The Impact of Militarism on the Environment

An Overview of Direct & Indirect Effects

By Abeer Majeed

A research report written for Physicians for Global Survival (Canada)

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Foreword

This report is the product of a summer studentship and has been prepared for *Physicians for Global Survival (Canada)* with the intent of identifying the effects of militarism on the environment. Throughout history armed conflict has had an impact on the local environment. However, the technological aspects of modern warfare and preparations for war have dramatically changed the immediate and potential long-term impact of military activities on the environment. These technologies include not only biological, nuclear and chemical weapons, but also the increase in intensity and diversity of explosive devices.

The report involves a broad and general review of literature and is meant to establish a preliminary framework to be further developed at a later date. While an attempt has been made to be as comprehensive as possible, the report has been limited by the time allocated for the project. As such it often draws upon specific examples and cites references to selected nations or case studies. The focus is placed on the detailed effects on the environment. However, this is in no way meant to mitigate the very devastating human and social costs of militarism. The information presented in some of the report's tables and figures is also often incomplete in nature and serves primarily to indicate the potential scope of the issues discussed.

The content of the report is based on the reading of various sources such as books, journal articles, reports, and has also been dependant on internet sources. The author has relied on the theoretical perspectives of selected researchers in defining terms such as 'militarism'. Where applicable, these references have been provided and discussed. In conducting the research for this report, the author noted some challenges and these are also addressed during the course of the report.

Acknowledgements

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Contents

1. Introduction

The contribution of military activities to the unprecedented series of environmental crises facing the world today has been largely overlooked and, to an extent, wilfully ignored. This, despite the reality that 163 of the 192 current sovereign countries maintain regular armed forces (Westing 2000). Although the use of weapons of mass destruction has been a prominent feature in the media in recent months, there is a disturbing lack of detailed analysis on the consequences of their use, particularly with regard to the environment. Often vehemently defended for their role in insuring national security, peacetime military operations, in fact, pose a constant and major health threat to the citizens of militarized countries. Yet, governments still refuse to conduct serious assessments comparing the highly actualized national security threat posed by their own armed forces versus those posed by perceived external threats.

Asit Biswas, writing for the Environmental Law Institute, voices another related concern, the conspicuous absence of detailed, comprehensive, and authoritative studies on the short-, medium-, and long-term environmental impacts of any major conflict to date (Biswas 2000). In particular, he observes a tendency amongst environmental scholars, development experts, and political scientists to, for whatever reasons, refrain from carrying out such environmental assessment studies on military activities. The same, he notes, can be said of international organizations such as the various United Nations agencies (UNEP, UNDP, UNESCO etc.).

This report simply attempts to identify the many direct and indirect ways militarism impacts the environment based on available information. The author relies on the definition for ‘military activities’ used by Gurinder Shahi and Victor Sidel:

> *“(...)the term ‘military activities’ will therefore be used to include (1) the active use of weapons in war, civil disturbances, civil war and low-intensity war [summarized as ‘war’]; (2)weapons development, production, testing, storage, transport and disassembly and disposal, and military training (‘military preparation’); and (3) the prevalence of military oriented attitudes and practices within a nation or in the world (‘militarism’).”*
>
> *(Shahi and Sidel 1997, p.283)*

The term ‘militarism’ is expanded by the author to also include relevant but diverse considerations ranging from trade and/or smuggling in small arms to colonial enterprises such as slavery and resource acquisition. It, furthermore, includes within its parameters the use of armed force by: government forces (deployed within the state or externally), armed opposition groups, and private security formations (paramilitary units, corporate-sponsored forces, foreign mercenaries).

2. Wartime Environmental Effects of Military Activities

2.1 The Environmental Effects of Weapons Use

The types of weapons and extent to which they are used, along with the duration and intensity of the war are major determinants of the total environmental damage caused in wartime. While the different weapons systems all present threats to environmental integrity, they vary in the effects they cause.

2.1.1 Major Conventional Weapons Use

SIPRI (1998) has defined conventional weapons as weapons that do not have mass destruction effects, in contrast to nuclear, biological or chemical weapons. The destruction caused by conventional warfare, however, should not be underestimated.

2.1.1a High explosive fragmentation (HEF) weapons— HEF munitions consist of a high explosive filler, which upon detonation produces rapidly expanding gases that shatter the metal casing. As a result, fragments of metal and debris fly outwards from the point of explosion with substantial force (Hogendoorn and Prokosch 2002). The deployment of HEF munitions can cause significant disruption to transport, agriculture and forestry. The United States bombing campaign in Vietnam used about 14 million tons of high explosives, creating more than 20 million bomb craters covering about 200,000 hectares (Levy et al. 1997).

2.1.1b Incendiary weapons— Incendiary weapons use flame or heat to set fire to targets. Scorched-earth tactics have been used in war since ancient times although they were limited to the restricted range of catapults up until the 17^{th} century (Westing 1977). Traditionally, scorched earth policy meant burning everything in advance of an invading army, but World War I ushered in the era of air delivered incendiary bombs. Incendiary bombs are commonly filled with thickened oil known as napalm or with oil and metal mixtures called pyrogels. Their effect was to produce similar devastation.

Incendiary weapons have the greatest impact on the vegetation of an ecosystem but also degrade soil and contaminate water sources (Westing 1977). The degree of damage caused to the environment by incendiary weapons is dependant on the prevailing weather conditions during bombing as well as the species of trees involved. The ability of the more mature trees of a species to withstand fire damage is a function of its bark characteristics, particularly thickness. However, the greatest damage to a tree is caused when fungi (and to a lesser extent insects) gain entry via its fire wounds. Damage to the soil is especially acute in tropical ecosystems. Westing (1977) states that in such forests the soil litter and associated humus are both scarce commodities. They are severely reduced by major fires and as a consequence, not only are nutrients such as phosphorus and potassium lost but the soil also becomes exposed to further degradation. Flood danger is also enhanced. The cumulative effects of incendiary weapons result in ecosystems that are able to support a far less diversified plant and animal community.

Depleted uranium (DU) munitions, may be considered incendiary weapons although their radioactive properties put them in a new class. The DU used in antitank projectiles is metallic, but is encased, because uranium metal oxidizes rapidly in air. Upon striking the wall of a tank, however, the greatly heated uranium, which becomes exposed to air on impact, burns brightly, producing small oxide particles in consequence. Thus, such projectiles, which are pyrophoric on impact, have an incendiary effect (Hogendoorn and Prokosch 2002). The environmental consequences of DU use are enduring in nature. 70-80% of all DU weapons — around 250 tons in the Gulf War region alone — are thought to remain buried in soil (Royal Society 2002).

Decades on, corroding weapons may still release DU into the soil, to be taken up by plants and animals or leached into human water supplies. In an assessment of the health effects of DU weapons use, IPPNW conclude:

> *"Furthermore, DU weapons indiscriminately contaminate the places in which they are used, and the contamination persists long after the conclusion of hostilities, adding to the radioactive and toxic burden imposed upon civilians, wildlife and ecosystems. From this perspective, DU weapons should be considered a form of ecological warfare prohibited by the Geneva Conventions."*
>
> *(IPPNW 2001, website)*

There is an imperative need that comprehensive and independent studies be conducted to assess the detailed impact of uranium on ecosystems.

2.1.1c Enhanced blast munitions— Enhanced blast munitions disperse material in the atmosphere before the process of detonation is completed. Therefore, the explosion occurs over a larger area creating a blast wave that is destructive throughout the area (Hogendoorn and Prokosch 2002). Enhanced blast munitions are effective against 'soft' targets, including human beings, both adults and children, animals and crops and targets open to the atmosphere including unreinforced buildings and woody vegetation. The blast munitions are of three types: fuel-air explosives, reactive surround warheads, and slurry explosive munitions.

The U.S. 'daisy cutter' bomb, considered the largest conventional weapon, is an example of a slurry explosive munition. The bomb's warhead contains 12,600 lb (5,700 kg) of GSX, a slurry of ammonium nitrate (the basis of nitrogen fertilizer), highly flammable aluminium powder, and polystyrene-based soap as a thickener (BBC 2001). In a daisy cutter explosion the pressure reaches about 70 kg/sq cm (1,000 psi) at the centre and affects an area typically reported to be the size of several football pitches (BBC 2001).

2.1.1d Herbicides and defoliants— Although some nations classify herbicides and defoliants as chemical weapons, the US does not do so because they do not fit within the meaning of arms control treaties. They serve primarily to destroy forestry and vegetation thereby denying the enemy means of cover and concealment (Westing 2002). To a lesser extent they also deny the enemy timber as a resource. Herbicides and defoliants can cause severe damage to upland and coastal forest ecosystems. Due to loss of habitat, wildlife is also severely harmed in forest ecosystems. The soil and its nutrients are eroded and washed away. Depending on the severity of the attack, vegetation type, and local site conditions, natural recovery can take years or span decades.

The United States used about 72 million litres of herbicides in Vietnam between 1961 and 1971. Agent Orange, which represented 61% of the U.S. military's herbicide volume, was sprayed over 35 % of southern Vietnam. The resulting devastation is described by Levy et al. (1997):

- *"Destruction of million of trees and often their replacement with grass: an estimated 20 million square meters of commercial timber destroyed;*
- *135,000 hectares of rubber plantations; 124,000 hectares of mangroves;*
- *Widespread debilitation of land via soil erosion and loss of nutrients in the ground;*
- *Losses in freshwater fish, mainly because of reduced availability of food species; and*
- *Possible contribution to the decline of the offshore fishery."*

(Levy et al. 1997, pp.55-56)

In addition, dioxin contained in Agent Orange persists, with elevated levels still found in soil, food, wildlife, human breast milk and adipose tissue (Shahi and Sidel 1997). Among the Vietnamese, exposure to Agent Orange is considered to be the cause of an abnormally high incidence of miscarriages, skin diseases, cancers, birth defects and congenital malformations (often extreme and grotesque) from the 1970's to the 1990's (Encyclopedia Britannica 2002). Many US, Australian and New Zealand servicemen who suffered long exposure to Agent Orange in Vietnam later developed a number of cancers and other health disorders. Despite the difficulty of establishing conclusive proof that their claims were valid, US veterans brought a class - action lawsuit against seven herbicide makers that produced Agent Orange for the US military.
The suit was settled out of court with the establishment of a $180,000,000 fund to compensate some 250,00 claimants and their families. Separately, the US Department of Veteran Affairs awarded compensation to about 1,800 veterans (Encyclopedia Britannica 2002).
More definitive epidemiological studies are required to clarify the effects of Agent Orange on human populations.

2.1.1e Anti-personnel mines (APM)— An anti-personnel mine is a mine designed to explode by the presence, proximity, or contact of a person and that will incapacitate, injure or kill one or more persons (Landmine Action UK 2003). The 2002 Landmine Monitor Report estimates that there are some 230 million anti-personnel mines in the arsenals of 94 countries, with the biggest estimated to be China (110 million), Russia (60-70 million), United States (11.2 million), Ukraine (6.4 million), Pakistan (6 million), India (4-5 million), and Belarus (4.5 million). Its research identifies 90 countries that are currently affected to some degree by landmines and/or unexploded ordnance. Estimates suggest that over 110 million anti-personnel landmines still lie in the soil (Gangwar 2003). These mines cause extensive damage to the environment which are presented below.

