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REVIEW

Biodiversity conservation and armed conflict: a warfare ecology perspective

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The activities involved in preparing for, executing, and recovering from armed conflict are globally pervasive and consequential, with significant impacts on natural systems. Effects on biodiversity are predominantly negative, produced by direct and indirect battlefield impacts, as well as the general breakdown of social, economic, and governance systems during wartime. Certain conservation opportunities do occur, however, particularly on lands set aside for training exercises, buffer zones, and peace parks. Here, the relationship between armed conflict and biodiversity is reviewed using the temporal framework of warfare ecology, which defines warfare as an ongoing process of three overlapping stages: preparations, war (armed conflict), and postwar activities. Several themes emerge from recent studies, including a heightened awareness of biodiversity conservation on military lands, the potential for scientific and conservation engagement to mitigate negative biodiversity impacts in war zones, and the importance of the postwar period for incorporating biodiversity priorities into reconstruction and recovery efforts. Research limitations and knowledge gaps are also discussed.

Keywords: armed conflict; biodiversity; conflict; conservation; postconflict; postwar; protected areas; war; warfare ecology

Introduction and theoretical context

Violent behavior is nearly universal in primate societies,[1] and conflicts over territory, resources, and social position trace their roots deep into human prehistory.[1–3] Evidence of coordinated intergroup violence (hereafter “armed conflict” or “war”) dates at least to the Mesolithic (c. 7500–8500 BC),[4] and perhaps far earlier.[3] Conscripted armies, fortifications, and a class of military professionals all became common during the Bronze Age (c. 3300–1600 BC), when city-states in the Near East developed policies for group defense and conquest.[5] Warfare strategies, technologies, and outcomes are considered major themes in human history,[6] and armed conflicts remain common today. Between 2000 and 2014, there were an average of 35 active conflicts every year around the globe, with total battle-related casualties for the period estimated at more than 520,000 (see Ref. 7). Global military expenditures exceeded \$1.7 trillion in 2016 (2.2% of global GDP),[8] with 165 of the world’s 195 countries maintaining armed forces on active duty.[9] Most governments give a high priority to military readiness. In the United States, for example, the defense budget in 2015 accounted for 50% of all discretionary spending, more than six times the total for any other federal program.[10] While there is evidence that violence in human societies has declined over time,[11] the activities involved in preparing for, executing, and recovering from wars remain pervasive and consequential.

Overt relationships between armed conflict and the environment have long been recognized, such as what Thucydides described as the systematic “ravaging” of Athenian crops, orchards, and vineyards by Spartan armies during the Peloponnesian War (431–404 BC).[12] Formal study of such connections, however, did not gain traction until much later. Arthur Westing documented the lingering impacts of Agent Orange and other defoliants used during the Vietnam War,[13,14] and argued for a broader ecological understanding of international security issues.[15] In the decades since Westing’s

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work, a growing body of literature has described the effects of war on various natural resources, including forests,[16,17] fisheries,[18,19] soils,[20] lakes and rivers,[21] and wildlife.[22–24] For biodiversity conservation, the relevance of armed conflicts is confirmed by their prevalence in "biodiversity hotspots," regions that hold more than half the world's plant and animal species in only 2.3% of its land area.[25] Between 1950 and 2000, over 90% of major armed conflicts took place within countries containing biodiversity hotspots, and more than 80% included fighting directly within hotspot areas.[26] Conserving global biodiversity therefore requires not only an understanding of the links between wars and the environment, but also the ability to work effectively in landscapes where armed conflicts occur.[26,27]

Direct and indirect links between armed conflict and the environment often cross disciplinary boundaries and occur at multiple spatial and temporal scales, producing effects that range from intuitive (e.g., contamination from weapons development and testing) to surprising (e.g., the creation of *de facto* nature preserves in uninhabited buffer zones). Given this complexity, and the fragmented nature of early research, Machlis and Hanson[28] called for a dedicated subdiscipline to help organize the field. "Warfare ecology" offers a conceptual framework that recognizes armed conflicts as something more than sporadic eruptions of violence. It defines warfare as an ongoing process of three overlapping stages: preparations (e.g., weapons development and military training); war (i.e., a discrete period of armed conflict); and postwar activities (e.g., reconstruction, restoration, and recovery). This approach highlights temporal and topical connections among diverse areas of research, revealing warfare as a continuous, multifaceted force acting on natural systems. Biodiversity is impacted during all three stages, and case studies show that maintaining conservation engagement throughout a conflict, even at reduced levels, can significantly improve outcomes for wildlife and protected areas.[24,29,30] Protecting healthy ecosystems in turn reduces the likelihood of future conflicts,[31] thus promoting peace and security, the ultimate aim of all warfare ecology research.

In this review, I use the warfare ecology framework to assess studies of biodiversity conservation and armed conflict, with sections devoted to the effects of preparations, war, and postwar activities. For practitioners already familiar with armed conflict issues, this paper highlights recent advances and shows the value of organizing themes temporally. For those new to the topic, it offers a comprehensive survey of major implications and policy issues. Security concerns, knowledge gaps, and other limitations to war-related research are also discussed. While some early papers are cited, this review focuses on research since 2000, with an emphasis on noting empirical examples and case studies for all theoretical concepts.

Preparations

Maintaining armed forces in a state of readiness requires the continuous housing, training, equipping, and routine deployment of troops and support staff, as well as the development and testing of weapons. Many of these activities take place on dedicated military reserves that range in size and circumstance from small urban bases to vast wilderness training areas, and are estimated to cover from 1% to as much as 6% of global land area.[32] The UK's Ministry of Defense, for example, oversees 4000 domestic sites with a total area larger than the counties of Cornwall or Kent,[33] and in the United States, more territory outside of Alaska is devoted to military purposes than to either National Parks or National Wildlife Refuges.[34] While the expense of military readiness incurs indirect opportunity costs for other government activities,[35,36] including maintaining ecosystems and biodiversity,[37] the most measurable effects of war preparation involve contamination and disturbance from weapons and training, and the implications of managing large swathes of land.[38,39]

Environmental contamination from training and testing is diverse and widespread on military lands,[40] and includes everything from radioactive waste[41] to lead[42] to a range of chemicals associated with propellants, explosives, solvents, and fuels.[40] These compounds often persist for decades or longer and reach plants and wildlife through tainted soils and groundwater, but studies of their impacts are limited and often inconclusive. Amphibians experience weight loss and mortality from exposure to a common explosive component, for example, but concentrations in the soil at military sites rarely reach symptomatic levels.[43] White phosphorous poisoning has led to waterfowl mortality at an Alaskan firing range,[44] but the persistent incineration of phosphorous and other chemicals over a 10-year period at Johnston Atoll had no effect on nesting success of red-tailed tropicbirds.[45] Sublethal doses of military contaminants have been documented in the tissues of fish,[46,47] marine invertebrates,[47] sea turtles,[48] birds,[49] seagrass,[50] and marine mammals,[51] but without clear physiological consequences. In one of few community-level studies, multiple indices of coral reef health declined in close proximity to unexploded ordinance at Vieques Island, Puerto Rico,[47] but on the other hand, the same reefs do not exhibit measurable impacts from military activities at larger spatial scales.[52] The effects of contaminants on terrestrial plants are more straightforward, and numerous studies have shown changes to germination and growth rates in a range of species, with the potential to shift community composition at contaminated military sites toward hardy, disturbance-tolerant vegetation.[53]

Immediate, tangible impacts from training activities also have the potential to affect biodiversity, particularly the cratering, wildfires, and disturbance to vegetation and soils associated with live fire training and mechanized maneuvers.[38] Planned habitat modification (e.g., forest clearing and road building) may also occur in preparation for training exercises, shifting species composition at the landscape level.[38] Studies have documented multiple taxa responding to training-related changes in habitat structure at Fort Carson, Colorado,[54] and Fort Riley, Kansas.[55] At Fort Carson, training exercises shifted a piñon-juniper woodland community toward a more open, prairie like habitat, with corresponding changes to plant, songbird, and small mammal communities.[54] Plant diversity and cover decreased with training intensity in prairies at Fort Riley, contributing to increased sedimentation and altered fish communities in adjacent streams.[55] Both studies noted loss of native perennial grasses and increased abundance of nonnative plants and areas of bare soil. Compaction and other training-related changes to the soil at military sites appear to be particularly long-lived,[20] with implications for a range of associated organisms. Cryptobiotic soil crusts and intershrub flora at sites in the U.S. Army's National Training Center in the Mojave Desert, for example, have yet to recover from tank maneuvers conducted prior to General George Patton's North Africa campaign in World War II.[56] Large-scale cratering can have similarly lasting impacts in marine systems. The diversity of coral assemblages at Bikini Atoll in the Marshall Islands, for example, had largely recovered five decades after nuclear testing, with the exception of lagoon habitats affected by cratering and associated siltation.[57] While physical training impacts are detrimental to some organisms and communities, they can favor others, particularly those that rely on disturbance-dependant systems. Endangered Karner blue butterflies (*Lycaeides melissa samuelis*) thrive in lupine patches disturbed by tracked vehicles at Fort McCoy, Wisconsin,[58] as do rare blue-winged grasshoppers (*Oedipoda caerulescens*) and northern dune tiger beetles (*Cicindela hybrida*) in disturbed grasslands at training areas in Germany.[59] Similarly, grassland habitat and associated Eastern regal fritillary butterflies (*Speyeria idalia idalia*) declined at Fort Indiantown Gap National Guard Training Center in Pennsylvania following cessation of tank and troop maneuvers, and later recovered in response to artificial disturbance.[60] A recent modeling study suggests, however, that training activities require proactive management to avoid causing long-term environmental decline.[61]

