Westing (1976) divides deliberate environmental manipulations during wartime into two broad categories: those involving massive and extended applications of disruptive techniques to deny to the enemy any habitats that produce food, refuge, cover, training grounds, and staging areas for attacks; and those involving relatively small disruptive actions that in turn release large amounts of "dangerous forces" or become self-generating. Examples of the latter are the release of exotic micro-organisms that could cause disease or the planting of landmines — over 100 million now litter active and former war zones around the world (Strada, 1996).

This discussion could be long and dreary, but only a few illustrative cases will be mentioned. Perhaps the most outstanding example is Vietnam, where US forces cleared 325,000 ha of land and sprayed 72,400 cubic meters of herbicides in the name of security (Westing, 1982). The impact on biodiversity was severe; spreading herbicides on 10 percent of the country (including 50 percent of the mangroves) led to extensive low-diversity grasslands replacing high-diversity forests, mudflats instead of highly productive mangroves, major declines in both freshwater and coastal fisheries, and so forth (Nietschmann, 1990a).

Other problems are more systemic. The State Law and Order Restoration Council (SLORC), the military government in Myanmar (formerly Burma), has been involved in violent confrontations with many of the tribal groups who inhabit the densely forested mountain regions along the country's borders with Bangladesh, India, China, Laos, and Thailand. Some of these tribal groups, such as the Karen, have turned to intensive logging to fund their war effort, even though such over-exploitation will eventually destroy the forest cover and make them more open to attack (Harbinson, 1992). The general lawlessness along the border with

Thailand has greatly increased the flow of logs, both with and without government permission, leading to the virtual clear felling of many of the country's most productive forests. The trade in wild animals, especially to China, is also booming.

Africa provides several recent war-related disasters for biodiversity in tropical forests. Like the upper Amazon, the Virunga Volcanoes region (including parts of the Central African countries of Rwanda, Democratic Republic of Congo, and Uganda) is exceptionally rich in species diversity, including the rare and endangered mountain gorilla (*Gorilla gorilla*) whose total population is approximately 600. The civil war against the government of Rwanda was launched in 1990 from within the Virunga Volcanoes region, spreading deeper into Rwanda until 1994 and sending large numbers of refugees fleeing to North Kivu District in what was then Zaire, which then began a civil war of its own. The headquarters of several tropical forest World Heritage sites in Zaire were taken over by the military, including Virunga National Park, Kahuzi-Biega National Park and the Okapi Wildlife Reserve. In 1994, some 850,000 refugees were living around Virunga National Park, partly or completely deforesting some 300 sq km of the park in a desperate search for food and firewood. Up to 40,000 people entered the park every day, taking out between 410 and 770 tons of forest products. The bamboo forests have been especially seriously damaged, and the populations of elephants, buffalo, and hippos have been much reduced. Organizations such as the Red Cross, Médecins Sans Frontière, and CARE have supported well-meaning relief operations on the park boundaries and have even established a dump for medical wastes inside the park, with the obvious disease transmission risks associated with such practices (Pearce, 1994). At least 80 of Virunga's park staff have been killed in battle with insurgents since 1996.

A few other examples (among many that could be provided):

- The administrator and two rangers of the Saslaya National Park in Nicaragua (15,000 ha) were kidnapped by the Contras in 1983, forcing the National Environment Agency to abandon the management of the area (Thorsell, 1990).

- In 1996, the Kibira and Ruvubu national parks in Burundi were used as sanctuaries and entry points for guerrillas fighting the government. As a result they also became operational areas for government troops, with both sides heavily involved in poaching (Winter, 1997).

- India's Manas Wildlife Sanctuary, a World Heritage site, has been taken over by guerrillas from the Bodo tribe, who have burned down park buildings, looted most park facilities, killed guards, destroyed bridges, poached rhinos (*Rhinoceros unicornis)*, elephants (*Elephas maximus*), tigers (*Panthera tigris)*, and other wildlife, cleared forests, and depleted fish stocks in the Manas river.

- In Sri Lanka, Wilpattu National Park was attacked by Tamil rebels in 1989, killing over a dozen guards and destroying facilities. This caused a withdrawal of conservation staff, and a great increase in military activity.