- **Crops and Vegetation—** APMs render vast tracts of farmland completely idle or with decreased productivity. In Libya, for example, it is estimated that about 8.49% of its arable land is contaminated by landmines (Westing et al. 1985). The additive impacts of landmines also dramatically reduce the soil productivity. In Vietnam, for example, landmines are thought to contribute to the 50 % reduction in rice yield (Gangwar 2003). In a study investigating the social impact of landmines in Afghanistan, Bosnia, Cambodia, and Mozambique, Andersson et al. (1995) found that without mines, agricultural production could increase by 88-200% in Afghanistan, 11% in Bosnia, 135% in Cambodia, and 3.6% nationally in Mozambique. Landmines also destroy the flora of an ecosystem contributing to processes of soil erosion. In addition to the actual explosions and loss of life and limb, the influence of fear of landmines lying hidden in the ground are a factor in the reluctance to farm vast areas of potentially fertile ground. Moreover, bomb craters in Vietnam became filled with water that harbored malaria-carrying mosquitos.
- **Livestock—** The economic and social consequences of livestock loss due to APMs can be devastating. In Libya, between 1940 and 1980, an average of 3,125 animals were lost *a year* due to unexploded ordinances, including APMs, left over from World War II (Torres Nachón 1999). A Reuters report (1999) estimated that nearly 1 million head of livestock were either killed or wounded by landmines in the past 15 years of civil war in Sudan.
- **Wildlife—** Wildlife is also severely affected by landmines. Torres Nachón (1999) observes that in certain cases "there is a repetitive geographical coincidence between mine-affected zones and biodiversity hotspots. Such coincidence is acutely present in diverse regions of the planet." Project Mkono has maintained a record of wildife loss

due to landmines at their website. Losses, as reported by various news agencies and environmental organizations, include: threatened extinction of the Snow Leopards and other species in Afghanistan, 14 brown bears killed between 1991-1995 in Croatia, a silverback gorilla killed in Rwanda in 1994, 20 elephants killed per year in Sri Lanka, and hundreds of antelopes and gazzelles killed in Angola and Libya respectively over the years (Project Mkono 2003). APMs are also used by poachers. For example, in the Mupa National Park in Angola, poachers have been reported to purposely kill elephants using landmines in order to finance weapons purchase from ivory tusk sales (Torres Nachón 1999).

- **Soil Pollution—** APMs are planted on the surface of the land or just beneath the surface and directly impact soil quality and composition in two key ways. The explosion of a landmine degrades the soil. Alternatively, leaking of toxic substances over a prolonged period of time due to corrosion (metal APM) or decomposition (wooden APM) contaminates the land. Toxic elements include: mercury, iron, manganese, chromium, and zinc (Torres Nachón 1999). In agricultural regions, toxic substances can easily enter the food chain and bioaccumulate in humans and animals. Mines commonly use 2,4,6- trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX or "cyclonite") (Gangwar 2003). TNT, RDX, and the compounds derived from them are water-soluble, long-lived, carcinogenic, and toxic even in small amounts as they leach and decompose. Both are lethal to mammals, aquatic micro-organisms, and fish (Gangwar 2003). RDX is particularly lethal to mammals.
- **Water Pollution—** In many African localities, landmines have been installed in and around sewage and water treatment facilites. Landmines have also been reported to be used for fishing in places such as the Tanganika Lake in Tanzania (Torres Nachón 1999). As a consequence, lakes and water supplies become contaminated with heavy metals.
- **Demining—** While demining also degrades the environment, perhaps the most controversial issue surrounding it is the use of animals for detecting mines. Dogs, bees, and more recently rats have all been used in efforts to demine mine-affected zones (Torres Nachón 1999). The data on animals that have been maimed or killed by APMs during demining operations in not known. Displaced villagers also,out of necessity, often resort to using their domesticated animals to detect mines upon returning to their farms.

2.1.2 Biological Weapons Use

The WHO (2001) defines biological weapons as those "whose intended target effects are due to the effectivity of disease causing micro-organisms, and other replicative entities, including viruses, infectious nucleic acids and prions." In addition, toxins produced by biological organisms and that are integrated into weapons systems are also considered biological weapons.

Biowarfare has been practiced against enemy forces since ancient times. Ancient Persians, Greeks, and Romans used to drop diseased cadavers into wells to poison the drinking water of the enemy (Mäkelä 2003). The use of small-pox contaminated blankets to spread disease among Native American tribes in northeastern North America by the British colonial army in the 18th century is well documented (Connell and Gould 1997). Research into what are considered modern biological weapons, however, began during World War I and by the end of World War II modern biowarfare programs were well established in Japan, Germany, the USSR, the U.K. and the U.S.

The stated objectives of biowarfare programs are: to use human pathogens to inflict casualties amongst the enemy, to destroy the livestock of the enemy, and to cause disease in crop plants thereby affecting the nutrition and the economy of the enemy (Mäkelä 2003). See Table 1. All three objectives, have potentially devastating environmental consequences and these are discussed next.

Dudley and Woodford (2002) identify some key threats posed by biowarfare:

- Animal and plant pathogens that are used to target livestock and agricultural crops can have potentially disastrous spillover effects on wildlife species. The Great African Rinderpest epizootic of the 19th century provides a useful model. The rinderpest virus, introduced into Africa in 1887 through cattle imported from India to supply European colonial armies caused, within three years of its appearance in East Africa, death in an estimated 90 to 95 percent of the native African cattle breeds, African buffalo (*Syncerus caffer*), and wildebeast (*Connochaetes taurinus*).
- The use of human pathogens in biowarfare can also affect other species. For example, three of the four genetically modified pathogens (i.e. anthrax, plague, tularemia) created specifically for bioweapon attacks against human populations can, if released into the environment, pose direct and indirect threats to wildlife populations.
- Once introduced and established in new areas, exotic diseases can be difficult or impossible to eradicate. In the case of anthrax, the risk of subsequent disease outbreaks whithin contaminated areas may continue for decades and even centuries after the total eradication of hosts and vectors. Viable and infectious anthrax bacilli have been cultured from animal bones buried for 150 to 200 years in archeological sites.

New Developments— The introduction of modern biotechnology during the past 25 years has markedly changed the qualitative and quantitative impact that biological warfare, or the threat of such warfare, can have on military forces, cities and towns. The Federation of American Scientists (1998) has summarized the potential capability of the new technology:

> *"(1) development of biological agents that have increased virulence and stability after deployment; (2) ability to target the delivery of organisms to populations; (3) protection of personnel against biological agents; (4) production, by genetic modification, pathogenic organisms from non-pathogenic strains to complicate detection of a biological agent; (5) modification of the immune response system of the target population to increase or decrease susceptibility to pathogens; and (6) production of sensors based on the detection of unique signature molecules on the surface of biological agents or on the interaction of the genetic materials in such organisms with gene probes."*
>
> ***(FAS 1998, website)***

Table 1: **Selected Plant and Animal Pathogens with Bioweapons Potential and their Environmental Impacts** Source: *Animal and Plant Health*, Department of Primary Industries, Queensland Government Australia; *Biological Warfare against Crops*, Simon M. Whitby 2002.

Plant Pathogen	**Disease Caused**	**Environmental Effects**	**Environmental Stability**	**Bio-weapons Potential**
Colletotrichum coffeanum var virulans	Coffee berry disease	-Very destructive in terms of yield loss and seedling death	-Can survive as latent infection	-Not a staple food but may cause serious worldwide economic problems
Tilletia tritici	-Cover smut, Stinking smut, and Common bunt of wheat	-Fungus attacks the flower, replacing the kernels with bunt balls of black teliospores. -suppresses yield and lowers quality	-Teliospores can survive up to 2 years in soil	-Good, could be enhanced by genetic manipulation
Sclerotinia sclerotorium	-cottony soft rot and white mould of vegetables, beans, sunflower, groundnuts and soya beans	-The fungus can attack any above ground part and is extremely destructive under cool, moist conditions		-High. Good candidate for genetic manipulation to broaden its temperature spectrum
Animal Pathogen or Disease Caused	**Animals Affected**	**Key Signs**	**Spread**	**Virus Persistence**
African swine fever (highly contagious)	-domestic and feral pigs	-blue blotching of skin at extremities, loss of appetite, incoordination, 100%death rate in severe forms	-virus spread by direct contact with infected pigs	-virus is very stable in a wide range of acid and alkaline levels (pH4-13) and at temperature below freezing.
Foot and Mouth Disease(highly contagious)	-all cloven hooved animals including cattle, sheep, pig, goat, camels, and deer. Horses are not susceptible	-fluid-filled blisters on tongue, lameness, reduced milk yield, mortality does not exceed 5%	-direct contact or via respiratory particles or droplet	-FMD virus may remain infective in environment for several weeks. Some recovered animals remain long-term carriers
Rinderpest (acute and fatal viral disease)	-cattle and buffalo	-fever, acute diarrhea, death in 6-12 days after onset of clinical signs	-virus is excreted 1-2 days before clinical signs are observed. Transmission mainly through aerosols	-virus is relatively heat sensitive, and rapidly inactivated at 56ºC and does not persist in the environment

2.1.3 Chemical Weapons Use

Chemical weapons are poisonous or toxic compounds that have been developed to kill or disable persons by direct effects on body organs or systems (Lockwood 1997). Chemical warfare agents are predominantly of five general types (Henry L. Stimson Center 2003):

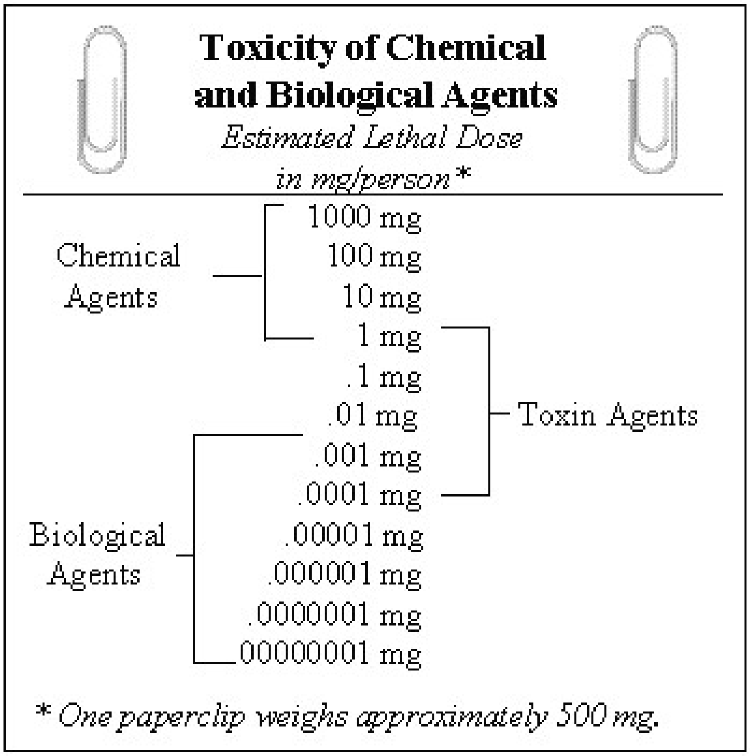
- **Blister agents**— Agents that cause blisters on skin and damage the respiratory tract, mucous membranes and eyes.
- **Nerve agents**— Lethal substances that disable enzymes responsible for the transmission of nerve impulses.
- **Choking agents**— Substances that damage the respiratory tract, causing extensive fluid build-up in the lungs.
- **Blood agents**— Agents that interfere with the absorption of oxygen into the bloodstream.
- **Riot control (Incapacitating) agents**— Substances that rapidly produce temporary disabling effects.

While the physiological effects of chemical warfare agents on humans have been extensively studied, there is a surprising lack of research on the environmental consequences of chemical weapons use. Westing (1977) has compiled available data exploring the ecological consequences of two arbitrarily chosen chemical agents, 'CS' (an incapacitating agent) and 'VX' (a lethal nerve agent).

- **CS (*o*-clorobenzalmalononitrile)** — In humans, CS induces intense lacrimation (crying), sternutation (sneezing) and irritation of the upper respiratory tract. It results in militarily significant harassment of unprotected personnel at a particulate concentration in the atmosphere at above 1mg/m^2. CS is toxic to warm-blooded vertebrates at roughly the same levels as for humans. Rabbits (*Oryctolagus cuniculuc*), and guinea pigs (*Cavia porcellus*), however, are more sensitive. In the aquatic habitat the common killifish (*Fundulus heteroclitus*)is killed by 4g/m^2 (50 percent mortality in 96 hours) and the duckweed (*Wolffia papulifera*) is injured by concentrations of 5g/m^2 and killed by 100g/m_. While these concentrations may not be achieved in the field, they could result from accidents in production facilities. CS is also reported to be somewhat toxic to terrestrial vegetation.