Sensitivity of wildlife to the noise and disturbance of military training varies widely by taxa and context. Desert tortoise (*Gopherus agassizii*) health and abundance decreased with proximity to training activities at Fort Irwin, California,[62] and multiple strandings and behavioral disturbances to whales and dolphins have occurred in proximity to the use of active naval sonar arrays.[63,64] In an extreme case, underwater shock waves from 137 nuclear tests at Mururoa Atoll between 1976 and 1995 caused repeated, and nearly complete defaunation of fish communities within a 12.5 km^2 area.[65] On the other hand, low overflights of military aircraft had no apparent effect on the behavior of mountain sheep (*Ovis canadensis nelsoni*),[66] or on the behavior and nesting success of golden eagles (*Aquila chrysaetos*)[67] or peregrine falcons (*Falco peregrinus*).[68,69] Nor did the noise of live fire training significantly impact the behavior of black bears (*Ursus americanus*),[70] or the behavior and nesting success of red-cockaded woodpeckers (*Leuconotopicus borealis*).[71] Many observers have noted that the risks to plants and wildlife posed by training activities can often be mitigated through planning and remediation, and that military lands offer enormous opportunities for biodiversity conservation.[28,32,39,72,73]

In addition to their breadth, military lands often harbor disproportionate concentrations of rare habitats and species, a pattern found in studies conducted in the United States,[72] Europe,[74,75] and Brazil.[76] Several factors contribute to this trend: (1) military planners purposely set aside diverse landscapes to provide realistic training opportunities in a wide variety of conditions;[77] (2) training activities often create a disturbance mosaic across the landscape, sometimes maintaining habitats and communities that would otherwise disappear (e.g., grasslands maintained via frequent fires from munitions);[74,78] (3) military areas are generally off-limits to other human activities that might impact biodiversity (e.g., hunting, fishing, agriculture, timber extraction, and mining);[57] and (4) bases and training areas located near population centers often preserve habitats that have otherwise been lost to or fragmented by urban sprawl.[72] As a result, military lands are increasingly viewed as important reservoirs of biodiversity.[28,72,79,80] Decommissioned bases have been converted to wildlife refuges in the United States[73] and Europe,[79] although often with little funding and a lingering burden of toxic contamination.[81] Conservation efforts have also been incorporated into training activities on numerous active bases.[79,82] The U.S. Army, for example, recently identified 233 threatened or endangered species living on or around its training installations,[83] and the U.S. Department of Defense spent a cumulative US$ 1.32 billion on endangered species management from 1991 to 2016 (see Ref. 84). Conflicts between training priorities and species protection do occur,[83,85] but there are now a range of internal military programs,[86] interagency collaborations,[87] and public–private partnerships[88,89] in place to help balance conservation and military readiness. In short, biodiversity conservation has become a routine planning element for military lands in North America,[82,90] Europe,[79,91] and Australia,[92] and awareness is increasing elsewhere, including in Brazil,[76] and on western military bases overseas.[93,94]

War

The inherent security, humanitarian, and political urgencies associated with wartime present unique challenges for biodiversity conservation. Environmental laws and practices are often waived or ignored for the duration of a conflict,[95] and conservation projects in or near the fighting are usually suspended.[26,30,96] Protected areas and other wilderness landscapes offer potential cover for combatants and often become contested terrain,[16] forcing the evacuation of staff and the abandonment of equipment and infrastructure.[30,96,97] Ecotourism and sustainable development activities are also often suspended,[26,98] and there can be a near or complete breakdown in local governance. This instability combines with the direct effects of combat and campaign logistics to produce a host of negative consequences for biodiversity, although limited conservation opportunities may also arise.[16,22,26,99]

The battlefield impacts of war on biodiversity reflect the disturbances associated with military training. For small conflicts where fighting is sporadic, the magnitude may be similar, but the sustained fronts and massive energy flows associated with larger wars can broaden those impacts to a regional scale.[28,38,99–101] The best-known example comes from the Vietnam War, when U.S. forces applied Agent Orange and other aerial defoliants to more than 2.6 million hectares of forests and coastal mangroves,[102] a tactic with assumed but largely unexamined consequences for a wide range of associated taxa.[14,103] Other documented examples of tactical habitat destruction include deliberate forest fires set by Turkish forces to reduce cover for Kurdish fighters in the ongoing conflict with the PKK[104,105] and the draining of Iraq's Mesopotamian wetlands in the 1990s, an attempt by Saddam Hussein's regime to quell resistance from the Marsh Arab community.[106] Environmental contaminants can also be weaponized during wartime, such as the targeting of petroleum storage facilities by Israel during the 2006 Lebanon War,[107] or the firing of Kuwaiti oilfields and related infrastructure by retreating Iraqi forces during the 1991 Gulf War.[108] The former created an oil slick along 100 km of the Lebanese coastline, causing immediate mortality to seabirds, marine invertebrates, and plants, and presumed but undocumented mortality to fish and endangered sea turtles.[109] The Kuwaiti example caused region-wide air pollution and the largest terrestrial oil spill in history,[108] as well as a marine spill implicated in high seabird mortality,[110] lasting damage to intertidal communities[111] and declines in regional shellfish populations.[18] Because war zones are intrinsically dangerous, researchers often rely on remote sensing to examine measurable proxies for biodiversity, such as trends in forest cover. Analysis of satellite imagery has revealed war-related increases in deforestation in the Democratic Republic of Congo,[96,112] as well as complex patterns of forest loss and recovery in Nicaragua,[113] Colombia,[114] Rwanda,[115] and along the South Sudan-Uganda border.[116] In all cases, however, these trends had less to do with tactics and munitions than with another pervasive effect of armed conflict: changes in human settlement and activity patterns.

Wars cause massive social disruption, often leading to depopulation or greatly reduced human activity in conflict zones. This trend has been invoked to explain historically dense wildlife populations in rarely hunted buffers between hostile indigenous groups in North America[117] and the Amazon,[118] as well as some patterns of reforestation measured during contemporary conflicts.[113,114] Extractive or land-intensive economic activities may also stall in war zones, with measurable impacts on biodiversity. Documented examples include the cessation of commercial fishing and accompanying recovery of North Sea cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), plaice (*Pleuronectes platessa*), and whiting (*Merlangius merlangus*) stocks during World War II,[19,119] the suppression of commercial logging during a series of wars in Cambodia,[120] and the widespread abandonment and rewilding of farmland during the 1991–1994 Nagorno-Karabakh War in Azerbaijan.[121] Although such economic and development interruptions may relieve local pressure on natural systems, they are often counterbalanced by increased activity elsewhere.[121] In some cases, they offer the possibility for permanent "peace parks" in the postwar period (see below), particularly along disputed borders. But such opportunities are limited, and often diminished by the considerable biodiversity impacts made by armed forces during their occupation of contested areas.

Historically, armies obtained many of their provisions, firewood, and other supplies from the landscapes they marched through and occupied. Alexander the Great shrewdly timed his campaigns to coincide with local grain harvests, which could then be confiscated to feed soldiers and horses.[122,123] In Roman times, systematic hunting by troops contributed to the elimination of large game from parts of the Mediterranean Basin,[122] and when the emperor Trajan's victory over Dacia was commemorated on a column, the illustrations tellingly showed how a wooded kingdom filled with animals was transformed by conquest into a barren plain supporting one denuded tree.[122] Hunting and local provisioning continue during contemporary wars, particularly by insurgent groups in rural settings, but most armed forces can now be provisioned from afar by modern supply chains. Biodiversity is often more strongly affected when militaries engage in the organized extraction and sale of "lootable" resources.[124] There is now a broad literature describing how both state and nonstate actors in many conflicts fund their operations through illegal logging, mining, and other resource extraction,[125,126] often targeting the rich natural capital found in protected areas.[127] Abundant examples range from the rampant trade in "conflict" timber and diamonds during civil wars in Liberia, Sierra Leone, and elsewhere[128,129] to the petroleum exported by ISIS forces during their occupation of Iraqi and Syrian oilfields.[130] Biodiversity suffers from habitat loss and contamination associated with such activities, which typically take place without environmental oversight, and also from direct mortality when the lootable resources include wildlife.[24,127] Systematic hunting of African elephants (*Loxodonta* spp.) for their ivory has helped fund conflicts in Angola,[131] Central African Republic,[97,132] South Sudan,[132] and the Democratic Republic of Congo,[30] and conflict-related poaching has also been reported for other high-value wildlife species, including the Indian rhinoceros (*Rhinoceros unicornis*),[133–135] hippopotamus (*Hippopotamus amphibius*),[136] Grauer's gorilla (*Gorilla beringei graueri*),[137] bonobo (*Pan paniscus*),[138] sun bear (*Helarctos malayanus*),[139] and tiger (*Panthera tigris*).[133,135,139] A comprehensive analysis of large mammal populations in African protected areas found that armed conflict—even if only occasional—was the strongest predictor of population declines between 1946 and 2010.[24] Many smaller and lesser-known species are also affected. During the Nepalese Civil War (1996–2006), for example, communist insurgents not only participated in the illegal wildlife trade, they also profited from the harvest and sale of rare medicinal fungi and plants.[133] In addition to poaching, armed forces have also been implicated in the capture of live animals for the exotic pet market. Observers during the civil war in eastern Democratic Republic of Congo regularly documented soldiers in possession of live parrots and monkeys, as well as baby gorillas and bonobos.[138]