- Liberia's civil war has forced rural people to hunt duikers (*Cephalophus spp.)*, pygmy hippos (*Choeropsis liberiensis)*, forest elephants (*Loxodonta africanus*), and chimpanzees (*Pan troglodytes*) for food (Wolkomir and Wolkomir, 1992).

- During the Vietnam war, elephants were specifically targeted by helicopter gunships because they might be used as pack animals by the Viet Cong. The white rhino (*Ceratotherium simum*) was exterminated from Sudan during the 17 years of civil war from 1955 to 1972 (Abdullah, 1997).

- In the Democratic Republic of Congo, civil war has stopped efforts to protect the last habitat of the pygmy chimpanzee (*Pan paniscus)*, a species endemic to that country. Fewer than 15,000 of the apes survive, but they are increasingly threatened by local people who are forced increasingly to depend on the forest for survival. This includes hunting of pygmy chimpanzees for bushmeat, which many westerners consider just one small step removed from cannibalism. One western researcher reported that poachers and army deserters armed with machineguns are hunting in Salonga National Park, a World Heritage site that is a stronghold of this species.

The conclusion is not surprising: war is bad for biodiversity.

3.2. Positive impacts of war on biodiversity

But war, or the threat of war, can also be good for biodiversity, at least in some places under certain conditions. As Myers (1979) put it, "In some respects, indeed, wildlife benefits from warfare: combatant armies effectively designate war zones as 'off limits' to casual wanderers, thus quarantining large areas of Africa from hunters and poachers". Of course, any benefits of war to biodiversity are incidental, inadvertent, and accidental rather than a planned side-effect of conflict. But even so, it is useful to review some cases where war, or preparations for war, has benefited biodiversity, perhaps supporting the views of some anthropologists that war helps societies adapt to their dynamic environmental constraints.

For example, the border between Thailand and Peninsular Malaysia was a hotbed of insurgency during the mid-1960s to mid-1970s. On the Malaysian side of the border, the military closed off all public access and potential logging activity in the Belum Forest Reserve. As a result, this extensive area of some 160,000 ha has remained untouched by modern logging pressures and therefore is rich in wildlife resources. Malaysia is now converting this into a national park that will form a transboundary protected area with matching protected areas in southern Thailand.

BOX 1: IMPACTS OF WAR ON BIODIVERSITY

Negative Impacts	Positive Impacts
• Deforestation • Erosion • Wildlife poaching • Habitat destruction • Pollution of land and water • Reduces funds for conservation • Stops conservation projects • Forces people on to marginal lands • Creates refugees who destroy Biodiversity	• Creates "no-go" zones • Slows or stops developments that lead to loss of biodiversity • Focuses state resolve • Reduces pressure on some habitats • Allows vegetation to recover in some areas • Disarms rural populations, thereby reducing hunting Can increase biodiversity-related research

While the second Vietnam War was an ecological disaster, it also led to some important biological research, such as the extensive, long-term, review of migratory birds in eastern Asia carried out by the Migratory Animals Pathological Survey (McClure, 1974). The excuse for this research was its relevance to the war effort, but it has yielded data that are useful for numerous civilian conservation applications. And the watersheds through which ran the Ho Chi Minh trail, some of the most heavily-bombed parts of Indo-China during the second Vietnam War, have more recently been remarkably productive in new discoveries of previously unknown species. New discoveries of large mammals include two species of muntjak or barking deer (*Megamuntiacus vuquangensis* and *Muntiacus truongsonensis*), a unique variety of forest antelope (*Pseudoryx nghetinhensis)*, and a bovid ultimately related to wild cattle (*Pseudonovibos spiralis*) (Dillon and Wikramanyake, 1997) as well as the rediscovery of a species of pig that formerly was known only by a few fragmentary specimens. That such species could survive in such a heavily-bombed area is testimony to the recuperative power of nature, and the ability of wildlife to withstand even the most extreme kinds of human pressure during warfare. Interestingly, these species now are even more severely threatened by the peacetime activities of development than they were by the Indochina wars.