- **VX (*S*-(2-diisopropylaminoethyl) *O*-ethyl methyl phosphonofluoridate)** — The ecological impact of VX agents is assessed indirectly via the organophosphorous insecticides with which they share anti-cholinesterase activity. Available information on organophosphorous insecticides indicates that if VX was used in attacks at levels lethal to humans, then it would simultaneously kill other non-human vertebrates. It would also destroy many invertebrates, particularly anthropods. Exposed plants, although not directly affected, would provide a secondary source of contamination for herbivores feeding on them. The impact on the aquatic environment is expected to be somewhat greater than in terrestrial habitats.

Figure 1: Relative Toxicity of Chemical and Biological Agents



Source: Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction* (Washington, D.C.: U.S. Government Printing Office, December 1993), p. 77.

2.1.4 Nuclear Weapons Use

Nuclear weapons have been used in war twice: on Hiroshima on August 6, 1945 and on Nagasaki, three days later. Kamada and Yokoro (1997) describe the nature of the bombs used. The power of the Hiroshima bomb was estimated to be equivalent to the explosive power of 15 kilotons of TNT (TNT is 2,4,6-trinitrotoluene, the explosive ingradient in dynamite) while the Nagasaki bomb had an explosive power equivalent to 21 kilotons of TNT. The Hirohima bomb exploded at an altitude of 580 meters over the center of the city and killed about 40% of the city's population (140,000 people). Its fissile material was uranium-235. The Nagasaki bomb exploded 500 meters over the northeastern area of the city and killed about 26% of the city's population (74,000 people). Its fissile material was plutonium-239. The energy distribution of both blasts was approximately: 50% blast, 35% radiation heat, and 15% ionizing radiation. Moreover, the energy of a nuclear weapon is released in an extraordinary short time, less than one hundredth of a microsecond. This means that the instantaneous power of such weapns is awesome, even by the smallest nuclear bomb or "mininuke," etc, because here we are talking of power as the rate at which work is done or energy released.

The blast, radiation heat, and ionizing radiation are responsible for the effects of a nuclear weapons explosion (Westing 1977). The **blast** is the mechanical force of the explosion and it travels at the speed of sound. The **radiation heat** is the intense heat and the effects of massive fires (conflagarations and firestorms). In the bombing of Hiroshima and Nagasaki the fireballs ignited wood at about 2km and ensuing fires created areas of "burnout" of $13km^2$ and $6.7km^2$ respectively (Freedman 1995).These were followed by "black rains" which were induced by the upward moving convective air masses caused by the enormous fires. The radiation heat travels at the speed of light. **Ionizing radiation** consists of fast charges particles resulting from the interaction of gamma rays and neutrons generated by the initial nuclear explosion as they interact with ordinary matter. Further ionizing radiation is emitted by radionuclides, the fission fragments from the explosion. About one third of the ionization radiation was emitted within 1 minute of the bombings of Hiroshima and Nagasaki while the rest continued gradually through the decay of radioactive fallout (Freedman 1995).

The Nuclear Age Peace Foundation has assessed the environmental consequences of nuclear weapons use and particularly exposure to ionizing radiation. Their analysis is presented here:

- **Agriculture**— Although radiation occurs naturally in soil, excessive contamination of agricultural lands results in human exposure through ingestion of food. Radiation bioaccumulates and the most dangerous isotopes are those readily taken up by plants and passed on to animal products like milk and meat. Factors that further intensify exposure include: soil type, method of tilling crops, climate, season, and biological half-lives that determines amount taken up by plants or leached into the ground.

- **Forests**— The deposition of radioactive material is higher in forests than in agricultural fields. Trees act like filters, resulting in increased absorption and retention of radioactive particles. Large doses of radiation kill trees, and the loss is increased by organic content and stage of forest growth. Flora such as lichen, mosses and mushrooms also often exhibit high concentrations of radioactive isotopes. The transfer of radioactive particles to wild game dwelling in a forest poses a high risk for those who are heavily dependant on this game as a primary food source.

- **Water Bodies**— Contamination of water bodies can result from direct deposition from the air and discharge as effluent after a nuclear accident. It can also be caused indirectly by washout from the catchments of basins. Isotopes contaminating large bodies of water are quickly redistributed and tend to accumulate in bottom sediments, and within living organisms, plants and fish.

- **Climatic Effects**— The potential effect a nuclear exchange could have on climate was first presented in 1983 and is most commonly known as "Nuclear Winter". A large-scale nuclear exchange between nations could conceivably have a catastrophic global effect on climate. It would expel large enough quantities of dust and smoke into the atmosphere from resulting firestorms after the blast, so as to block sunlight for several months particularly in the northern hemisphere. The reduced ability of solar radiation to enter the atmosphere would result in reduced temperatures, destroying plant life and creating a subfreezing climate until the dust is dispersed. Damage to the ozone layer and the subsequent inability to screen out ultraviolet radiation would further harm the planet's flora and fauna. In a commonly used scenario, a 6.5 thousand megaton (MT) exchange would inject 330-825 million tons (Tg) of particles and 180-300Tg of sooty smoke from fires into the atmosphere (Freedman 1995). Reflection by dust and absorption and re-radiation by sooty smoke could reduce the amount of energy received at the planet's surface by 90%. Additionally, it is estimated that a 6.5 thousand MT nuclear exchange would produce 36.9 Tg of gaseous NO, 225 Tg of CO and large emissions of sulfur oxides, hydrocarbons and other toxic substances; resulting in a 17% decrease in the concentration of stratospheric ozone but a potential increase in tropospheric ozone (Freedman 1995).

Table 2: Comparative damage to biota caused by nuclear bomb detonations in the troposphere or on the surface. Source: Modified from *Weapons of Mass Destruction and the Environment,* Westing 1977

	Area suffering the given type of damage (ha)			
	Tropospheric air burst		**Surface detonation**	
Type of Damage	**0.91 MT bomb**	**9.1 MT bomb**	**0.91 MT bomb**	**9.1 MT bomb**
Craterization by blast wave	0	0	12	57
90% of trees blown down by blast wave	14,100	82,000	9,040	52,500
Trees killed by nuclear radiation	648	1,250	12,800	63,800
All vegetation killed by nuclear radiation	312	759	2,830	12,100
Vegetation ignited by thermal radiation	33,300	183,000	21,300	117,000
Vertebrates killed by blast wave	591	2,740	332	1,540
Vertebrates killed by nuclear radiation	1,080	1,840	36,400	177,000
Vertebrates killed by thermal radiation	42,000	235,000	26,900	150,000

New developments— On May 20th 2003, the US Senate lifted a ban on conducting research to develop "low-yield" nuclear weapons (Washington Post 2003). These weapons have an explosive yield of less than five kilotons, or one-third the force of the bomb dropped on Hiroshima near the end of World War II. The Senate also authorized $15 million to continue funding a study of ways to turn an existing nuclear weapon into a high-yield "bunker-buster" bomb capable of burrowing deep into the earth before exploding. Designed to destroy underground facilities, it would have a force 10 times that of the Hiroshima blast. An IPPNW study concluded that even a very low-yield nuclear earth-penetrating weapon exploded in or near an urban environment would disperse radioactive dirt and debris for several square kilometers (Associated Press 2003)

2.1.5 <u>Weather Manipulation</u>

The military has attempted to alter meteorological phenomena in the past. Beginning in 1963 and continuing at least into 1972, the US Central Intelligence Agency and then the US military attempted extensive trials to manipulate the rainfall in Vietnam (Westing 1977). The cloud-seeding agents employed included silver iodide and lead iodide. Attempts intensified between 1966 and 1972 to prolong the annual rainy season in order to make the Ho Chi Minh trail so muddy as to render it impassable or difficult to use.

The adverse ecological impacts of weather modification are difficult to assess empirically. Rainfall augmentation, however, enhances the possibility of flood damage. With respect to the Vietnam War, Westing (1977) notes that it remains unknown whether the serious flooding that occurred in North Vietnam in 1971 can be attributed at least in part to the US attempts at weather manipulation. 1971 was the peak year of US cloud-seeding activity. Increased rainfall also causes more land erosion particularly in areas previously disturbed by bombing. Finally, the cloud-seeding agents also can exert at least minor damage on the ecosystems into which they are introduced. Certain aquatic biota, such as algae, invertebrates and some fish are especially likely to be affected by the presence of silver iodide and lead iodide.

New developments— The High Frequency Active Auroral Research Project (HAARP) is a joint effort of the US Air Force and the Navy. Its construction began in Alaska in 1995. HAARP's electronic transmitters are capable of beaming in excess of one billion watts of radiated power into the Earth's ionosphere and could harm people, endanger wildlife and trigger unforeseen environmental impacts (Smith and Zickuhr 1998). The military applications of HAARP include: disrupting the global communications capabilities of adversaries while preserving US defense communications, to destroy enemy missiles and to change weather. HAARP's ability to generate radiated power could conceivably interfere with the migration of birds, marine life and Arctic animals that are now known to rely on the Earth's magnetic fields to navigate over long distances. The impacts of heating the ionosphere are unknown.

2.2 The Environmental Consequences of Refugee Creation

The total number of persons of concern falling under the United Nations High Commissioner for Refugees (UNHCR) mandate is currently 20,556,781 and includes 10,389,582 refugees and 4,630,895 internally displaced persons (IDPs) (UNHCR 2003). The large scale entry of displaced persons into receiving territories, as a consequence of armed conflict and war, can place enormous stress on the environment. While outside the scope of this project a related and significant issue concerns environmental refugees, displaced by the increasingly acute effects of climate change. The environmental impact of refugee movements as a result of armed conflict is noted next.

2.2.1 Deforestation

Deforestation is perhaps the most widely recognized environmental problem in refugee-populated areas. It is accelerated by many factors including: land that is cleared for refugee campsites, trees cut down to provide firewood for cooking and to construct refugee shelters, and shrubs that provide fodder for foraging livestock (Levy et al. 1997). These same factors can also cause desertification in arid and semi-arid regions. In Malawi, prior to the repatriation of Mozambican refugees in the early 1990s, it was estimated that between 500,000 and 700,000 cubic meters of wood were consumed annually for cooking and heating purposes by the approximately one million refugees (UNHCR 1995). This rate of consumption far exceeded the country’s natural replenishment capacity. In 1994, when about 2 million refugees fled Rwanda to northwestern Tanzania and eastern Zaire, the largest refugee camp in Tanzania experienced an incredible rate of deforestation. Within nine months of their arrival, refugees were having to walk 12 kilometers in order to reach the nearest source of fuelwood (UNHCR 1995).

2.2.2 Loss of Biodiversity

In situations where rare species or unique ecosystems are threatened by mass population displacements, irreversible losses in global biodiversity may occur. Loss of biodiversity is closely linked to deforestation. For example, during the Rwandan crises, some 800,000 kilograms of wood and grass were collected by refugees each day in December, 1994 from Zaire’s Virunga National Park — a UNESCO World Heritage Site (UNHCR 1995). A serious problem in terms of biodiversity is not only species extinction by both direct and indirect effects of militarism, but also declines of species specific populations The latter is more likely as a result of military activities.

2.2.3 <u>Land Degradation</u>

Overgrazing and inappropriate farming methods cause land degradation and can accelerate soil erosion. The soil can also be so badly degraded that many years may be needed for it to recover. For example, studies undertaken in the Burundian, Rwandan and Mozambican refugee settlements of Tanzania, have indicated that the fertility of the land in those areas is progressively declining and that the structure of the soil is now breaking down (UNHCR 1995). As a consequence, weeds are invading the land and crop yields are declining. This process may be unstoppable, and the affected areas may no longer be able to sustain the indigenous population even if the refugees are able to return home.

2.2.4 <u>Waste Production and Water Pollution</u>

The pollution of water sources poses a major problem in refugee-receiving territories, especially in the early stages when proper sanitation systems have not yet been established. Lack of proper disposal mechanisms results in accumulation of solid wastes including garbage and human wastes. The poor sanitary conditions in combination with high population concentrations in refugee camps can cause fecal contamination of water supplies in rivers, wells, or oases. Also, often, additional boreholes are drilled to meet increased demand of the limited water supply. However, this contributes to long term depletion of underground reserves, a problem further compounded in coastal areas by the effects of salt water incursion.