The extraction of many lootable resources feeds demand from international markets, but local trade in wild-harvested products can also increase dramatically during wars. Bush meat harvested by soldiers or independent contractors is often sold to mining and logging operations in conflict areas, as well as to local communities where normal agricultural and commercial activities have been disrupted.[137,138] Desperate or displaced populations lack the luxury of choice and must take sustenance however they can find it. An estimated 850,000 refugees from the Rwandan Civil War were living in or around Virunga National Park in neighboring Zaire (now Democratic Republic of Congo) in 1994, leading to an estimated 300 km^2 of partial or complete deforestation.[16] Demand for firewood, charcoal, and building materials has led to similar losses of forest and woodlands around settlements of internally displaced Darfuris in Sudan,[140] Somali refugees in Kenya,[141] and Afghan refugees in Pakistan.[142] Repatriation may not occur until years or decades after the cessation of fighting, often extending these impacts long into the postwar period. Similarly, the small arms that proliferate locally during wars do not go away, often leading to permanent increases in the scale and efficiency of local hunting and poaching.[139]

Postwar activities

The Greek philosopher and botanist Theophrastus once observed that fields trampled by armies would later produce sparse and stunted crops.[122] That kind of lasting soil compaction is just one of many direct and indirect war-related impacts that can endure long into the postwar period. In many ways, postwar activities echo the themes already discussed. They involve the long-term biological and human responses to battlefield impacts, environmental contamination, and a range of disruptions to socio-economic and settlement patterns.[28,99,100] The scope and longevity of these activities are often surprising, however, and because they take place within the context of reconstruction, they often have significant practical and policy implications for biodiversity conservation.[27,139,143]

Restoring landscapes affected by war often involves massive clean-up efforts, ranging from the removal of landmines and unexploded ordnance[144] to the remediation of sites contaminated during munitions production, testing, and disposal.[145,146] Military installations account for more than 10% of "Superfund" environmental clean-up sites in the United States,[147] for example, a figure that swells to nearly 70% if industrial sites related to military activities are included.[148] Battlefield damage may also continue affecting biodiversity long after the cessation of hostilities. Algae, invertebrates, and fish in the Slovenia's Isonzo River, for example, still contain elevated mercury levels from munitions discharged nearby during World War I,[149] and large swathes of mangrove forests defoliated during the Vietnam War have never recovered.[150] Some postwar biodiversity impacts represent a straightforward continuation of effects begun during wartime, such as persistent deforestation near long-term refugee camps,[151] but others play out more subtly. The previously mentioned reduction in North Sea fisheries during World War II, for example, altered the abundance of various age classes for multiple fish species in a way that affected population dynamics for decades afterward.[119] The most significant impact to biodiversity during the postwar period, however, may come in the form of increased resource extraction. The same lootable natural resources that help fund conflicts can also be liquidated in their aftermath to help pay for reconstruction, to fund political activities, or to attain rapid development goals. Abundant examples include the increased logging of roesewood (*Dalbergia maritima*) following the 2009 Malagasy conflict in Madagascar,[152] and the postwar mining booms in Sierra Leone[153] and the Democratic Republic of Congo.[154]

There is growing consensus that the postwar period is a critical time for scientific and professional engagement in biodiversity conservation planning.[26,155,156] Decisions made during recovery and reconstruction often shape future policies on a range of natural resource issues, from protected area management to forestry, mining, fisheries, and agriculture.[157] Immediate development and reconstruction priorities often compete with environmental concerns, but biodiversity threats can be mitigated through an emphasis on sustainability. The promise of long-term income from ecotourism, for example, helped avert a proposed road through Volcanoes National Park in postwar Rwanda.[158] In some cases, biodiversity goals can be coupled with cultural and political priorities, such as the restoration of the Mesopotamian wetlands in postwar Iraq for wildlife habitat as well as a homeland for the Marsh Arab community.[106] Proactive efforts in Afghanistan have already helped the government adopt a National Protected Area System Plan[159] and establish its first provisional national park.[160] Efforts are also underway to include biodiversity goals in rural development plans for postwar Colombia, where territory controlled by FARC rebels for over five decades remains largely forested.[156,161] Sustained commitment is necessary for biodiversity conservation to succeed in the postwar period, however. Initial progress in the Mesopotamian marsh restoration, for example, has been largely reversed in part due to upstream water diversion for irrigation, flood control, drinking water, and hydropower.[162]

The developing theory of "environmental peacebuilding" suggests that local and international cooperation over environmental issues, including biodiversity conservation, can play a valuable role in promoting postwar security.[163,164] The United Nations Environment Programme now conducts regular postwar assessments of war-torn regions,[165] and many humanitarian and reconstruction efforts have begun including environmental priorities as a matter of course.[155] Examples related to biodiversity include reforestation near refugee camps in Tanzania,[151] Cameroon,[166] and Sudan,[167] and local involvement in the postwar recovery and management of protected areas in Ethiopia,[168] Liberia,[169] Nepal,[170] Afghanistan,[160] and elsewhere. In some cases, buffer zones and other contested areas have been successfully set aside as permanent "peace parks," establishing biodiversity conservation as a recognized tool for postwar compromise and cooperation.[171,172] Following the 1995 Cenapa War between Peru and Ecuador, for example, treaty negotiations included formation of adjacent protected areas along the disputed border through the Cordillera del Condor.[173] Similar conservation measures have been proposed for other biodiverse boundary areas, including the Green Line Buffer Zone in Cyprus[174] and the Demilitarized Zone separating North and South Korea.[175,176]

Limitations

The inherent dangers of working in a war zone limit direct, real-time studies of armed conflict and biodiversity. Would-be scholars often find themselves limited to anecdotal evidence, such as news reports of, to cite only a few examples: large forest fires during the Russo-Georgian War in 2008;[177] the fate of elephant and antelope herds during strife in South Sudan;[178] wolf packs thriving in the minefields of the Golan Heights;[179] or a Congolese rebel group charging tourists to view endangered mountain gorillas.[180] Security issues and the stigma of war can also hamper studies during the postwar period. Following the 1990–1994 Rwandan Civil War, for example, Volcanoes National Park remained shuttered for 5 years and tourism and research operations did not return to prewar levels for a decade.[98] Even during times of peace, military sites and information often remain inaccessible due to safety and security concerns, habits of secrecy, and lack of regular communication between military and science professionals. In China, for example, biodiversity on vast military lands remains poorly known, and has yet to be included in national conservation planning efforts.[181] Knowledge gaps are also common about baseline conditions in landscapes where wars take place,[99] and the capacity for postwar environmental monitoring can be limited,[182] making it difficult to definitively quantify the effects of conflict. In spite of such challenges, there are many examples of increasing communication and cooperation between the military and conservation science communities,[82] including NATO Advanced Research Workshops on ecological integrity,[183] warfare ecology,[184] and the role of biodiversity conservation in promoting postwar sustainability.[185,186] Additionally, many war-related trends relevant to biodiversity can now be studied safely through use of remote sensing, drones, or other new research tools. Crowdsourcing geotagged photographs, for example, is already informing protected area management during peacetime,[187] and could be very helpful in establishing prewar baseline conditions and documenting postwar recovery. Crowdsourcing has also been used to track conflict-related damage to archaeological sites in Syria and Iraq from satellite images,[188] a technique that could easily be transferred to vegetation cover or other biodiversity measures. In another innovative new study, researchers used carbon isotope ratios in hippopotamus teeth to show how a conflict-related spike in large mammal poaching during the 1970s altered the vegetation community in Uganda's Queen Elizabeth National Park.[189]

Table 1. A summary of the major impacts and policy implications of armed conflict for biodiversity conservation, organized by the three stages of warfare

	Stage of warfare		
	Preparations	War	Postwar activities
Negative impacts	• Environmental contamination from weapons development, testing, and other training activities.[41,50] • Habitat alteration and degradation from training activities.[20,55] • Direct wildlife mortality from training activities.[65] • Behavioral disturbance to wildlife from training activities.[62,64]	• Habitat degradation and wildlife mortality from incidental and tactical habitat destruction or weaponization of contaminants.[105,107] • Suspension or waiver of environmental regulations during wartime.[95] • Breakdown in governance and administration of protected areas.[30,96] • Reduction or abandonment of conservation, scientific, and sustainable development activities.[97,98] • Increased extraction of "lootable" natural resources (e.g., timber and minerals) to finance war activities.[129,130] • Increased poaching of high-value wildlife species to finance war activities.[131,135] • Increased poaching to provision troops and supply local and regional bush meat trade.[137,138] • Deforestation around encampments of refugees and internally displaced populations.[140,141]	• Persistent contamination and habitat degradation from activities carried out during preparations and wars.[146,149] • Increased extraction of natural resources to fund reconstruction and recovery.[152,153] • Persistent deforestation and elevated hunting levels near long-term camps for refugees and internally displaced populations.[151] • Persistent increase in hunting from proliferation of small arms.[139] • Lasting ecological effects from wartime impacts to wildlife populations and habitats.[119,189]
Positive impacts	• Coincidental protection of biodiversity on large tracts of land set aside for training and weapons testing.[75,76] • Maintenance of disturbance regimes via training activities that favor disturbance-dependent species.[59,60]	• Biodiversity recovery from depopulation and reduced human activity in war zones.[113,114] • Reduced human activity and in buffer zones between warring factions.[117,176] • Biodiversity recovery from disruption of resource extraction industries.[119,120]	• Creation of permanent "peace parks" along disputed borders.[173] • Opportunities to include biodiversity conservation priorities in postwar planning, reconstruction, and recovery efforts.[156,159]
Major policy implications	• Awareness of biodiversity conservation on military lands is increasing in North America,[72] Europe,[75] and elsewhere,[76] creating opportunities for integrated environmental management that preserve training capacity while promoting biodiversity and avoiding long-term habitat degradation.[39]	• Case studies suggest that even limited conservation activity in conflict zones, particularly the support of local protected area staff, can significantly reduce harm to biodiversity.[29,30] • Broad policy opportunities exist to reduce international markets for "lootable" resources from conflict zones.[124,126]	• Biodiversity conservation can be incorporated into postwar planning via "peace parks" and other natural resource policies.[156,159] • The emerging discipline of "environmental peacebuilding" offers potential for cooperation around management of shared natural resources.[163,164]

NOTE: Representative citations from the literature review accompany each point.