Some other species are likely to have benefited from the war in Vietnam. Orians and Pfeiffer (1970) say that tigers "have learned to associate the sounds of gunfire with the presence of dead and wounded human-beings in the vicinity. As a result, tigers rapidly move toward gunfire and apparently consume large numbers of battle casualties. Although there are no accurate statistics on the tiger populations past or present, it is likely

that the tiger population has increased much as the wolf population in Poland increased during World War II". And many species of amphibians have found ponds formed by bomb craters to be good breeding grounds — a ray of hope in the gloomy global picture for frogs and toads (Stuart and Davidson, 1999).

Many examples can be quoted for Africa. For example, Fairhead and Leach (1995) report that parts of the Ziama region of Guinea, which includes an extensive biosphere reserve, became forested following a series of wars that affected the area from 1870 to 1910. The resident Toma people first fought with Mandinka groups from the north and subsequently with the French colonial armies, causing major depopulation and economic devastation that in turn allowed the forest to reclaim agricultural land. The human disaster of war enabled nature to recover.

The impact of war on biodiversity is often decidedly mixed, with a complex combination of damages and benefits. Nicaragua provides an illuminating example. Engaged in civil war for over 20 years, nearly half of the country's population was relocated in one way or another, and nearly 100,000 casualties resulted. The human tragedy was immense, but biodiversity was able to recover from a long history of exploitation, as trade in timber, fish, minerals, and wildlife was sharply reduced. The domestic cattle population, which was roughly equivalent to the human population when the war started, was reduced by two-thirds, freeing pastures for re-colonization by forests, enabling the recovery of animal populations such as white-tailed deer (*Odocoileus virginianus)*, collared peccaries (*Tayassu angulatus*), mantled howler monkey (*Alouatta villosa*), white throated capuchin (*Cebus capucinus*), night monkey (*Aotus paniscus*), red backed squirrel monkey (*Saimiri oerstedii*), crocodiles (*Caiman crocodilus)*, iguanas (*Iguana iguana)*, large birds, and various mammalian predators. Fishing boats were destroyed and fishermen fled, leading to drastic declines in the catches of fish, shrimp and lobsters, which in turn revitalized these fisheries. On the other hand, some hunting by soldiers had at least local negative impacts on wildlife, and new military bases and roads were established in formerly remote areas, opening them up to exploitation. Further, the country's once outstanding system of protected areas fell into neglect, and new areas planned were not established; the collapsing economy forced villagers into environmentally destructive activities, including clearing forest for firewood and harvesting wildlife for food. Nietschmann (1990b) concludes that a significant portion of this conflict was over resources and territory, not ideology. Biodiversity rejuvenated by the war came under renewed threat by people impoverished by the war; the post-war period saw a great acceleration of such impacts and now that peace has broken out, biodiversity is under renewed pressure.

On the other side of the world, the Indochina war was disastrous to Cambodia, in both human and ecosystem terms. Years of fighting have created a climate of lawlessness in which those who control the guns also control the country's most valuable natural resources, namely forests and fisheries. Overturning any feeble efforts at control, both are being depleted at dangerous rates, according to studies being carried out by the World Bank and the Asian Development Bank. Uncontrolled logging, much of it illegal, could virtually clear all economically productive forests in the country within five years, according to the Asian Development Bank (ADB), with current harvesting at over three times the sustainable yield. The fish, especially from Cambodia's Tonle Sap (Great Lake), are being over-harvested, primarily for export to surrounding — and wealthier — countries. The ecological productivity of the lake was based largely on the 10,000 sq km of flooded forest that ensured a healthy flow of nutrients into the lake. But less than 40 percent of the flood forest remains under natural vegetation. Since 1993, military commanders have come to regard the forest resources as their own, treating them as a supplemental source of finance irrespective of the long-term impact on the country's security. Continuing loss of forests will further affect the climate, cause erosion that fills irrigation channels and fishing grounds with silt, and leave Cambodian farmland more vulnerable to both drought and flooding. This complex of problems is very similar to that which faced Cambodia some 400 years ago, when the great civilization centred on Ankor Wat collapsed under environmental pressure (McNeely and Wachtel, 1988).