2.3 The Targeting of Civilian and Industrial Facilities

The deliberate targeting of civilian and industrial facilities is an oft executed war strategy intended primarily to terrorize civilians and inflict casualties. In fact, the effects of bombing hydrological, chemical, or nuclear facilities are understood in terms of releasing 'dangerous forces' into the environment .

2.3.1 <u>Civilian Infrastructure</u>

2.3.1a Hydrological facilities— Hydrological facilities include all water related structures supplying an area and population including dams, dikes, pipelines, water tanks, and water and sewage treatment facilities. One of the most telling examples of the devastation caused by the targeting of hydrological facilities is the World War II Allied bombing of three major dams in the Ruhr valley of Germany (Bergstrom 1990). Upon being breached in May 1943, the Mohne and Eder dams released about 120 million and 150 million cubic meters of water respectively, one in 12 hours and the other in 36 hours. The immediate effects caused 1,300 deaths and 120,000 people were made homeless. 3,000 hectares of arable land were ruined and 25 water treatment plants were destroyed. Also damaged or destroyed were 125 factories, 12 power stations, 7 dams, 11 highway bridges, four railroad bridges, and 30 kilometers of railroad track.

2.3.1b Hospitals, roads and airports— When hospitals, roads, or airports are bombed the effects on the environment can be both direct and indirect. Hospitals, for example, store an array of pharmaceuticals, chemicals, and other substances that are toxic if released into the environment. Breakdowns in medical and veterinary support systems during wars and conflicts can also result in epidemic outbreaks of diseases among human, livestock, and wildlife populations. For example, disruption of government veterinary services during the civil war in Southern Rhodesia (now named Zimbabwe) is believed to have contributed to epidemic outbreaks of anthrax and rabies among the wild and domesticated animals in that country (Dudley and Woodford 2002). Anthrax mortality among humans and livestock reached epidemic proportions in 1979 and 1980 and continued to proliferate for more than 4 years following the end of the civil war.

2.3.1c Agricultural land— Environmental destruction serves as a tool of war when the land upon which civilians are dependant for subsistence is deliberately targeted. In the Occupied Palestinian Territories for example, there has been a significant loss of agrobiodiversity due to

the clearing of land of vegetation by Israeli military forces in its ongoing occupation. In addition to the economic and social cost incurred, land clearing exposes agricultural land to enhanced effects of erosion and desertification.

Table 3: Damage to agricultural crops in the Occupied Palestinian Territories to December 2001 Source: *Desk Study on the Environment in the Occupied Territories, UNEP 2003.*

Tree/Vine	Number destroyed/damaged	Value (US$ million)
Olive	155 343	38.84
Citrus	150 356	37.59
Almond	54 223	8.13
Date palm	12 505	12.51
Grape	39 227	5.88
Banana	18 400	0.92
Other fruit	49 851	7.48

2.3.2 Industrial Facilities

2.3.2a Chemical and fertilizer factories— The ecological effect of conventional warfare can exceed the effect of chemical warfare when chemical factories are targeted. Matousek (1990) observes that in effect, the damage from a conventional war could approach the damage that would result from a war in which chemical or nuclear weapons were employed. Peacetime accidents in chemical facilities, such as at the Union Carbide plant in Bhopal, India on 3 December 1984, give an indication of the potential destruction that could be unleashed. The pesticide production plant released 40 tons of lethal gases including methyl isocyanate, hydrogen cyanide and other toxic gases, causing 2,300 early fatalities and 30,000 to 40,000 serious injuries (Greenpeace 2003, Matousek 1990). In 1999, Greenpeace conducted an environmental assessment of ongoing contamination by testing groundwater and soil samples in and around the factory site. The survey found substantial and in some cases severe contamination of land and water supplies with heavy metals and chlorinated chemicals 15 years after the accident. Mercury, from soil samples, was present at levels between 20,000 to 6 million times the expected concentrations (Greenpeace 1999). Twelve volatile organic compounds, most greatly exceeding EPA standard limits, were found to have seeped into the water supplies of an estimated 20,000 people in local communities.

2.3.2b Nuclear power stations— There have been no military attacks against any operating nuclear facility to date. Nuclear power plants, however, represent potential targets which if attacked would have catastrophic consequences for health and environment. There are over 400 operational nuclear power reactors in more than 20 countries around the world (Krass 1990). These sites are vulnerable to assault, and if certain conditions are met, bombardment could possibly release into a surrounding area measurable in thousands or millions of hectares, iodine-131, cesium-137, strontium-90 and other radioactive elements. These conditions include an attack on a reactor which a) penetrated the reactor building, b) and exploded within the reactor core or within the spent fuel storage facility, and c) the reactor went to "prompt critical," a term used to describe a situation where the nuclear reaction cannot be controlled on the time-scale of milliseconds. The most heavily contaminated inner area would become life threatening, an outer zone of less contamination would become health threatening and a still greater zone would become agriculturally unusable (Westing 2002).

The Chernobyl nuclear reactor accident in April 1986, although not strictly comparable, provides some background for anticipating possible effects of an attack on a nuclear facility. The total radioactive release from the Chernobyl reactor was enormous: virtually all of the noble gases; at least 20% of the iodine, and 10 to 20% of the cesium (Krass 1990). The International Chernobyl Research and Information Network (ICRIN 2003) have assessed the continuing environmental impact of the accident:

- **Soil Contamination**— In Belarus, which received 70% of the fallout, about 22% of the country was contaminated with cesium-137 after the accident in 1986. Today, 21% remains contaminated. The Belarussian government's Chernobyl Committee estimates that 16% of the territory will still be contaminated in 2016. The Chernobyl accident resulted in the radioactive contamination of 18,000 km^2 of agricultural land. 2,640 km^2 of this area can no longer be farmed.

- **Plants**— In Ukraine the forest was particularly affected by the fallout: 35,000 km^2 of forested areas — 40% of the total — were contaminated. Currently, the most severe contamination is found in typical forest plants such as berries, mushrooms, heather, lichens and ferns. It is also noted that seeds no longer germinate as readily as in the past. There are reports of reduced photosynthesis and protein synthesis.

- **Animals**— Among domestic animals and agricultural livestock, grazers such as cattle and goats have been especially susceptible to bioaccumulation of radioactivity, in both meat and milk. In the contaminated forest areas, game is still severely contaminated, because it feeds on contaminated lichens, berries and mushrooms. Predators such as the wolf and fox are up to 12 times more contaminated than the herbivores on which they feed.

- **Water Contamination**— In the rivers and lakes of the contaminated territories, radiation has concentrated particularly in the sediments, with values of up to 1 million becquerel (Bq) per cubic metre of sludge observed in Belarus, for example. Since some fish are bottom feeders, they too are heavily contaminated. It is important to appreciate the relationship between becquerels and curies. One becquerel is one radioactive disintegration per second. One curie is 37 billion radioactive disintegrations per second, or 37 billion becquerels. The becquerel is a very small unit of radioactivity, while the curie is a very large one. Radioactive sources in a laboratory are typically from nanocuries to a few millicuries.

There is, additionally, reason to believe that a wartime attack on a nuclear power reactor would have far more severe consequences than an accident in peacetime because of impaired ability to muster the necessary resources in wartime (Krass 1990).

2.3.2c Oil refineries and fuel dumps— The Gulf War of 1991 saw the intentional release of approximately 10 million cubic meters of oil from about 730 oil wells (approximately 630 of which were torched), about 20 collecting centres, and 3 or more oil tankers (Westing 2002). Various oil storage tanks and pipelines were also breached. The creation of about 200 small oil lakes on land caused deaths in many species of wildlife and posed additional environmental problems such as groundwater contamination. Roughly 1 million cubic meters of oil was released into the Persian Gulf and severely contaminated Kuwaiti offshore waters, as well as about 400 kilometres of coastline. Marine habitats suffered enormous degradation and much migratory marine wildlife (avian, mammalian, reptilian) was killed. The smoke released into the atmosphere, darkened parts of Kuwait and Iran during the day, reducing temperatures by 20 degrees in some areas (Audubon 1991). It is also thought to have been responsible for the acid rain experienced in areas as far away as in Pakistan and India.

2.4 The Environmental Impact of Military Personnel

In 2001, the world's total armed forces consisted of 19,564,000 persons (UNDP 2003). The collective consumption and waste production of armed forces during war can have a tremendous impact on the environment. For example, the European bison was slaughtered nearly to extinction to supply the mess kitchens of German and Soviet troops in eastern Poland at successive stages of World War II (Audubon 1991). By the spring of 1945 only a score of bison were left. During the Gulf War of 1991, coalition forces left huge quantities of refuse and between 45 and 54 million gallons of sewage in sand pits (Miller and Ostling 1992). During the Vietnam War, arrival of American G.I.s in 1965 and subsequent rise in demand for lobsters, led Vietnamese fishermen to harvest lobster beds off of the South Vietnamese town of Nha Trang using grenades. After supplying American forces with lobsters for 6 months, irrevocable damage was done to lobster breeding grounds resulting in the loss of the entire Nha Trang lobster population (Audubon 1991).

2.5 Inadequate Wartime Environmental Legislation

The environment suffers indirectly from weak legislation that fails to provide adequate environmental protection from the effects of wartime military activities. This is explored in further detail below.

2.5.1 Internal Armed Conflict

Although all but a handful of the dozens of ongoing armed conflicts in the world are internal, there is a glaring lack of applicable international law constraining actions that cause environmental harm in these conflicts (ELI 1998). Gleditsch et al. (2001) report a total of 204 armed conflicts for the period 1946–99, of which only 40 were interstate conflicts. All of the 37 armed conflicts that were ongoing at the end of 2002 were intrastate conflicts (civil wars) (Regehr 2003).

Westing (2000) observes that while insurgent forces are beyond the reach of domestic law on the one hand, on the other hand existing treaty constraints dealing with non-international conflicts are purposely weak so as not to undermine the national sovereignty of the state parties and also so as not to legitimize and encourage insurgencies. The primary source of law, the **1977 Protocol Additional II to the Geneva Conventions**, provides very limited environmental protection during internal armed conflicts and ie noticeably weaker than the constraints that apply during international conflicts: Protocol Additional II lacks provisions comparable to the article 35 prohibition of "widespread, long-term and severe damage to the natural environment" and the similar article 55 of Protocol Additional I (ELI 1998).

2.5.2 Inter-state Conflicts

The application of domestic environmental law to wartime activities is very limited. International conventions, in comparison, do address the environmental effects of military activities during war. The **1976 Environmental Modification (ENMOD) Convention**, for example, demands of nations to not "engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects (…)" (ELI 1998). The prohibited techniques are defined as "any technique for changing — through the deliberate manipulation of natural processes — the dynamics, composition or structure of the earth, including its biota, lithospere, hydrosphere, and atmosphere, or of outer space" (ELI 1998).

International law pertaining to wartime environmental damage, however, has proved to be inadequate in preventing or redressing the environmental consequences of war. In many cases, conventions are intentionally vague on what constitutes a violation (ELI 1998). For instance, in ENMOD, terms such as "widespread", "severe", and "long-term" have not been defined. The inability to *implement* international norms has further weakened virtually all of the conventions. The ENMOD Treaty, toothless though it may be in practice, applies equally to militaries in peacetime and in wartime.

Richard Falk (2000) summarizes that the existing framework of international law regarding environmental protection consists of "vague and scattered legal norms" that do not provide a realistic basis for acceptable levels of implementation under wartime conditions. He adds that "at most, it leads to an arbitrary and ad hoc pattern of enforcement that often tends to be punitive in character." He notes that currently, if environmental accountability is invoked at all, it is in relation to the defeated and politically isolated state. A victorious state or a state with geopolitical clout, however, tends to be exempted from any accountibility for its environmentally destructive wartime activities. The response of the international community, therefore, tends to be markedly inconsistent. For example, while a United Nations Compensation Commission was created by the UN Security Council and charged with assessing the environmental damages against Iraq for the 1990-91 Gulf War, the same due process was not applied to the NATO bombing campaign against the former Yugoslavia.