Further limitations to the study of conflict and biodiversity lie in the sheer complexity of warfare, and how its effects on natural and human systems are closely intertwined.[23,28,39,99–101] It goes without saying that humanitarian concerns take precedence over environmental issues during wars. But even in the preparation and postwar periods, biodiversity conservation is often complicated by other priorities, from development to land use to social justice. Among many examples, the U.S. Navy leases a naval base from the UK's British Indian Ocean Territory in the Chagos Archipelago, at the heart of the world's largest marine protected area, on land also claimed by the Republic of Mauritius and a forcibly displaced population of native Chagossians.[190] Ecological models offer one way to frame such complexity, and have been used to examine case studies such as the impacts of a new military base in Canada in the 1950s,[191] and the consequences of military pollution for Italian shellfish farming during World War I.[192] Most links between warfare and biodiversity have yet to be examined in a theoretical context, however. Nor has the field yet reconciled recent trends in nontraditional conflicts, such as the increasing militarization of antipoaching efforts,[193,194] or military campaigns against the production of narcotics in wilderness settings.[195]

Conclusions

This review confirms earlier assertions that the consequences of armed conflict for biodiversity conservation are predominantly negative,[22,24,26,99,196] produced by direct and indirect battlefield impacts, as well as the general breakdown of social, economic, and governance systems during wartime. Certain conservation opportunities do occur, however, particularly on lands set aside for training exercises, buffer zones, and peace parks. Though security concerns and the classified nature of military activities are limiting, research on the subject has increased dramatically in recent years—the many examples cited herein represent a thorough but not exhaustive survey. Major themes and policy implications from this review of the literature are summarized in Table 1.

Viewing the effects of armed conflict on biodiversity conservation through the lens of warfare ecology provides a valuable temporal perspective, highlighting impacts during all stages of warfare and allowing important themes to emerge, such as the relevance of studies from training grounds to the postwar rehabilitation of battlefields, the vulnerability of "lootable" natural resources during both the war and postwar periods, or the widespread utility of using forest cover change as a proxy for biodiversity trends in conflict zones. Recurring issues like these contribute to several conclusions from this review with relevance for future research and action:

- **Biodiversity on military lands**. The potential for biodiversity conservation on military lands is now widely recognized, and the armed forces of many countries routinely include conservation priorities in the planning and management of their training activities. The UK's Ministry of Defense, for example, goes so far as to publish its own nature magazine.[197] Opportunities exist for the conservation and scientific communities to support this trend through partnerships with various militaries,[82] and to help it spread to countries beyond North America and Europe.[198]
- **Engagement during conflict**. Continued engagement from the scientific and conservation communities throughout periods of armed conflict can help mitigate negative impacts to biodiversity. Multiple case studies show that ongoing support, particularly for local staff of protected areas, helps reduce rates of illegal activities such as poaching and deforestation.[24,26,29,30,112,168]
- **Engagement in postwar activities**. The postwar period represents a critical stage for biodiversity, with an imperative to include conservation priorities in recovery and reconstruction policies, including natural resource management,[155] the delineation and management of protected areas,[159] and the creation of transboundary peace parks.[172]
- **Increasing research and policy attention**. Studies of warfare and the environment have expanded to the point of requiring literature reviews specific to discipline[17] or geography.[199] Attention by policymakers has also increased, as reflected by recent United Nations actions including a resolution against conflict pollution,[200] a resolution on protecting the environment during armed conflict,[201] a review of environmental protection during wartime,[202] support for postwar

environmental assessments,[165] and the declaration of November 6th as the "International Day for Preventing the Exploitation of the Environment in War and Armed Conflict."[203]

- **Major knowledge gaps**. Though both the scope and volume of research have increased, major knowledge gaps remain. Only a handful of studies have tracked biodiversity impacts across more than one stage of warfare,[30,139] for example, and lack of baseline data prevents analysis of conflict-related trends for many areas.[99] Socioeconomic and institutional pathways have been widely recognized as important but poorly understood drivers of biodiversity trends during and after conflicts.[23,24] There has also been little consideration of the potential interactions between biodiversity conservation and humanitarian relief efforts in conflict zones, such as the ability of food and agricultural aid to reduce hunting pressure,[204] or how cooking technologies and traditions impact deforestation rates around refugee camps.[205]

While humanitarian concerns necessarily outweigh environmental issues during the urgent depths of armed conflict and recovery, there is increasing consensus that healthy, biodiverse environments support human populations more resilient to war.[155,196,206] Given their vulnerability and the potential to affect positive change during transitions to peace, high biodiversity conflict areas have been identified as a priority for spending limited conservation funding.[207] Research into links between armed conflict and biodiversity therefore holds real promise for reducing environmental harm and promoting peace and security. This imperative is even more pressing in an era of climate change, where well-established links between higher temperatures, weather patterns, resource stress, and human violence are expected to increase the frequency of wars.[208–211] In the face of such challenges, this review highlights an increasing appreciation of biodiversity issues in the literature of warfare studies. As a final note, there are encouraging cases where a shared interest in biodiversity is helping create paths toward peace. In the volatile border region between Israel, Jordan, and the Palestinian Authority, for example, scientists and citizens from all sides have worked across boundaries to study barn owl (*Tyto alba*) and kestrel (*Falco tinnunculus*) populations, and helped get the Jordanian and Israeli armies to cooperate on a project converting abandoned bunkers into roosting habitat for bats.[212] Participants in these highly successful projects recently published a paper with a title worth repeating: "Nature Knows No Boundaries."

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Competing interests

The author declares no competing interests.

References

1. Wrangham, R. & D. Peterson. 1996. *Demonic Males: Apes and the Origins of Human Violence.* Boston: Houghton Mifflin.
2. Keeley, L. 1996. *War Before Civilization.* Oxford: Oxford University Press.
3. Shackelford, T.K. & V.A. Weekes-Shackelford, Eds. 2012. *The Oxford Handbook of Evolutionary Perspectives on Violence, Homicide, and War.* Oxford: Oxford University Press.
4. Lahr, M.M., F. Rivera, R.K. Power, *et al.* 2016. Inter-group violence among early Holocene hunter–gatherers of West Turkana, Kenya. *Nature* **529:** 394–398.
5. Hamblin, W.J. 2006. *Warfare in the Ancient Near East to 1600 BC: Holy Warriors at the Dawn of History.* New York: Routledge.
6. Parker, G., Ed. 2005. *The Cambridge History of Warfare.* Cambridge: Cambridge University Press.
7. Pettersson, T. & P. Wallensteen. 2015. Armed conflicts, 1946–2014. *J. Peace Res.* **52:** 536–550.
8. Fleurant, A., P.D. Wezeman, S.D. Wezeman & N. Tian. 2017. Trends in world military expenditure, 2016. Stockholm International Peace Research Institute, Solna.
9. International Institute of Strategic Studies. 2017. *The Military Balance.* New York: Routledge.
10. Congressional Budget Office. 2016. The federal budget in 2015: a closer look at discretionary spending. Accessed October 23, 2017. https://www.cbo.gov/publication/51112.
11. Pinker, S. 2011. *The Better Angels of Our Nature: Why Violence Has Declined.* New York: Penguin.
12. Thucydides. 1831. *History of the Peloponnesian War.* A. Smith, transl. London: Jones and Co.
13. Westing, A.H. 1975. Environmental consequences of the Second Indochina War: a case study. *Ambio* **4:** 216–222.
14. Westing, A.H. 1984. *Herbicides in War: The Long-term Ecological and Human Consequences.* London: Taylor and Francis.
15. Westing, A.H. 1986. *Global Resources and International Conflict.* New York: Oxford University Press.
16. McNeely, J.A. 2003. Conserving forest biodiversity in times of violent conflict. *Oryx* **37:** 142–152.