So while war is bad for biodiversity, peace can be even worse: in the 1960s, when Indonesia and Malaysia were fighting over border claims on the island of Borneo, they did relatively little damage to its vast wilderness, but in the 1990s they peacefully competed to cut down and sell its forests; in Indonesia, the 1997-1998 forest fires that caused US$4.4 billion in damage were set primarily by businesses and the military to clear forests in order to plant various cash crops. Ironically, the prices of these commodities that were to be grown have fallen considerably in recent years, making them even less profitable. Vietnam's forests are under greater pressure now that peace has arrived than they ever were during the country's wars;

Nicaragua's forests are now under renewed development pressures; and Laos is paying at least part of its war debts to China and Vietnam with timber concessions: I was told in Laos that the Chinese and Vietnamese timber merchants and logging companies are able to operate with impunity in Laos, irrespective of logging regulations, protected area boundaries, or any other considerations. This is perhaps not surprising given the dependence of the Pathet Lao on the support of Vietnam and China during the Indo-China wars. The motivations may be more noble in times of peace, but the impacts of inappropriate development on biodiversity often are even worse than the impacts of war. Market forces may be more destructive than military forces, but the latter may moderate the former.

4. BIODIVERSITY LOSS AS A CONTRIBUTOR TO CONFLICT IN TROPICAL FORESTS

Resource degradation, including loss of biodiversity, can create scarcities that push people out of the regions where they live. Insufficient supplies of firewood and timber, depleted aquifers, and soil erosion can form a feedback loop of poverty, insecurity, and environmental degradation. As Kane (1995) points out, "Felled trees, for example, no longer anchor soil, which washes away and clogs rivers, and the disrupted flows of water cause further soil erosion and disrupt harvests of fish. In rural areas where people directly depend on the soil and water and forests for sustenance, poverty is essentially an environmental trend. These people are usually cash poor, yet so long as they are natural-resource rich, they can remain at home and prosper. But when people flee poverty they are often fleeing environmental impoverishment — after the top soil blew away or the well ran dry — in places without a rural economy that offers them alternative sources of livelihood".

Resource scarcity can arise from three sources: degradation or depletion of a resource; increasing consumption of the resource (for example, due to population growth or rising per capita resource consumption); and uneven distribution that gives relatively few people disproportionate access to the resource and subjects the rest to scarcity. Resource scarcity can lead to declining agricultural production, economic hardship, migrations of people from areas of environmental stress, and tensions within and among groups — a melange of factors that contribute to violent conflict (Homer-Dixon, 1994). When resource scarcity reduces the ability of states to meet the needs of their population, dissatisfaction can lead to declining state authority, which sooner or later nurtures violent collective action.

Homer-Dixon (1994) concludes, "Within the next 50 years, the planet's human population will probably pass 9 billion, and global economic output may quintuple. Largely as a result, scarcities of renewable resources will increase sharply. The total area of high-quality agricultural land will drop, as will the extent of forests and the number of species they contain. Coming generations will also see the widespread depletion and degradation of aquifers, rivers, and other water resources; the decline of many fisheries; and perhaps significant climate change". Resource scarcities in many parts of the developing world are already contributing to violent conflicts that are probably early signs of an upsurge of violence in the coming decades that will be induced or aggravated by scarcity. Poor people in tropical forest countries will be particularly affected because they are less able to buffer themselves from resource scarcities and resulting social crises. These people typically already are suffering acute hardship from shortages of water, forests, and fertile land. A major problem is that fast-moving, unpredictable, and complex environmental problems can overwhelm efforts at constructive social reform. Moreover, scarcity can sharply increase demands on key institutions, such as the State, while it simultaneously reduces their capacity to meet those demands. These pressures increase the chance that the State will either disintegrate or become more authoritarian, both of which enhance the likelihood for conflict, even war.

5. CONCLUSIONS AND POSSIBLE SOLUTIONS

One conclusion is that national and international security can no longer be conceived in narrow military terms. Ethnic conflict, environmental degradation and pollution, and famine leading to civil unrest or massive migrations of refugees, constitute threats to both social stability and the preservation of a productive material base — the planet's biodiversity. Thus stopping deforestation or augmenting food production capabilities in deficit areas can directly and substantially contribute to the security of society, and can help

prevent — or at least postpone — armed conflict. Allocating international resources to environmental monitoring and impact assessment, protection of economically important species, quick response to disasters and accidents, energy conservation, and the minimization and management of waste are all highly appropriate activities that will prevent strife and therefore reduce the likelihood of conflicts leading to war. As Thacher (1984) put it, "Trees now or tanks later".