3. Peacetime Environmental Effects of Military Activities

3.1 Military Use of Resources

The world's militaries are a significant contributor to resource depletion with some sources estimating that they account for 6 percent of all raw materials consumed (Donohoe 2003; Renner 1991; Shahi and Sidel 1997). In her general review of literature on military production and consumption, Ana Schjolden (2000) notes that there are very few sources that address military consumption. Military secrecy and scarcity of data are recurring obstacles in attempts to investigate the impact of militarism on the environment. The military use of land, airspace, oceans, fuel, and non-fuel minerals is discussed below based on available data.

3.1.1 <u>Land</u>

A 1981 estimate places the global direct military land use in the range of 0.5 to 1% worldwide or roughly 750,000 to 1.5 million km^2 , an area roughly larger than the combined surface areas of France and the United Kingdom (797,000 km^2) (Biswas 2000). This area, however, would be substantially greater if the land used by arms producing enterprises and indirectly by military forces were also included.

In the United States, at least 200,000 km^2 or 2% of total US territory is devoted to military purposes (Renner 1991). In Canada, the Auditor General's report (2003) notes 18,000 km^2 of land, over three times the size of Prince Edward Island, is used for training and other military activities by the Department of National Defence.

The environmental consequences of military activities on land are discussed later. Worth noting at present, however, is the disproportionately high number of habitat for endangered plant and animals often contained in military lands. In the US, more than 220 federally listed threatened or endangered species have been confirmed as residents or migrants in and around US military installations and military training ranges (Dudley and Woodford 2002). Land area that is used for military purposes also prevents it from being used for alternative and more productive uses such as habitat preservation or agricultural production. In Kazakhstan, for example, more land is currently reserved for the use of the military than is made available for wheat production (Biswas 2000).

3.1.2 <u>Airspace</u>

The worldwide military use of airspace is not known. Canada, however, may have the world's most extensive airspace for military purposes. The zone assigned to Goose Bay air base at the northeastern coast of Labrador extends over 100,000 km^2 (Renner 1991) and in Alberta and Saskatchewan, the Cold Lake air weapons range stretches over 450,000 km^2 (Miller and Ostling 1992). In the US, at least 30% and as much as 50% of airspace is used by the military (Renner 1991).

One of the most contentious issues surrounding military aviation isthe low-level supersonic flights. Noise levels of up to 140 decibels (at which acute hearing damage can occur in humans and other mammals) are produced by planes flying at an altitude of 75 meters. In Nitassinan, near Goose Bay, Labrador, four NATO countries (Canada, Netherlands, Germany, and the United Kingdom) have yearly performed thousands of low-level flights at the height of 100-250 feet, almost at maximum speed (Heininen 1994). The land over which the exercises occur are inhabited by the Innu. As a consequence of these activities (sonic booms and aircraft emissions), the feeding and migration behaviour of caribou herds have been disturbed and the livelihoods of the Innu imperiled. In 1996, Canada renewed the 1986 Multinational Memorandum of Understanding (MMOU) for another 10 year period with the UK, Germany, and the Netherlands. The current memorandum allows for up to 15,000 low level and 3,000 medium/ high level training flights annually (Newfoundland and Labrador Department of Finance 2001). Italy also signed the memorandum in 2000 while France, Belgium and Norway conducted trial activities at Goose Bay in 2001.

3.1.3 Oceans

The global military use of oceans has not been assessed although the US Navy, is known to operate in over 765,000 square nautical miles of designated navy sea ranges (Willard 2002). Naval activities, however, can affect ocean ecosystems far beyond their designated ranges. The military use of the sonar system known as Surveillance Towed Array Sensor System Low Frequency Active sonar (or LFA),for example, can potentially cover 80% of the planet's oceans by broadcasting from only four locations (Science Wire 2001). The LFA sonar was developed in the 1980s and used by the U.S. Navy to detect the presence of deep sea Soviet submarines by bombarding them with high intensity, low frequency noise. It has had a profound impact on marine species.

The frequencies that dolphins and whales use for hearing, to find food, families and direction fall within the range used by the military — 100 to 500 Hz (Science Wire 2001). Whales send signals out at between 160 and 190 db and the Navy has tested its sonar signals at levels up to 235 db. In March 2000, four different species of whales and dolphins were stranded on beaches in the Bahamas after a US Navy battle group used active sonar in the area. A government investigation found evidence of hemorrhaging around the dead whales' eyes and ears, indicating severe acoustic trauma. Causation was established to the mid-frequency sonar used by Navy ships passing through the area (NRDC 2003). Since the incident, the area's beaked whales population has disappeared. This has led scientists to conclude that they have either abandoned their habitat or died at sea. On August 26 2003, a US federal judge ruled that the Navy's plan to deploy a new high-intensity sonar system is illegal, violating numerous federal environmental laws and endangering whales, porpoises and fish (NRDC 2003).

3.1.4 Outer Space

Space is considered the ultimate military high ground and also offers the potential for unsurpassable political and economic power projection. It has been used for military purposes in the past. Historical as well as ongoing use have been largely passive and include activities such as reconnaisance, communications, and navigation (Marshall et al. 2003). The Global Positioning System (GPS), for example, provides precision targeting for military missions, while civilian customers use less accurate frequencies as navigational aids (Wirbel 2002). Military expenditure on space has consistently outweighed civil spending (Marshall et al. 2003) and despite a UN Outer Space Treaty enjoining nations to reserve the use of space for peaceful purposes only, the 1996 *Vision for 2020* report of the US Space Command reveals plans for offensive space weaponization.

Due to limitations imposed by time, this report is unable to present a detailed analysis of the environmental consequences of intensified use of space or a space war. However, such an assessment would first requires identifying the weapons that may be used. Distinct classes of space weapons include: (1) direct-energy weapons such as space based lasers (2) kinetic-energy weapons against missile targets (3) kinetic-energy weapons against surface targets and (4) conventional warheads delivered by space-based, or space-traversing, vehicles (Garwin 2003). In addition, non-space weapons also need to be considered and include: (1) surface-based anti-satellite (ASAT) weapons such as high-power lasers, or missiles with pellet warheads, or hit-to-kill vehicles and (2) rapid-response delivery of conventional munitions by forward-deployed cruise or ballistic missiles, or non-nuclear payloads on inter-continental ballistic missiles (ICBMs) (Garwin 2003).

Li Bin (2003) offers an assessment of the space debris that would be created in a potential war. The destruction, for example, of Cosmos, a Soviet anti-satellite interceptor with a mass of 1,400kg, would triple the population density of the debris in Low-Earth Orbit (LEO). In addition to the interceptors themselves, those satellites targeted by them would constitute another source of debris. A process of collisional cascading may set in (collisional fragments trigger further collisions) and could eventually form a *"debris barrier"* that would prevent the stationing of any new stations or other space activities in Low Earth Orbit (Bin 2003). Other defensive counter-space measures such as the use of microsatellites ('space mines') and nuclear detonation in space would also severely impact upon the space environment.

3.1.5 Energy and Fuel Resources

The world's militaries depend on petroleum products for nearly three quarters of their energy use and consume approximately 25% of all global jet fuel (Renner 1991). The global petroleum consumption for military purposes is almost one-half of the total consumption of all developing countries combined (Biswas 2000). The Pentagon is considered the single largest domestic consumer of oil and quite possibly the largest worldwide (Miller and Ostling 1992). Additionally, it is estimated that worldwide military-related carbon release could be as high as 10% of the global total (Renner 1991). A significant consideration with regards to sustainable use of resources is military diversion of fuel resources from environmental applications. For example, the Pentagon uses enough energy in 12 months to run the entire US urban transit system for almost 14 years (Renner 1991).

3.1.6 Non-Fuel Minerals

Available global figures in the absence of reliable data are rough estimates. However, the worldwide use of aluminum, copper, nickel and platinum for military purposes is thought to surpass the total consumption of these materials by all developing countries combined (Biswas 2000). The military is estimated to account for 11% of global copper use, 9% of iron, and 8% of lead (Renner 1991). Overall, on a global basis, between 2 and 11% of fourteen important minerals is consumed for military purposes: aluminum, chromium, copper, fluorspar, iron ore, lead, manganese, mercury, nickel, platinum, silver, tin, tungsten, and zinc (Biswas 2000). The manufacture of a single F-16 jet requires 5,000kg of materials: 2,044kg titanium, 1,715kg nickel, 543 kg chromium, 330kg cobalt, and 267kg aluminum (Renner 1991).

Military demand for these minerals contributes to the major and highly visible environmental damage caused by mining operations. Ponting (1991) cites 70% of the world's ore (95% in the US) is obtained by the most environmentally destructive of all methods — open cast mining. Durning (1990) explores the potentially powerful effects that military demand for minerals can have on the environment. In an assessment of apartheid's environmental toll in South Africa, broad land areas were revealed to have been deeply scarred by reckless mining to finance the military superstructure that upheld minority rule (Durning 1990). The connections between natural resources, armed conflict, state oppression, and mining corporations are examined later in the report.

3.2 Arms Production, Storage, and Disposal

The production, maintenance, transportation, storage, and disassembly of weapons systems and equipment generate vast quantities of toxic materials. However, due in part to military secrecy, it is difficult to quantify the contribution of military-related hazardous waste to overall environmental pollution. Nonetheless, military production facilities and bases are significant sources of contamination. For example, the Pentagon alone generates half a billion tons of toxic waste per year, more than the top five chemical companies combined (Donohoe 2003).

Table 4 shows the ecotoxicology of selected hazardous substances generated at arms and military equipment production facilities.

Table 4: **Ecotoxicology of Selected Chemical Wastes Generated by Military Processes**
Sources: *Chemistry and Ecotoxicology of Pollution,*Connell and Miller 1984; *Persistent Organic Pollutants Assessment Report*, IOMC 1995.

Hazardous Material	**Application to Military Production Processes**	**Relative Lethal and Sublethal Toxicity in Selected Organisms**	**Ecological Effects**
Polychlorinated Biphenyls (PCBs)	-Present in paints and adhesives	-**Mammals**: low lethal toxicity, reduced weight gain, reduced growth. -**Birds**: low lethal toxicity, eggshell thinning, embryo deaths prior to hatching. -**Fish**: very high lethal toxicity, reduced mating, decreased growth, premature egg hatching.	-cause reproductive and immunotoxic effects in wildlife -bioaccumulation in organisms; correlations with trophic levels in aquatic birds and mammals
Dibenzo-*p*-dioxins and Dibenzo-*p*-furans	-Chemical weapons incineration -Explosives and production systems	**-Mammals:** suppressed immune reaction, adverse reproductive effects, wasting -**Birds:** decreased growth, shortened beaks -**Fish**: lethargic swimming, feeding inhibition, eggs exhibit high toxicity	-potential of bioaccumulation of significant concentrations - bioconcentration factor of 26, 707 reported in rainbow trout
Heavy Metals (cadmium, zinc, lead, copper, mercury)	-Elecroplating of aircraft and other military hardware	-reproduction affected in aquatic organisms in parts per billion -freshwater fish exhibit impaired processes such as feeding, swimming -suppression of growth in vertebrate and invertebrate aquatic species.	-significant to severe modifications in community structure involving reductions in a number of species, including complete absence of some species.

The threats posed by the production, storage and disposal of biological, chemical, and nuclear weapons are discussed below.