17. Price, S.V. 2003. *War and Tropical Forests: Conservation in Areas of Armed Conflict.* Binghamton, NY: Food Products Press.
18. Mathews, C.P., S. Kedidi, N.I. Fita, *et al.* 1993. Preliminary assessment of the effects of the 1991 Gulf War on Saudi Arabian prawn stocks. *Mar. Pollut. Bull.* **27:** 251–271.
19. Smith, T.D. 1994. *Scaling Fisheries: The Science of Measuring the Effects of Fishing.* Cambridge: Cambridge University Press.
20. Certini, G., R. Scalenghe & W.I. Woods. 2013. The impact of warfare on the soil environment. *Earth-Sci. Rev.* **127:** 1–15.
21. Francis, R.A. 2011. The impacts of modern warfare on freshwater ecosystems. *Environ. Manage.* **48:** 985–999.
22. Dudley, J.P., J.R. Ginsberg, A.J. Plumptre, *et al.* 2002. Effects of war and civil strife on wildlife and wildlife habitats. *Conserv. Biol.* **16:** 319–329.
23. Gaynor, K.M., K.J. Fiorella, G.H. Gregory, *et al.* 2016. War and wildlife: linking armed conflict to conservation. *Front. Ecol. Environ.* **14:** 533–542.
24. Daskin, J.H. & R.M. Pringle. 2018. Warfare and wildlife declines in Africa's protected areas. *Nature* **553:** 328–332.
25. Mittermeier, R.A., P. Robles-Gil, M. Hoffmann, *et al.* 2004. *Hotspots Revisited.* Mexico City: CEMEX.
26. Hanson, T., T.M. Brooks, G.A. Da Fonseca, *et al.* 2009. Warfare in biodiversity hotspots. *Conserv. Biol.* **23:** 578–587.
27. Hanson, T. 2011. War and biodiversity conservation: the role of warfare ecology. In *Warfare Ecology*. G. Machlis, T. Hanson, Z. Spiric & J.E. McKendry, Eds.: 125–132. Dordrecht: Springer.
28. Machlis, G.E. & T. Hanson. 2008. Warfare ecology. *BioScience* **58:** 729–736.
29. de Merode, E., K.H. Smith, K. Homewood, *et al.* 2007. The impact of armed conflict on protected-area efficacy in Central Africa. *Biol. Lett.* **3:** 299–301.
30. Beyers, R.L., J.A. Hart, A.R. Sinclair, et al. 2011. Resource wars and conflict ivory: the impact of civil conflict on elephants in the Democratic Republic of Congo—the case of the Okapi Reserve. *PLoS One* **6:** e27129.
31. Butler, C.D. & W. Oluoch-Kosura. 2006. Linking future ecosystem services and future human well-being. *Ecol. Soc.* **11:** 30. [Online] http://www.ecologyandsociety.org/vol11/iss1/art30/.
32. Zentelis, R. & D. Lindenmayer. 2015. Bombing for biodiversity—enhancing conservation values of military training areas. *Conserv. Lett.* **8:** 299–305.
33. UK Ministry of Defense. 2017. Ministry of Defense UK land holdings 2017. London: United Kingdom Ministry of Defense.
34. Vincent, C.H., L.A. Hanson & C.N. Argueta. 2017. Federal land ownership: overview and data. Congressional Research Service, Washington, DC.
35. Gold, D. 1994. Opportunity costs of military expenditures: evidence from the United States. In *Economics of Conflict and Peace.* J. Brauer & W.G. Gissy, Eds.: 109–124. London: Routledge.
36. White, J. 2017. A gluttonous military budget leaves our social welfare in poor health. In *Preventing War and Promoting Peace: A Guide for Health Professionals.* W.H. Wiist & S.K. White, Eds.: 205–216. Cambridge: Cambridge University Press.
37. Stockholm International Peace Research Insitute. 2016. Opportunity costs of world military spending. August 29, 2016. Accessed November 10, 2017. https://www.sipri.org/commentary/blog/2016/opportunity-cost-world-military-spending.
38. Demarais, S., D.J. Tazik, P.J. Guertin & E.E. Jorgensen. 1999. Disturbance associated with military exercises. In *Ecosystems of Disturbed Ground.* L.W. Walker, Ed.: 385–396. Amsterdam: Elsevier.
39. Zentelis, R., D. Lindenmayer, J.D. Roberts & S. Dovers. 2017. Principles for integrated environmental management of military training areas. *Land Use Policy* **63:** 186–195.
40. Clausen, J., J. Robb, D. Curry & N. Korte. 2004. A case study of contaminants on military ranges: Camp Edwards, Massachusetts, USA. *Environ. Pollut.* **129:** 13–21.
41. Burkitbayev, M., N. Priest, P. Mitchell, *et al.* 2011. Ecological impacts of large-scale war preparations: Semipalatinsk Test Site, Kazakhstan. In *Warfare Ecology*. G. Machlis, T. Hanson, Z. Spiric & J.E. McKendry, Eds.: 55–64. Dordrecht: Springer.
42. Etim, E.U. & P.C. Onianwa. 2012. Lead contamination of soil in the vicinity of a military shooting range in Ibadan, Nigeria. *Toxicol. Environ. Chem.* **94:** 895–905.
43. Johnson, M.S., J. Suski & M.A. Bazar. 2007. Toxicological responses of red-backed salamanders (*Plethodon cinereus*) to subchronic soil exposures of 2, 4-dinitrotoluene. *Environ. Pollut.* **147:** 604–608.
44. Racine, C.H., M.E. Walsh, B.D. Roebuck, *et al.* 1992. White phosphorus poisoning of waterfowl in an Alaskan salt marsh. *J. Wildl. Dis.* **28:** 669–673.
45. Schreiber, E.A., P.F. Doherty, Jr. & G.A. Schenk. 2001. Effects of a chemical weapons incineration plant on red-tailed tropicbirds. *J. Wildl. Manag.* **65:** 685–695.
46. Theodorakis, C., J. Rinchard, T. Anderson, *et al.* 2006. Perchlorate in fish from a contaminated site in east-central Texas. *Environ. Pollut.* **139:** 59–69.
47. Porter, J.W., J.V. Barton & C. Torres. 2011. Ecological, radiological, and toxicological effects of naval bombardment on the coral reefs of Isla de Vieques, Puerto Rico. In *Warfare Ecology*. G. Machlis, T. Hanson, Z. Spiric & J.E. McKendry, Eds.: 65–122. Dordrecht: Springer.
48. Villa, C.A., M. Flint, I. Bell, *et al.* 2017. Trace element reference intervals in the blood of healthy green sea turtles to evaluate exposure of coastal populations. *Environ. Pollut.* **220:** 1465–1476.
49. Kuzyk, Z.Z.A., N.M. Burgess, J.P. Stow & G.A. Fox. 2003. Biological effects of marine PCB contamination on black guillemot nestlings at Saglek, Labrador: liver biomarkers. *Ecotoxicology* **12:** 183–197.
50. Díaz, E., D. Pérez, J.D. Acevedo & A. Massol-Deyá. 2018. Longitudinal survey of lead, cadmium, and copper in seagrass *Syringodium filiforme* from a former bombing range (Vieques, Puerto Rico). *Toxicol. Rep.* **5:** 6–11.
51. Jarman, W.M., C.E. Bacon, J.A. Estes, *et al.* 1996. Organochlorine contaminants in sea otters: the sea otter as a bio-indicator. *Endangered Species Update* **13:** 20–22.

52. Riegl, B., R.P. Moyer, B. Walker, *et al.* 2008. A tale of germs, storms, and bombs: geomorphology and coral assemblage structure at Vieques (Puerto Rico) compared to St. Croix (U.S. Virgin Islands). *J. Coast. Res.* **24:** 1008–1021.
53. Via, S.M. & J.C. Zinnert. 2016. Impacts of explosive compounds on vegetation: a need for community scale investigations. *Environ. Pollut.* **208:** 495–505.
54. Diersing, V.E. & W.D. Severinghaus. 1984. (Construction Engineering Research Lab (Army) Champaign, IL). The effects of tactical vehicle training on the lands of Fort Carson, Colorado. An ecological assessment. US Army Corps of Engineers. Report No. CERL-TR-N-85/03.
55. Quist, M.C., P.A. Fay, C.S. Guy, *et al.* 2003. Military training effects on terrestrial and aquatic communities on a grassland military installation. *Ecol. Appl.* **13:** 432–442.
56. Prose, D.V. & H.G. Wilshire. 2000. The lasting effects of tank maneuvers on desert soils and intershrub flora. US Geological Survey, Washington, DC. Open-file Report No. 00-512.
57. Richards, Z.T., N. Beger, S. Pinca & C.C. Wallace. 2008. Bikini Atoll coral biodiversity resilience five decades after nuclear testing. *Mar. Pollut. Bull.* **56:** 503–515.
58. Smith, M.A., M.G. Turner & D.H. Rusch. 2002. The effect of military training activity on eastern lupine and the Karner blue butterfly at Fort McCoy, Wisconsin, USA. *Environ. Manage.* **29:** 102–115.
59. Warren, S.D. & R. Büttner. 2008. Active military training areas as refugia for disturbance-dependent endangered insects. *J. Insect Conserv.* **12:** 671–676.
60. Zografou, K., M.T. Swartz, V.P. Tilden, *et al.* 2017. Severe decline and partial recovery of a rare butterfly on an active military training area. *Biol. Conserv.* **216:** 43–50.
61. Zentelis, R., S. Banks, J.D. Roberts, *et al.* 2017. Managing military training-related environmental disturbance. *J. Environ. Manage.* **204:** 486–493.
62. Berry, K.H., T.Y. Bailey & K.M. Anderson. 2006. Attributes of desert tortoise populations at the National Training Center, central Mojave Desert, California, USA. *J. Arid Environ.* **67:** 165–191.
63. Parsons, E.C.M. 2017. Impacts of navy sonar on whales and dolphins: now beyond a smoking gun? *Front. Mar. Sci.* **4:** 295.
64. Harris, C.M., L. Thomas, E.A. Falcone, *et al.* 2017. Marine mammals and sonar: dose–response studies, the risk-disturbance hypothesis and the role of exposure context. *J. Appl. Ecol.* https://doi.org/10.1111/1365-2664.12955.
65. Planes, S., R. Galzin, J.P. Bablet & P.F. Sale. 2005. Stability of coral reef fish assemblages impacted by nuclear tests. *Ecology* **86:** 2578–2585.
66. Krausman, P.R., M.C. Wallace, C.L. Hayes & D.W. Young. 1998. Effects of jet aircraft on mountain sheep. *J. Wildl. Manage.* **62:** 1246–1254.
67. Grubb, T.G., D.K. Delaney, W.W. Bowerman & M.R. Wierda. 2010. Golden eagle indifference to heli-skiing and military helicopters in northern Utah. *J. Wildl. Manage.* **74:** 1275–1285.
68. Ellis, D.H., C.H. Ellis & D.P. Mindell. 1991. Raptor responses to low-level jet aircraft and sonic booms. *Environ. Pollut.* **74:** 53–83.
69. Palmer, A.G., D.L. Nordmeyer & D.D. Roby. 2003. Effects of jet aircraft overflights on parental care of peregrine falcons. *Wildl. Soc. Bull.* **31:** 499–509.
70. Telesco, D.J. & F.T. Van Manen. 2006. Do black bears respond to military weapons training? *J. Wildl. Manage.* **70:** 222–230.
71. Delaney, D.K., L.L. Pater, L.D. Carlile, *et al.* 2011. Response of red-cockaded woodpeckers to military training operations. *Wildl. Monogr.* **177:** 1–38.
72. Stein, B.A., C. Scott & N. Benton. 2008. Federal lands and endangered species: the role of military and other federal lands in sustaining biodiversity. *AIBS Bull.* **58:** 339–347.
73. Havlick, D.G. 2011. Disarming nature: converting military lands to wildlife refuges. *Geogr. Rev.* **101:** 183–200.
74. Warren, S.D., S.W. Holbrook, D.A. Dale, *et al.* 2007. Biodiversity and the heterogeneous disturbance regime on military training lands. *Restor. Ecol.* **15:** 606–612.
75. Cizek, O., P. Vrba, J. Benes, *et al.* 2013. Conservation potential of abandoned military areas matches that of established reserves: plants and butterflies in the Czech Republic. *PLoS One* **8:** e53124.
76. Arimoro, S., O. Alhambra, R. Lacerda, *et al.* 2017. Artillery for conservation. *Trop. Conserv. Sci.* **10:** 1–13.
77. Doe, W.W., III. 2010. Military lands as spatial analogs for a twenty-first century army: natural environments for testing and training. In *Modern Military Geography*. F.A. Galgano & E.J. Palka, Eds.: 264–277. New York: Routledge.
78. Jentsch, A., S. Friedrich, T. Steinlein, et al. 2009. Assessing conservation action for substitution of missing dynamics on former military training areas in Central Europe. *Restor. Ecol.* **17:** 107–116.
79. Gazenbeek, A. 2005. LIFE, Natura 2000 and the military. European Commission, Environment Directorate General, Brussels, Belgium.
80. Reif, J., P. Marhoul, O. Cizek & M. Konvicka. 2011. Abandoned military training sites are an overlooked refuge for threatened bird species in a central European country. *Biodivers. Conserv.* **20:** 3645–3662.
81. Havlick, D.G. 2014. Opportunistic conservation at former military sites in the United States. *Prog. Phys. Geogr.* **38:** 271–285.
82. Benton, N., J.D. Ripley & F. Powledge, Eds. 2008. *Conserving Biodiversity on Military Lands: A Guide for Natural Resource Managers.* Arlington, VA: NatureServe.
83. Sperry, J.H., W.A. Wall & M.G. Hohman. 2016. Evaluation of 757 species under U.S. Endangered Species Act review on U.S. Department of Defense Lands and their potential impact on army training. U.S. Army Corps of Engineers, Washington, DC. Report No. ERDC/CERL TR-16-3.
84. Dalsimer, A.A. 2017. Threatened and endangered species on DoD lands. Fact Sheet. United States Department of Defense Natural Resources Program, Washington, DC.
85. Lee Jenni, G.D., M.N. Peterson, F.W. Cubbage & J.K. Jameson. 2012. Assessing biodiversity conservation conflict on military installations. *Biol. Conserv.* **153:** 127–133.
86. Ripley, J.D. 2008. Legal and policy background. In *Conserving Biodiversity on Military Lands: A Guide for Natural Resource Managers.* N. Benton, J.D. Ripley & F. Powledge, Eds.: 54–73. Arlington, VA: NatureServe.