More broadly, some countries are recognizing the possibility of using protected areas designed to conserve biodiversity along their borders as ways of promoting peace (e.g., Hanks, 1998). In many countries, boundaries are found in mountainous areas which also tend to be biologically rich because of the great variety of habitats and ecosystem types found within relatively small areas, affected by differences in elevation, microclimate, and geological factors. While such ecologically diverse areas are often particularly important for conservation of biodiversity, they also are frequently sanctuaries in war, especially civil wars and guerrilla wars.

Peace Parks are far more than a fond hope. Peru and Ecuador fought three territorial wars in the 20th century, but Peruvian President Alberto Fujimori and Ecuadorian President Jamil Mahuad resolved their violent border dispute in 1998 with an innovative plan that included creation of two national "peace parks" near the most contested stretch of their frontier. Four mediators, the United States, Argentina, Brazil, and Chile, helped resolve the hottest regional dispute in South America through binding arbitration. The agreement also granted Ecuador free trade and navigational access to the economically important shipping routes of Peru's Amazon territory. While the agreement fell far short of Ecuador's desire for sovereignty over the disputed territory, leading to demonstrations against the government, many of Ecuador's economic goals were achieved. The area is also the territory of several Jivaro-speaking tribes, who frequently are at war with each other. The new peace with protected areas will need to involve the indigenous peoples as well (Faiola, 1998).

BOX 2: TRANSFRONTIER PROTECTED AREAS IN TROPICAL FOREST REGIONS

Many protected areas are located on national borders, and some have adjacent protected areas on the other side of the border, forming complexes that could be the focus of collaboration. IUCN (1997) calls these (perhaps optimistically) "Parks for Peace". The following is an indication of how widespread and important such areas are.

Continent	Transfrontier Protected Area Complexes	Designated Protected Areas
Africa	39	110
Asia	31	74
Latin America	35	89
TOTALS:	**105**	**273**

Compiled on the basis of information presented in IUCN (1997).

Given that national frontiers are especially sensitive areas where conflict is endemic and biological resources often are especially rich, the idea of establishing protected areas on both sides of the border — as so-called "peace parks" — has attracted considerable attention, providing a symbol of the desire of the bordering countries to deal with many of their problems in a peaceful way (see, for example, Westing, 1993, Westing, 1998, and Thorsell, 1990). Zbicz and Greene (1998) have found that transboundary protected areas cover well over 1.1 million sq km, representing nearly 10 percent of the total area protected in the world (see Box 2). In addition to indicating the importance of transfrontier protected areas, this also demonstrates how much of the world's land area devoted to biodiversity conservation is in remote frontier areas where risks of war historically are highest.

Brock (1991) concludes that although peace parks have probably had relatively little independent effect on international relations, transfrontier cooperation on biodiversity issues has the potential to develop into an important factor in at least regional politics by helping to internalize norms, establish regional identities and interests, operationalize routine international communication, and reduce the likelihood of the use of force.

Such areas also need to be ready to adapt to unstable conditions. Hart and Hart (1997) conclude that "the best preparation for conservation in the face of regional instability is the professional development of national staff and strong site-based conservation programmes". But a key element is that these site-based initiatives must be tied to an international structure that endures when nations crumble. They propose establishing a fund that provides for continued professional development and support for field activities by the staff of protected areas during crisis periods. Such support might be focused on specific sites of international biological significance with the goal of developing semi-autonomous management within those areas. The mission of the proposed fund would be to build professional identity in national staff where national institutions have failed and to facilitate their reintegration into conservation activities after the crisis has passed.

To conclude, trying to tease out causality in the relationship between war, conflict, and biodiversity issues in tropical forests is highly complex, because individuals make multiple, mutually constraining decisions that are shaped by interacting environmental and social conditions, all of which themselves have multiple interrelationships. People often learn through conflict, as fundamental interests are challenged. As Lee (1993) points out, "Conflict is necessary to detect error and to force corrections. But unbounded conflict destroys the long-term cooperation that is essential to sustainability. Finding a workable degree of bounded conflict is possible only in societies open enough to have political competition". In other words, the solution to destructive conflict — war — is constructive conflict that leads to improved conservation of the natural resources upon which people depend.

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