3.2.1 Biological Weapons

The stages involved in the production of biological agents are described by the Federation of American Scientists (FAS 1998) and include: selection of the organisms, large-scale production of organisms from small starter cultures, and stabilization of the organisms. Biological weapons production does involve risk of contamination. By the end of World War II, for example, every major combatant nation had a biological weapons program and today, many of these countries' production facilities and field test sites remain reservoirs of disease (Choffnes 2001). The main production facilities include(d) (Sidel 2000, MIIS 2002):

- **United States**— Fort Detrick (Maryland), Pine Bluff Arsenal (Arkansas), Dugway Proving Ground (Utah). Six biowarfare agents had been weaponized by these facilities: Venezuelan equine encephalitis, Q fever, tularemia, anthrax, wheat rust, and rice blast. Furthermore, research is known to have been conducted on another 23 agents.
- **Soviet Union**— Stepnagorsk (Kazakhstan), Obolensk (Moscow Region, Russia), Omutninsk (Kirov Region, Russia), Sergiyev Posad (Moscow Region, Russia), Novosibirsk (Siberia, Russia), Sverdlovsk (Russia), and Vozrozhdeniye Island (in the Aral Sea). These facilities weaponized 10 agents and conducted research on a further 16 biowarfare agents.
- **United Kingdom**— Porton Down (England). The British biowarfare program weaponized anthrax. In addition, it conducted experiments on plague, typhoid, and botulium toxin.
- **Japan**— Pingfan, in northeastern China (1939). The Japanese biowarfare had weaponized 8 agents and conducted research on another 9 agents.

In addition to contamination risks during the production process, the storage and disposal of biological weapons represent potential sources for future contamination. The Soviet experience following the Cold War is illustrative of the challenges posed in the disposal of biological weapons.

In 1988, Soviet scientists placed hundreds of tons of anthrax into huge stainless steel canisters and used bleach to kill the spores (Choffnes 2001). The canisters were then transported by train to Vozrozhdeniye Island in the Aral Sea. The island is considered the world's largest anthrax burial ground and also served as a biological weapons testing site (Choffnes 2001). The anthrax mixture was disposed of in 11 shallow pits, covered with more bleach, and buried under Vozrozhdeniye Island's sand soil. The Uzbek mainland population, now over a decade later, is confronted with increased possibility of exposure to resistant strains of anthrax as the Aral Sea shrinks and is expected eventually to connect the island to the mainland (Choffnes 2001).

3.2.2 Chemical Weapons

Production of chemical weapons has also led to extensive environmental degradation. In the US, approximately 150 public and private chemical and biological warfare laboratories in more than 30 States of the USA and in 15 other countries are of questionable safety and may pose environmental threats (Shahi and Sidel 1997).

Many of the toxic contaminants polluting US military bases today are direct results of the chemical weapons programs. One major example is the Rocky Mountain Arsenal in Colorado. This longtime chemical weapons production and storage facility for nerve gas has stored thousands of gallons of the toxins since the 1950s. At first, waste products from the manufacturing facility were dumped on the arsenal grounds but after contamination of underground water supplies and subsequent destruction of irrigated crops, officials began pumping the toxic waste into a 2.5 mile deep well (Lanier-Graham 1993). During the five years of pumping in the 1960s, 165 million gallons of waste from the chemical and biological program were dumped deep into the ground. In addition to domesticated animals, an estimated 2 000 duck and other wildfowl died annually as a result of landing on the reservoirs at the arsenal and drinking the water (Lanier-Graham 1993). Similar pollution has occurred in the Soviet Union.

For example, Dzerzhinsk, a city that was home to decades of chemical weapons production, is reported to have the world's highest concentration of dioxin (Sidel 2000).

The total tonnage of global chemical weapons stockpiles is not known. Russia and the US, however, have the largest stockpiles with approximately 40,000 and 30,000 tons of weapons respectively (Sidel 2000). From April 1997 until December 2001, 9.3% of the total declared weight of chemical agents were destroyed under the auspices of the Chemical Weapons Convention which entered into force 29 April 1997 (OPCW 2001).

Chemical weapons disposal is perhaps, second only to radioactive waste disposal among serious threats to the environment from military programs (Shahi and Sidel 1997). Following World War II and up until the 1970s, sea dumping was the preferred method of disposing of chemical weapons. Today, the world's oceans are home to more than 200,000 tons of chemical agents (Chepesiuk 1997). Between 1945 and 1970, more than 100 sea dumpings of chemical weapons took place in every ocean except the Arctic. The effects on the marine environment are unkown. Since no deep sea probes have been conducted, the fate of the chemical weapons at the bottom of the oceans and seas remains uncertain. The rate of deterioration of the munitions is also unclear and not all dump sites are known. Furthermore, the behaviour of leaking weapons in the marine environment has not been studied.

There is no doubt, however, that some leaks have occurred. For example, mustard bombs have been recovered on German and Polish beaches and fishing nets have been contaminated (Chepesuik 1997). Between 1985 and 1995 Dutch fishermen reported more than 350 cases where chemical weapons, dumped into the Baltic Sea, were caught in fishing nets, some resulting in serious burns (Harigel 2001). In the United States, the Marine Protection Research and Sanctuaries Act of 1972 made it illegal to dump chemical and biological agents at sea.
The two methods of disposal used today are incineration and neutralization. Chemical neutralization is used in Russia and creates a complex "organic" soup that must be mixed with bitumen, a tar-like substance, before disposal in landfills (Sidel 2000). Incineration is used by the US and leads to the decomposition of chemical agents into smaller particles, which are released into the atmosphere through tall smokestacks (Sidel 2000). The process produces hazardous ash and scrubber wastes. The destruction of thousands of nerve gas munitions and other deadly chemical agents in U.S. owned Pacific island of Johnston Atoll in the 1990s generated low-levels of dioxin – the Johnston Atoll Chemical Agent Disposal System (JACADS) program was completed Nov, 2000 (IPB 2002).

3.2.3 <u>Nuclear Weapons</u>

Nuclear weapons production and testing is considered to have the most severe and enduring impact on health and the environment of all military operations. Every step in the nuclear bomb-making process involves major environmental threats. The nuclear weapons production cycle involves uranium mining and processing, production of weapons-grade plutonium, assembly and transportation of nuclear weapons, weapons testing, weapons storage, weapons disassembly with the required disposal of uranium, plutonium, tritium and chemical triggers (Shahi and Sidel 1997).

Radioactive wastes created in the manufacture of a *single* nuclear bomb containing 4 kg of plutonium-239 and 20 kg of uranium-235 include: 2,000 metric tons of uranium mining waste, 4 metric tons of depleted uranium, 12,000 curies of strontium-90, 12,000 curies of cesium-137, 50 cubic meters of 'low-level' waste and 7 cubic meters of transuranic waste (ATRC/ WILPF 2003). The estimated number of nuclear warheads built worldwide since 1945 is over 128,000 (CDI 2003). All but 2% of these nuclear warheads have been built by the United States (55% or 70,000+) and Russia (43% or 55,000+). The spread of nuclear debris is also global and plutonium has a half-life of 24,000 years (Renner 1997).

Virtually all nuclear production facilities are heavily polluted. Renner (1991) notes that more than 50 Nagasaki-size bombs could be manufactured from the waste that has leaked just from the underground tanks at Hanford Reservation's Purex plant in Washington state. The territories of the former Soviet Union, however, are far more contaminated. Whereas US radioactive dispersion into the environment from nuclear weapons production is estimated to be approximately 3 million curies, in the former Soviet Union it is approximately 1.7 billion curies (Sidel 2000).

Today, there are approximately 30,000 intact nuclear warheads throughout the world. 17,500 of these are considered operational and are primarily in the five nuclear weapon states: USA, UK, Russia, France, and China (CDI 2003, ATRC/ WILPF 2003). Worldwide, there are an estimated 257 tons of weapons-grade plutonium either stored or assembled in warheads; in addition, there are 1,300 to 1,800 tons of highly enriched uranium (Renner 1997).

There is no 'safe' method of disposing nuclear waste but the Soviet military is guilty of perhaps the single greatest failure to contain it. From 1952 onwards, the Soviet military dumped $4x10^{18}$ becquerels (10^8 curies) of nuclear waste from the Mayak Plant directly into Lake Karachay (AMAP 1997). The heat of the radionuclides began to dry out the 10 square km body of water. By 1988 it contained 120 million curies of strontium-90, cesium-137, residual plutonium, and other long-lived isotopes, two and a half times more than was released at Chernobyl. The lake is now covered by a thick layer of concrete but the Arctic Monitoring and Assessment Programme (AMAP 1997) notes that radionuclides can leach from the sediments into the groundwater, from where it might spread further into the Techa River. Lake Karachay is known as 'the most polluted spot on the planet'; and standing on its shore for an hour would kill a person within weeks (AMAP 1997).

The 'demilitarization' of nuclear weapons also poses great environmental risks. The US for example, in compliance with the Intermediate-Range Nuclear Forces (INF) Treaty, burned hundreds of its Pershing missiles in the open air or exploded them on a test stand at the Pueblo Army Depot in Colorado. The procedures released clouds of toxic hydrochloric acid (Shahi and Sidel 1997).

3.3 The Environmental Impact of Military Operations

Military operations represent yet another source of military-related peacetime environmental degradation and are briefly examined here.

3.3.1 Training and Practice Maneuvers

Land that is used for military training is prone to severe degradation. Maneuvers involving tanks and other military systems destroy natural vegetation, disturb wildlife habitat, erode and compact soil, silt up steams and cause flooding (Renner 1991). Bombing ranges render entire areas into wasteland while shooting ranges for tanks and artillery cause toxic contamination of soil and groundwater.

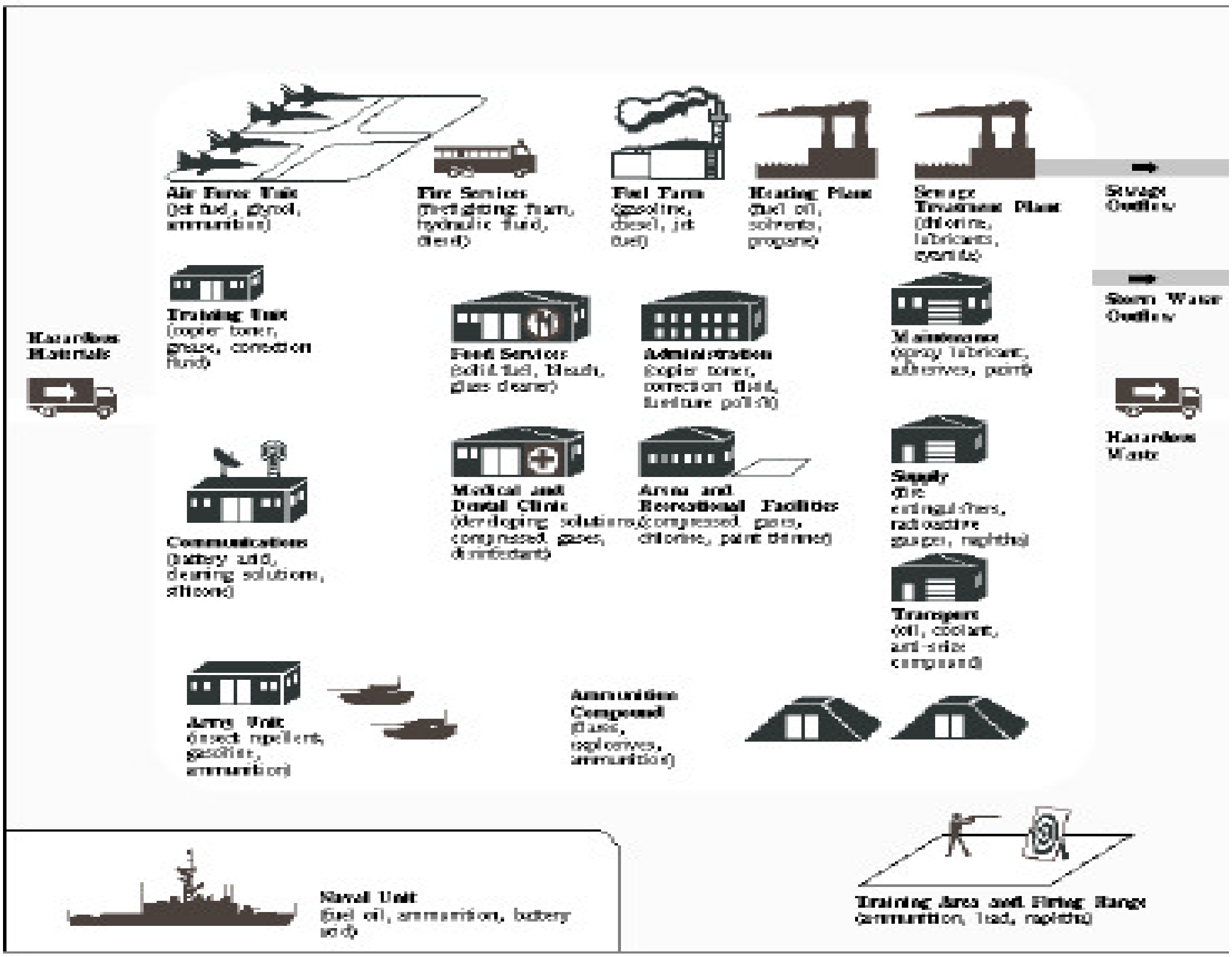
Military maneuvers also destroy large tracts of land far beyond the designations of military bases. For example, NATO maneuvers that were conducted in West Germany caused at least US$100 million in assessed, quantifiable damages to crops, forests, and private property in a typical year (Renner 1991). Fragile desert ecosytems may take hundreds of years to recover from military assault. The southern California desert still bears the scars of tank maneuvers conducted by General Geore S. Patton in the early 1940s (Audubon 1991).