87. Hartfield, P., J. Gerhardt Brown & R.A. Fischer. 2017. The role of interagency cooperation in the conservation of threatened and endangered species. DOER Technical Notes Collection. U.S. Army Engineer Research and Development Center, Vicksburg, MS. Report No. ERDC TN- DOER-E40.
88. Simon, M.C. 2004. Public participation in decisions relating to the environmental management of Ministry of Defense sites. In *Defense and the Environment: Effective Scientific Communication*. K. Mahutova, J.J. Barich, III & R.A. Kreizenbeck, Eds.: 65–70. Dordrecht: Kluwer Academic Publishers.
89. Powledge, F. 2008. Beyond the fenceline: partnerships with the surrounding communities. In *Conserving Biodiversity on Military Lands: A Guide for Natural Resource Managers*. N. Benton, J.D. Ripley & F. Powledge, Eds.: 144–153. Arlington, VA: NatureServe.
90. Government of Canada. 2011. Memorandum of understanding concerning cooperation on terrestrial species at risk matters under the responsibility of the Minister of Environment and present on Defence establishments. Accessed November 22, 2017. https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=1A1E22ED-1.
91. UK Ministry of Defense. 2017. Defence infrastructure organisation estate and sustainable development. January 16, 2017. Accessed November 22, 2017. https://www.gov.uk/guidance/defence-infrastructure-organisation-estate-and-sustainable-development#biodiversity-and-nature-conservation-on-the-mod-estate.
92. Australian Government Department of Defense. 2016. Environmental strategy 2016–2035. Accessed November 22, 2017. http://www.defence.gov.au/estatemanagement/Governance/Policy/Environment/Policy/Environment Strategy2016.PDF.
93. Procter, D. & L.V. Fleming, Eds. 1999. *Biodiversity: The UK Overseas Territories*. Peterborough: Joint Nature Conservation Committee.
94. Awuor, F.O. 2015. Impacts of military training on the distribution and abundance of small versus large wildlife herbivores on Mpala Ranch, Laikipia, Kenya. *Afr. J. Ecol.* **53:** 238–241.
95. Babcock, H. 2007. National security and environmental laws: a clear and present danger? *Va. Environ. Law J.* **25:** 105–156.
96. Nackoney, J.G., P. Molinario, S. Potapov, *et al.* 2014. Impacts of civil conflict on primary forest habitat in northern Democratic Republic of the Congo, 1990–2010. *Biol. Conserv.* **170:** 321–328.
97. Bouché, P., P.C. Renaud, P. Lejeune, *et al.* 2010. Has the final countdown to wildlife extinction in Northern Central African Republic begun? *Afr. J. Ecol.* **48:** 994–1003.
98. Maekawa, M., A. Lanjouw, E. Rutagarama & D. Sharp. 2013. Mountain gorilla tourism generating wealth and peace in post-conflict Rwanda. *Nat. Resour. Forum* **37:** 127–137.
99. Lawrence, M.J., H.L. Stemberger, A.J. Zolderdo, *et al.* 2015. The effects of modern war and military activities on biodiversity and the environment. *Environ. Rev.* **23:** 443–460.
100. Pearson, C. 2012. Researching militarized landscapes: a literature review on war and the militarization of the environment. *Landsc. Res.* **37:** 115–133.
101. Lawrence, M.J., A.J. Zoldredo & S.J. Cooke. 2017. The consequences of war on the natural environment. In *Preventing War and Promoting Peace: A Guide for Health Professionals*. W.H. Wiist & S.K. White, Eds.: 48–60. Cambridge: Cambridge University Press.
102. Stellman, J.M., S.D. Stellman, R. Christian, *et al.* 2003. The extent and patterns of usage of Agent Orange and other herbicides in Vietnam. *Nature* **422:** 681–687.
103. Orians, G.H & E.W. Pfeiffer. 1970. Ecological effects of the war in Vietnam. *Science* **168:** 544–554.
104. Van Etten, J., J. Jongerden, H.J. de Vos, *et al.* 2008. Environmental destruction as a counterinsurgency strategy in the Kurdistan region of Turkey. *Geoforum* **39:** 1786–1797.
105. Gurses, M. 2012. Environmental consequences of civil war: evidence from the Kurdish conflict in Turkey. *Civil Wars* **14:** 254–271.
106. Richardson, C.J. & N.A. Hussain. 2006. Restoring the Garden of Eden: an ecological assessment of the marshes of Iraq. *BioScience* **56:** 477–489.
107. Takshe, A.A., M. Huby, S. Frantzi & J.C. Lovett. 2010. Dealing with pollution from conflict: analysis of discourses around the 2006 Lebanon oil spill. *J. Environ. Manage.* **91:** 887–896.
108. Husain, T. 1995. *Kuwaiti Oil Fires: Regional Environmental Perspectives*. Oxford: Elsevier.
109. World Bank. 2007. Republic of Lebanon economic assessment of environmental degradation due to the July 2006 hostilities. World Bank, Washington, DC. Report No. 39787-LB.
110. Evans, M.I., P. Symens & C.W.T. Pilcher. 1993. Short-term damage to coastal bird populations in Saudi Arabia and Kuwait following the 1991 Gulf War marine pollution. *Mar. Pollut. Bull.* **27:** 157–161.
111. Jones, D.A., J. Plaza, I. Watt & M. Al Sanei. 1998. Long-term (1991–1995) monitoring of the intertidal biota of Saudi Arabia after the 1991 Gulf War oil spill. *Mar. Pollut. Bull.* **36:** 472–489.
112. Butsic, V., M. Baumann, A. Shortland, *et al.* 2015. Conservation and conflict in the Democratic Republic of Congo: the impacts of warfare, mining, and protected areas on deforestation. *Biol. Conserv.* **191:** 266–273.
113. Stevens, K., L. Campbell, G. Urquhart, *et al.* 2011. Examining complexities of forest cover change during armed conflict on Nicaragua's Atlantic Coast. *Biodivers. Conserv.* **20:** 2597–2613.
114. Sánchez-Cuervo, A.M. & T.M. Aide. 2013. Consequences of the armed conflict, forced human displacement, and land abandonment on forest cover change in Colombia: a multi-scaled analysis. *Ecosystems* **16:** 1052–1070.
115. Ordway, E.M. 2015. Political shifts and changing forests: effects of armed conflict on forest conservation in Rwanda. *Glob. Ecol. Conserv.* **3:** 448–460.
116. Gorsevski, V., E. Kasischke, J. Dempewolf, *et al.* 2012. Analysis of the impacts of armed conflict on the Eastern Afromontane forest region on the South Sudan—Uganda border using multitemporal Landsat imagery. *Remote Sens. Environ.* **118:** 10–20.
117. Martin, P.S. & C.R. Szuter. 1999. War zones and game sinks in Lewis and Clark's west. *Conserv. Biol.* **13:** 36–45.

118. Ferguson, R.B. 1989. Ecological consequences of Amazonian warfare. *Ethnology* **28:** 249–264.
119. Beare, D., F. Hölker, G.H. Engelhard, *et al.* 2010. An unintended experiment in fisheries science: a marine area protected by war results in Mexican waves in fish numbers-at-age. *Naturwissenschaften* **97:** 797–808.
120. Le Billon, P. 2000. The political ecology of transition in Cambodia 1989–1999: war, peace and forest exploitation. *Dev. Change* **31:** 785–805.
121. Baumann, M., V.C. Radeloff, V. Avedian & T. Kuemmerle. 2015. Land-use change in the Caucasus during and after the Nagorno–Karabakh conflict. *Reg. Environ. Change* **15:** 1703–1716.
122. Hughes, J.D. 2013. Warfare and environment in the ancient world. In *The Oxford Handbook of Warfare in the Classical World.* B. Campbell & L.A. Tritle, Eds.: 128–142. Oxford: Oxford University Press.
123. Engels, D. 2013. Logistics: sinews of war. In *The Oxford Handbook of Warfare in the Classical World.* B. Campbell & L.A. Tritle, Eds.: 128–142. Oxford: Oxford University Press.
124. Collier, P. 2000. Rebellion as a quasi-criminal activity. *J. Confl. Resolut.* **44:** 839–853.
125. Le Billon, P. 2012. *Wars of Plunder: Conflicts, Profits, and the Politics of Resources.* New York: Columbia University Press.
126. Burnett, M.T., Ed. 2016. *Natural Resource Conflicts: From Blood Diamonds to Rainforest Destruction.* Santa Barbara, CA: ABC-CLIO.
127. Douglas, L.R. & K. Alie. 2014. High-value natural resources: linking wildlife conservation to international conflict, insecurity, and development concerns. *Biol. Conserv.* **171:** 270–277.
128. Johnston, P. 2004. Timber booms, state busts: the political economy of Liberian timber. *Rev. Afr. Pol. Econ.* **31:** 441–456.
129. Le Billon, P. 2008. Diamond wars? Conflict diamonds and geographies of resource wars. *Ann. Assoc. Am. Geogr.* **98:** 345–372.
130. Martin, M. & H. Solomon. 2017. Islamic State: understanding the nature of the beast and its funding. *Contemp. Rev. Mid. East* **4:** 18–49.
131. Chase, M.J. & C.R. Griffin. 2011. Elephants of south-east Angola in war and peace: their decline, re-colonization and recent status. *Afr. J. Ecol.* **49:** 353–361.
132. Crayne, S. & C. Haenlein. Poaching, wildlife trafficking, and conflict. In *Poaching, Wildlife Trafficking and Security: Myths and Realities.* C. Haenlein & M.L.R. Smith, Eds.: 38–57. London: Routledge.
133. Baral, N. & J.T. Heinen. 2005. The Maoist people's war and conservation in Nepal. *Pol. Life Sci.* **24:** 2–11.
134. Thapa, K., S. Nepal, G. Thapa, *et al.* 2013. Past, present and future conservation of the greater one-horned rhinoceros *Rhinoceros unicornis* in Nepal. *Oryx* **47:** 345–351.
135. Goswami, R. & T. Ganesh. 2014. Carnivore and herbivore densities in the immediate aftermath of ethno-political conflict: the case of Manas National Park, India. *Trop. Conserv. Sci.* **7:** 475–487.
136. Kujirakwinja, D. 2010. The status and conservation of common hippopotamuses in Virunga National Park. MSc thesis. University of Cape Town, Rondebosch.
137. Plumptre, A.J., S. Nixon, D.K. Kujirakwinja, *et al.* 2016. Catastrophic decline of world's largest primate: 80% loss of Grauer's gorilla (*Gorilla beringei graueri*) population justifies critically endangered status. *PLoS One* **11:** e0162697.
138. Draulans, D. & E. Van Krunkelsven. 2002. The impact of war on forest areas in the Democratic Republic of Congo. *Oryx* **36:** 35–40.
139. Loucks, C., M.B. Mascia, A. Maxwell, *et al.* 2009. Wildlife decline in Cambodia, 1953–2005: exploring the legacy of armed conflict. *Conserv. Lett.* **2:** 82–92.
140. Hagenlocher, M., S. Lang & D. Tiede. 2012. Integrated assessment of the environmental impact of an IDP camp in Sudan based on very high resolution multi-temporal satellite imagery. *Remote Sens. Environ.* **126:** 27–38.
141. Braun, A., S. Lang & V. Hochschild. 2016. Impact of refugee camps on their environment. A case study using multi-temporal SAR data. *J. Geogr. Environ. Earth Sci. Int.* **4:** 1–17.
142. Allan, N.J. 1987. Impact of Afghan refugees on the vegetation resources of Pakistan's Hindukush-Himalaya. *Mt. Res. Dev.* **7:** 200–204.
143. Jensen, D. & S. Lonergan, Eds. 2012. *Assessing and Restoring Natural Resources in Post-Conflict Peacebuilding.* New York: Earthscan.
144. Frost, A., P. Boyle, P. Autier, *et al.* 2017. The effect of explosive remnants of war on global public health: a systematic mixed-studies review using narrative synthesis. *Lancet Public Health* **2:** e286–e296.
145. Ohayon, J.L. 2015. New battlegrounds over science, risk, and environmental justice: factors influencing the cleanup of military superfund sites. PhD dissertation. University of California, Santa Cruz.
146. Czub, M., L. Kotwicki, T. Lang, *et al.* 2018. Deep sea habitats in the chemical warfare dumping areas of the Baltic Sea. *Sci. Total Environ.* **616:** 1485–1497.
147. Martini, E.A., Ed. 2015. *Proving Grounds: Militarized Landscapes, Weapons Testing, and the Environmental Impact of US Bases.* Seattle, WA: University of Washington Press.
148. Hamilton, J.W. 2016. Contamination at US military bases: profiles and responses. *Stanf. Environ. Law J.* **35:** 223–249.
149. Horvat, M. 2011. Environmental biomonitoring as a tool in risk and impact assessment associated with post-conflict restoration and rehabilitation. In *Warfare Ecology*. G. Machlis, T. Hanson, Z. Spiric & J.E. McKendry, Eds.: 189–197. Dordrecht: Springer.
150. Benthem, W., L.P. Van Lavieren & W.J.M. Verheugt. 1999. Mangrove rehabilitation in the coastal Mekong Delta, Vietnam. In *An International Perspective on Wetland Rehabilitation.* W.J. Streever, Ed.: 29–36. Dordrecht: Springer.
151. Langer, S., D. Tiede & F. Lüthje. 2015. Long-term monitoring of the environmental impact of a refugee camp based on Landsat time series: the example of deforestation and reforestation during the whole lifespan of the Camp Lukole, Tanzania. *GI_Forum* **2015:** 434–437.
152. Waeber, P.O. & L. Wilmé. 2013. Madagascar rich and intransparent. *Madagascar Conserv. Dev.* **8:** 52–54.
153. Zulu, L. & S. Wilson. 2012. Whose minerals, whose development? Rhetoric and reality in post-conflict Sierra Leone. *Dev. Change* **43:** 1103–1131.