Nor are the effects of military training restricted to land areas. The oceans serve as training ranges for the world's navies. Nanoose (near Nanaimo, BC), for example, has served as a torpedo test range for US nuclear weapons capable warships since 1965. The US naval exercises and weapons tests at the range have generated tons of lead, copper wire, lithium, and other toxic wastes that are dumped into the fish bearing waters of the Geogia Strait and affecting the marine ecosystem (SPEC 2003).

3.3.2 Military Bases

Military bases also generate large quantities of a wide variety of toxic substances including fuels, solvents, PCBs, and phenols (See Figure 2). Tanks and airplanes are washed with caustic cleaning compounds and solvents, that leach into the ground or drain into ditches (Shahi and Sidel 1997). Electroplating shops that repair metal parts for military equipment generate cyanides, acids and heavy metals and chemical propellant bags, used to fire artillery shells at fire ranges, are regularly burned at military bases (Shahi and Sidel 1997).

Figure 2: Canadian Forces Base- Typical Activities and Types of Hazardous Materials Used.



Source: *1999 Report of the Auditor General*,(Canada) Exhibit 13.1

3.3.3 Weapons Testing

The environmental effects of weapons testing are similar to the effects caused by the use of weapons in war. However, the extensive nature of the test trials conducted and the secrecy shrouding them (past and present) suggest grave and as yet unkown consequences for the ecosphere.

3.3.3a Biological weapons testing— The testing of biological weapons peaked after World War II but Japan's biowarfare program was ended following its defeat in 1945 while, by the mid 1950s, the UK had ended its biowarfare program. The US conducted tests up until 1969 and the Soviet Union ended its program in 1992 (MIIS 2002). While the programs may have ended, the pathogens they released persist today in the test sites' animal, bird, reptile, and insect populations (Choffnes 2001). Choffnes (2001) describes the impact of tests conducted by three major biowarfare programs:

- **Former Soviet Union**— Vozrozhdeniye served for decades as the Soviet Union's major open-air bioweapons test site. The test site was used to study dissemination patterns of BW agent aerosols and methods to detect them. Experiments were conducted on livestock and lab animals. Scientists routinely released deadly organisms into the air — plague, smallpox, brucellosis, tularemia, and anthrax. Local fish kills, plague outbreaks, and other cases of infectious disease have been blamed on testing, and despite almost a decade of inactivity, the island remains a danger zone: soil samples show that some of the buried anthrax spores, and other pathogens, are still viable and potentially deadly.

- **Britain**— Gruinard Island, located a half-mile off the northwest Scottish coast, was chosen in 1942 for the first British anthrax bomb tests. The first weapon tested on Gruinard was a modified 25-pound chemical bomb — 18 inches high, 6 inches in diameter, and loaded with a "brown, thick gruel" of concentrated anthrax spores. Following the tests, the spores survived and impacted upon the island's ecosystem. Anthrax-laced carcasses of sheep used as test subjects escaped from burial sites below the island's cliffs and floated to the mainland; at least one outbreak of anthrax among livestock on the Scottish mainland has been attributed to activities on Gruinard (Choffnes 2001). There had been no sign of reduction in the amount of spores in 25 years, and the island was announced as fit for habitation only 50 years later, after intensive decontamination by irrigation with formaldehyde (Mäkelä 2002).

- **The United States**— All US field test sites were abandoned at the end of World War II with the exception of Dugway Proving Ground in Utah. From 1951 to 1969 hundreds to thousands of open-air germ warfare tests were conducted at Dugway on human volunteers and animal test subjects. Many of the aerosol dispersal tests during the Cold War introduced non-indigenous diseases (or increased the geographic range of the diseases) to Utah and surrounding states including encephalomyelitis, Rocky Mountain spotted fever, psittacosis, Q fever, anthrax, brucellosis, plague, tularemia, and hydatid disease. All of these diseases are now considered endemic among native wildlife. The US also conducted its tests at sea, in the tropics, in the arctic, in Central America, over the Pacific Ocean, in the Far East, and in the Caribbean.

3.3.3b Chemical weapons testing— Tests of mustard gas, nerve agents and psychochemicals, including LSD, during World War II involved thousands of military personnel, many of whom subsequently claimed disabilities from the exposures (Freeman 1991). The records of participation and of effects are so poor that only a small fraction of those who participated could be identified (Shahi and Sidel 1997). The effects on the environment, as a result of the tests, are even less understood. There is virtually no available information on the ecological impact of chemical weapons tests conducted in the US, Australia, India, Canada, and the UK.

The US Army Chemical Warfare Service test sites included Bushnell, Florida; San Jose Island, Panama; Dugway Proving Ground, Tooele, Utah; Edgewood Arsenal, Maryland; and Camp Sibert, Alabama. The stations under British control were Porton, England; Suffield (also a biological warfare site) in Alberta, Canada; Innisfail and surrounding areas in the Australian state of Queensland; and Rawalpindi, India.' (Freeman 1991).

3.3.3c Nuclear weapons testing— Roughly a quarter of all nuclear tests, most of them before 1963, were conducted in the atmosphere (Renner 1991). Atmospheric nuclear tests deposited both short-lived radionuclides (such as iodine-131) and long-lived radionuclides (such as strontium-90) at sites both near, as well as far-removed from the site of testing (Sidel 2000). The resulting contamination was severe. Bikini Atoll in the Pacific, for example, was rendered uninhabitable by US atmospheric tests. In a 1959 study reporting on the effects of radioactive fallout from a large, above-ground test on Bikini Atoll in 1954 and on other islands in the Marshall group, 13 species out of the total monitored flora of 15 species showed conspicuous pathological or other abnormal symptoms that were attributed to the radiation damage (Freedman 1995).

In a test area in the Mohave Desert of Nevada, which was subjected to at least 89 relatively small atmospheric detonations, the explosions cleared a central area of 73 to 204 hectares of all life. There was severe vegetation damage over an additional 400-1375 hectares (Freedman 1995). Although underground testing has cut down on radiation, some still escapes into the atmosphere (venting) and is also suspected of leeching into groundwater. In a few cases with the help of winds the vented radioactivity was detected across international borders. More than a third of U.S. underground tests and an unknown number of Soviet blasts have vented (Renner 1991).

Table 5: 21st Century Nuclear Sates and Nuclear Tests Conducted
Source: *Facts and Figures about Disarmament,* Reaching Critical Will- WILPF

Nuclear Weapon State	Nuclear Arsenal	Number of Tests Conducted
United States of America	12,070	1030
Russia	22,500	715
China	400	45
United Kingdom	260	45
France	450	210
Israel	100-200	Unknown
India	~65	6
Pakistan	~39	6

3.3.4 Military Accidents

Throughout history, military accidents have caused unintended damage, however up until the twentieth century, the scale of that destruction had been limited by the nature of weapons systems and equipment involved. With the development of Weapons of Mass Destruction (WMD), the potential for catastrophic and persistent harm has risen significantly. Three incidents, involving WMDs are briefly described.

- **Biological Weapons**— An outbreak of anthrax in 1979 in Sverdlovsk in the Soviet Union causing 66 deaths, was long suspected and, finally, in 1992 admitted to have been due to an accident in a biological-weapons production plant (Mäkelä 2002).

- **Chemical Weapons**— One of the best known examples of accidents involving chemical weapons occured at Dugway Proving Ground in Utah in 1968. In early 1968, a small amount of VX nerve agent escaped during testing. As far as forty-five miles away, sheep began to die. As a result of the accidental release, 4,377 sheep died and another 1,877 were disabled. Wild animals that died in the area were never counted , or at least the statistics were never made public (Lanier-Graham 1993).

- **Nuclear Weapons**— In September 1957, high-level nuclear waste stored in Kyshtym in the southern Urals region underwent a chemical explosion. The accident severely contaminated 15,000 square kilometers of land that was home to more than 250,000 people, forcing the evacuation of 10,000 of them. The explosion released about one-third as much overall radiation as did Chernobyl (Renner 1997). Overall, between 1945 and 1988, 212 nuclear accidents occurred in the major navies (Heininen 1994). As a result, at least 50 nuclear warheads and 11 nuclear reactors litter the ocean floor (IPB 2002).

3.3. 5 Small Arms Trade

There are around 500 million military small arms around the world and it is estimated that at least 1,134 companies in 98 countries worldwide are involved in some aspect of small arms and/or ammunition production (Shah 2003). They are the weapons of choice in resource-based conflicts because they are inexpensive, widely available, easy to conceal and smuggle, and easy to use and maintain (Renner 2002). 90 percent of civilian casualties are caused by small arms (Shah 2003).

There is a close connection between the trade/trafficking in arms and that in natural resources such as minerals, timber, and diamonds. The routes in which arms and commodities travel in opposite directions are often the same. Revenues from selling off raw materials finance the purchase of military related equipment including arms, ammunition, and uniforms. Weapons have also at times been directly bartered for natural resources, drugs, animal products, and other commodities (Renner 2003). The permanent UN Security Council members- the USA, UK, France, Russia, and China dominate the world trade in arms. Together, they are responsible for 88% of reported conventional arms exports (Shah 2003).

3.4 The Consequences for the Environment of Resource Diversion

Enviromental degradation is being increasingly recognized as one of the most significant challenges of the 21st century and its effects are being acutely felt worldwide. For example, India is losing more than US$10 billion annually or 4.5 % of its Gross Domestic Product (GDP) to human-induced land degradation (UNEP 2003). Massive military expenditures, military research and development (R&D), and federal subsidies to the military-industrial complex, all divert resources that are urgently required for environmental protection. Furthermore, by diverting resources from human development programs, military investment deepens the disparities that can contribute to environmental degradation. For purposes of sheer survival, impoverished people may be led to exploit the environment in ways similar to the actions of refugees in camps.

Another important consideration regarding military expenditure is the connection between military spending and receipt of development aid. For example, Israel, ranked the second largest in military spending per capita and the second largest importer of arms, is the country that receives the most economic aid per capita (Sivard 1996). Clive Ponting observes that much of the development aid given by developed nations to the developing world is mainly designed to help companies in the industrialized world,

> *"Some of the deals that have been struck have little to do with aid – in the mid 1980s £65 million of British aid was given so that India could buy helicopters from Westland, an ailing firm that needed government support. Each helicopter was worth more that the total of Britain's aid to Ethiopia, one of the poorest countries in the world suffering from acute environmental degradation."*
>
> *(Ponting 1991, pp.341-342)*

A related issue, but one that this report has been unable to explore further due to time limitations, is the embezzlement of foreign aid by corrupt governments for strategic military objectives.