154. Fahey, D. 2011. The new gold rush: post-conflict mining and trading in the Kilo Belt (DRC). In *Natural Resources and Local Livelihoods in the Great Lakes Region of Africa.* A. Ansoms & S. Marysse, Eds.: 170–191. London: Palgrave Macmillan.
155. Bruch, C., D. Jensen, M. Nakayama, *et al.* 2009. Post-conflict peace building and natural resources. *Yearbook Int. Environ. Law* **19:** 58–96.
156. Negret, P.J., J. Allan, A. Braczkowski, *et al.* 2017. Need for conservation planning in postconflict Colombia. *Conserv. Biol.* **31:** 499–500.
157. Lujala, P. & S.A. Rustad, Eds. 2012. *High-Value Natural Resources and Post-Conflict Peacebuilding.* New York: Earthscan.
158. Plumptre, A.J., M. Masozera & A. Vedder. 2001. *Effect of civil war on the conservation of protected areas in Rwanda.* Biodiversity Support Program, Washington, DC.
159. Johnson, M.F., N. Kanderian, C.C. Shank, *et al.* 2012. Setting priorities for protected area planning in a conflict zone—Afghanistan's National Protected Area System Plan. *Biol. Conserv.* **148:** 146–155.
160. Smallwood, P.D. 2014. The risks of greening in the red zone: creating Afghanistan's First National Park in the midst of conflict. In *Greening in the Red Zone.* K. Tidball & M. Krasny, Eds.: 297–303. Dordrecht: Springer.
161. Aguilar, M., J. Sierra, W. Ramirez, *et al.* 2015. Toward a post-conflict Colombia: restoring to the future. *Restor. Ecol.* **23:** 4–6.
162. Becker, R.H. 2014. The stalled recovery of the Iraqi marshes. *Remote Sens.* **6:** 1260–1274.
163. Carius, A. 2006. Environmental peacebuilding. Environmental cooperation as an instrument for crisis prevention and peacebuilding: conditions for success and constraints. Adelphi Consult GmbH, Berlin. Report No. 3-07.
164. Castro-Nunez, A., O. Mertz, A. Buritica, *et al.* 2017. Land related grievances shape tropical forest-cover in areas affected by armed-conflict. *Appl. Geogr.* **85:** 39–50.
165. Conca, K. & J. Wallace. 2009. Environment and peacebuilding in war-torn societies: lessons from the UN Environment Programme's experience with postconflict assessment. *Glob. Govern.* **15:** 485–504.
166. Moore, E.A. 2014. Reforestation activities at a Chadian refugee camp in Northern Cameroon. In *Greening in the Red Zone.* K. Tidball & M. Krasny, Eds.: 411–415. Dordrecht: Springer.
167. Ringuette, K. 2010. In Sudan, planting trees eases environmental impact of hosting refugees. July 1, 2010. Accessed December 15, 2017. http://www.unhcr.org/en-us/news/makingdifference/2010/7/4c2c472e9/sudan-planting-trees-eases-environmental-impact-hosting-refugees.html.
168. Jacobs, M.J. & C.A. Schloeder. 2001. Impacts of conflict on biodiversity and protected areas in Ethiopia. Biodiversity Support Program, Washington, DC.
169. Waugh, J. & J. Murombedzi. 2016. Social benefits in the Liberian forestry sector: an experiment in post-conflict institution building for resilience. In *Governance, Natural Resources, and Post-Conflict Peacebuilding.* C. Bruch, C. Muffett & S.S. Nichols, Eds.: 561–578. London: Earthscan.
170. Nirmal, K.B.K., R.K. Shrestha, S.G. Acharya & A.S. Ansari. 2009. Maoist conflict, community forestry and livelihoods: pro-poor innovations in forest management in Nepal. *J. Forest Livelihood* **8:** 93–100.
171. Ali, S.H., Ed. 2007. *Peace Parks: Conservation and Conflict Resolution.* Cambridge, MA: MIT Press.
172. Barquet, K., P. Lujala & J.K. Rød. 2014. Transboundary conservation and militarized interstate disputes. *Pol. Geogr.* **42:** 1–11.
173. Kakabadse, Y., J. Caillaux & J. Dumas. 2016. The Peru and Ecuador peace park: one decade after the peace settlement. In *Governance, Natural Resources, and Post-Conflict Peacebuilding.* C. Bruch, C. Muffett & S.S. Nichols, Eds.: 817–824. London: Earthscan.
174. Grichting, A. 2014. Cyprus: greening in the Dead Zone. In *Greening in the Red Zone.* K. Tidball & M. Krasny, Eds.: 429–443. Dordrecht: Springer.
175. Kim, K.C. 1997. Preserving biodiversity in Korea's Demilitarized Zone. *Science* **278:** 242–243.
176. Kim, K.G. & D.G. Cho. 2005. Status and ecological resource value of the Republic of Korea's De-militarized Zone. *Landsc. Ecol. Eng.* **1:** 3–15.
177. Barkin, N. & N. Mchedlishvili. 2008. Burnt Georgian forest shows costs of Russia war. September 11, 2008. Accessed December 18, 2017. Rueters. https://www.reuters.com/article/us-georgia-ossetia-forest/burnt-georgian-forest-shows-costs-of-russia-war-idUSL928450720080911.
178. Symmes, P. 2014. Born on the 9th of July. In *Best American Travel Writing 2014.* P. Theroux, Ed.: 241–255. Boston: Houghton Mifflin Harcourt.
179. Wallach, A.D. 2015. Wolves find sanctuary in minefields and militarised zone of the Golan Heights. *Guardian Weekly.* February 20, 2015. p. 31.
180. Jones, P. 2012. Congolese rebels use gorilla tourism to fund insurgency. *Guardian Weekly.* October 26, 2012. p. 20.
181. Liu, J., Z. Ouyang, S.L. Pimm, *et al.* 2003. Protecting China's biodiversity. *Science* **300:** 1240–1241.
182. Sierra, C.A., M. Mahecha, G. Poveda, *et al.* 2017. Monitoring ecological change during rapid socio-economic and political transitions: Colombian ecosystems in the post-conflict era. *Environ. Sci. Policy* **76:** 40–49.
183. Crabbé, P., Ed. 2000. *Implementing Ecological Integrity: Restoring Regional and Global Enivronmental and Human Health.* Dordrecht: Springer.
184. Machlis, G.E., T. Hanson, Z. Spiric & J.E. Mckendry, Eds. 2011. *Warfare Ecology: A New Synthesis for Peace and Security.* Dordrecht: Springer.
185. Kotlyakov, V., M. Uppenbrink & V. Metreveli, Eds. 1998. *Conservation of the Biological Diversity as a Prerequisite for Sustainable Development in the Black Sea Region.* Dordrecht: Spinger.
186. Light, S.S., Ed. 2004. *The Role of Biodiversity Conservation in the Transition to Rural Sustainability.* Amsterdam: IOS Press.
187. Walden-Schreiner, C., Y.F. Leung & L. Tateosian. 2018. Digital footprints: incorporating crowdsourced geographic information for protected area management. *Appl. Geogr.* **90:** 44–54.

188. Savage, S.H., A. Johnson & T.E. Levy. 2017. TerraWatchers, crowdsourcing, and at-risk World Heritage in the Middle East. In *Heritage and Archaeology in the Digital Age*. M. Vincent, V. López-Menchero Bendicho, M. Ioannides & T. Levy, Eds.: 67–77. Cham: Springer.
189. Chritz, K.L., S.A. Blumenthal, T.E. Cerling & H. Klingel. 2016. Hippopotamus (*H. amphibius*) diet change indicates herbaceous plant encroachment following megaherbivore population collapse. *Sci. Rep.* **6:** 32807.
190. De Santo, E.M., P.J.S. Jones & A.M.M. Miller. 2011. Fortress conservation at sea: a commentary on the Chagos MPA. *Mar. Policy* **35:** 258–260.
191. Dalton, S.E. 2011. Application of the human ecosystem model in warfare ecology. In *Warfare Ecology*. G. Machlis, T. Hanson, Z. Spiric & J.E. McKendry, Eds.: 245–257. Dordrecht: Springer.
192. Caroppo, C. & G. Portacci. 2017. The First World War in the Mar Piccolo of Taranto: first case of warfare ecology? *Ocean Coast. Manage.* **149:** 135–147.
193. Humphreys, J. & M.L.R. Smith. 2011. War and wildlife: the Clausewitz connection. *Int. Aff.* **87:** 121–142.
194. Duffy, R. 2014. Waging a war to save biodiversity: the rise of militarized conservation. *Int. Aff.* **90:** 819–834.
195. Rincón-Ruiz, A. & G. Kallis. 2013. Caught in the middle, Colombia's war on drugs and its effects on forest and people. *Geoforum* **46:** 60–78.
196. Milburn, R. 2014. The roots to peace in the Democratic Republic of Congo: conservation as a platform for green development. *Int. Aff.* **4:** 871–887.
197. UK Ministry of Defense. 2017. Sanctuary magazine. Accessed December 21, 2017. https://www.gov.uk/government/publications/sanctuary.
198. Wilkie, B. 2016. Bombs and biodiversity: a case study of military environmentalism in Australia. *Environment and Society Portal*. https://doi.org/10.5282/rcc/7678.
199. Solomon, N., E. Birhane, C. Gordon, *et al.* 2018. Environmental impacts and causes of conflict in the Horn of Africa: a review. *Earth-Sci. Rev.* **177:** 284–290.
200. United Nations. 2017. Draft resolution on pollution mitigation and control in areas affected by armed conflict or terrorism. UNEP/EA.3/L.5. Nairobi. United Nations Environment Assembly of the United Nations Environment Programme.
201. United Nations. 2016. Protection of the environment in areas affected by armed conflict. UNEP/EA.2/Res. 15. Nairobi. United Nations Environment Assembly of the United Nations Environment Programme.
202. Mrema, E., C. Bruch & J. Diamond. 2009. Protecting the environment during armed conflict: an inventory and analysis of international law. Nairobi. United Nations Environment Programme.
203. United Nations. 2001. Observance of the international day for preventing the exploitation of the environment in war and armed conflict. A/RES/56/4. New York. United Nations General Assembly.
204. Cawthorn, D.M. & L.C. Hoffman. 2015. The bushmeat and food security nexus: a global account of the contributions, conundrums and ethical collisions. *Food Res. Int.* **76:** 906–925.
205. Rogers, C., B.K. Sovacool & S. Clarke. 2013. Sweet nectar of the Gaia: lessons from Ethiopia's "Project Gaia." *Energy Sustain. Dev.* **17:** 245–251.
206. Rustad, S.A. & H.M. Binningsbø. 2012. A price worth fighting for? Natural resources and conflict recurrence. *J. Peace Res.* **49:** 531–546.
207. Hammill, E., A.I.T. Tulloch, H.P. Possingham, *et al.* 2016. Factoring attitudes towards armed conflict risk into selection of protected areas for conservation. *Nat. Commun.* **7**. https://doi.org/10.1038/ncomms11042.
208. Zhang, D.D., P. Brecke, H.F. Lee, *et al.* 2007. Global climate change, war, and population decline in recent human history. *Proc. Natl. Acad. Sci. USA* **104:** 19214–19219.
209. Burke, M.B., E. Miguel, S. Satyanath, *et al.* 2009. Warming increases the risk of civil war in Africa. *Proc. Natl. Acad. Sci. USA* **106:** 20670–20674.
210. Hsiang, S.M., K.C. Meng & M.A. Cane. 2011. Civil conflicts are associated with the global climate. *Nature* **476:** 438–441.
211. Hsiang, S.M., M. Burke & E. Miguel. 2013. Quantifying the influence of climate on human conflict. *Science* **341:** 1235367.
212. Roulin, A., M.A. Rashid, B. Spiegel, *et al.* 2017. 'Nature knows no boundaries': the role of nature conservation in peacebuilding. *Trends Ecol. Evol.* **32:** 305–310.