3.4.1 Military Expenditure

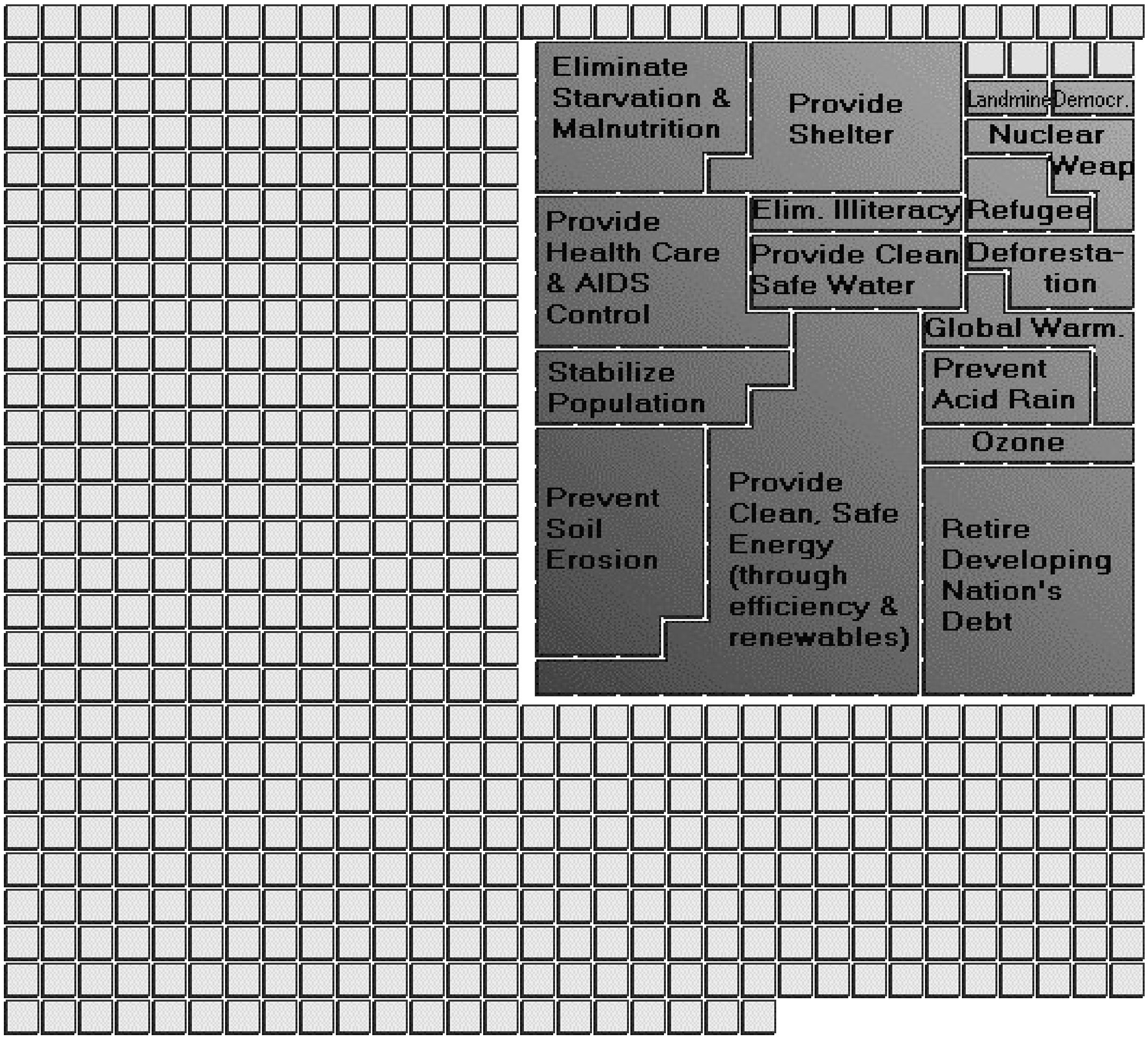
Global military spending had on average been declining from an all time high in 1987 of more than US$1,000 billion to the lowest levels of spending in 1996 of US$708 billion (Schjolden 2000). In 1998 it began to increase again. The world military expenditure rose sharply in 2002, and according to SIPRI (2003) increased by 6% to US$794 billion and accounted for 2.5% of world GDP or $128 per capita. The United States accounted for three quarter of the global increase in 2002, with a 10% increase in its military spending. SIPRI (2003) notes that further substantial increases are planned up to 2009. The estimated world military budget for 2003 was $839 billion (US). (53rd Pugwash conference, Halifax) Also, the budgets for fiscal year (FY) 2003 and FY2004 do not include the cost of the war in Iraq, for which an additional $80 billion has so far been appropriated.

In comparison, the United Nations and all of its agencies spend about US$10 billion each year or about US$1.70 for each of the world's inhabitants (Shah 2003). The UN's entire budget is only about 1.25% of the world's annual military expenditure. Even so, at the end of March 2003, members owed the UN $1.182 billion, of which the United States alone owed US$0.532 billion or 45% of the regular budget (Shah 2003).

The US now accounts for 43% of world military expenditure while the top 5 spenders: the USA, Japan, the UK, France and China, account for 62% of the world total (SIPRI 2003). The top 15 military spenders account for 82% of world military expenditure. SIPRI (2003) reports marked regional differences in a country's share of economic resources allocated towards military spending. The most recent year for which data are available is 2001 during which an estimated global average of 2.3% of GDP was spent on the military. In comparison, the Middle East spent 6.3% of GDP on the military, North America spent 3% and Central and Eastern Europe spent 2.7%. Falling below the 2.3% average were Latin America at 1.3%, and Asia and Oceania at 1.6%, Africa at 2.1% and Western Europe at 1.9%.

Based on data from 1995 and 1996, the World Game Institute indicates how a redirection of even 30% of the world's annual military expenditure can significantly halt and reverse environmental degradation and achieve global sustainability (see Figure 3).

Figure 3 Annual World Military Expenditure in US $788 billion based on 1995-95 Figures (1 grey box = US$1 Billion) Source: *What the World Wants,* World Game Institute 1997



3.4.2 Military Research and Development

World military R&D totals US$58 billion per year (IPB 2002). The largest spender of military R&D is the United States, accounting for 63% of the world total. It spends seven times more on military R&D than the second largest spender, France. Following France are the UK, Germany, Japan, China and Russia (SIPRI 1998). In the US, military R&D accounts for 70% of all federally funded research and 30% of all research (Schjolden 2000). However, SIPRI cites a more conservative estimate of 20% for the years 1996 onwards. According to the Center for Defense Information (CDI 2003), 60% of all federal research funding for universities in the United States is military-related.

The disproportionate spending on military R&D bears at least a couple of implications for the environment. Money spent on military R&D diverts money that can otherwise be used for environmental protection. Schjolden (2000) also notes that through a process of conversion, military technology can be used, to create environmental technology or cleaner technology for industrial production.

3.4.3 Federal Subsidies for Defence Contractors (Military-Industrial Complex)

Table 6: US Federal Subsidies to Defence Industry for Arm Sales 1996-97

Table

Subsidies to Defense Industry for Arms Sales

Annualized average for 1996 and 1997	$U.S. millions
Foreign Military Financing Program: Administered by the Defense Department, this program provides grants to foreign countries to buy American military equipment. Since 1994 more than two dozen countries have received FMF grants.	3,318
Excess Defense Articles: This Defense Department program gives away surplus weapons stocks or sells them at deep discounts. The cost calculation is based on the difference between the market value of the items and their eventual selling prices.	750
Economic Support Funds: Administered by USAID and ostensibly a fund for balance of payments supports, 90% of the program's funds go to major U.S. weapons clients Israel, Egypt, and Turkey, to help them offset the costs of arms purchases.	2,042
Eximbank Loan Subsidies: The Commerce Department subsidizes the costs of outstanding military-related Eximbank loans.	34
Forgiven/Bad Loans: Costs incurred on defaulted military-related loans.	1,000
Waiver of Recoupment Fees: Congress decided in 1995 to allow the Pentagon, at its discretion, to waive a 3% to 25% fee once required on weapons exports. Recoupment fees were intended to reimburse the government for development costs of the weapons sold.	200
Air Shows and Expos: The Pentagon subsidizes overseas promotional events and demonstrations for potential weapons buyers.	34
Personnel Costs: Currently, there are 6,500 full-time federal workers engaged in promoting and financing weapons exports.	410
Total	**7,788**

Source: William D. Hartung, *Welfare for Weapons Dealers 1998: The Hidden Costs of NATO Expansion* (New York: World Policy Institute, March 1998).

Government subsidies for the defense industry serve to maximize profits on arms sales and military technology transfers. Essentially, public funds are diverted towards creating a favorable environment for private sector contractors such as Lockheed Martin. Taxpayers in the United States, for example, pay over US$7 billion per year to subsidize actual arm sales (see Table 6).

Stephen Staples in his presentation at the *Hague Appeal for Peace* on May 12th 1999 made the connection between a neoliberal agenda and subsidies for the military-industrial complex:

> "*Industrialized countries negotiate free trade and investment agreements with other countries, but exempt military spending from the liberalizing demands of the agreement. Since only the wealthy countries can afford to devote billions on military spending, they will always be able to give their corporations hidden subsidies through defence contacts, and maintain a technologically advanced industrial capacity.*
> *And so, in every international trade and investment agreement one will find a clause which exempts government programs and policies deemed vital for national security. Here is the loophole that allows the maintenance of corporate subsidies through virtually unlimited military spending.*"
>
> *(Shah 2003, website)*

The consequences for the environment are identical to those of other forms of resource diversion discussed earlier.

3.5 Inadequate Peacetime Environmental Legislation

Both peacetime domestic and international environmental legislation have been inadequate in mitigating the impact of military activities on the environment. International environmental legislation, in particular, has been willfully blind in recognizing and including peacetime military activities under its auspices. Furthermore, there is a glaring failure on behalf of environmental regulatory bodies to enforce legislation in the face of noncompliant behaviour by the military.

3.5.1 Domestic Law

At present, domestic legislation exercises the greatest jurisdiction over peacetime military activities. However, in at least four states- Germany, Switzerland, UK, and Serbia/Montenegro, the military sector is explicitly exempt in part or in whole from domestic environmental law (Westing 2000).

In the United States, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) allows the President to exempt the Department of Defense from the requirements under CERCLA if it is necessary to protect national security interest. The Resource Conservation and Recovery Act (RCRA) also includes a 'national security' exemption clause (Werner 1993). Furthermore, the Pentagon, backed by the current Bush administration, has been seeking to exempt itself from other federal environmental protection laws. In May 2003, the House Resources Committee approved a bill granting the Pentagon broad exemption from the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) (ENN 2003).

An issue of great concern over the years has been legislation (or rather, lack thereof) regulating military activities in overseas installations. US military operations conducted at bases abroad, for example, are exempt from the US National Environmental Policy Act and, under basing agreements, from pertinent host-nation laws as well (Renner 1991). As a result, enormous environmental damage has been inflicted by US operations overseas. In the Philippines, only after the U.S. military evacuated Subic Naval Station and Clark Air Base in 1992 did Filipinos discover the toxic legacy left behind including tons of toxic chemicals dumped on the ground and into the water, or buried in uncontrolled landfills (Lindsay-Poland and Morgan 1998).

In Canada, the Department of National Defence is exempt from all or part of many federal laws governing hazardous materials. As a federal agency, it is also not subject to most provincial and municipal laws. Furthermore, the issues of noncompliance and enforcement require consideration. For example, a 1999 federal audit of 10 military bases identified 800 instances of noncompliance between 1993 and 1998 with *applicable* federal law requirements governing hazardous materials (Auditor General's Report 1999). In the US in 1999, the EPA found that the Navy had violated its Clean Water Act National Pollution Discharge Elimination System permit to discharge ordnance into waters around the island of Vieques 102 times in five years (Taylor 2003).

3.5.2 International Law

Virtually none of the international environmental treaties address the effects of peacetime military activities on the environment. For example, numerous multilateral environmental protection treaties dealing with the marine environment specifically exempt naval ships from their constraints (Westing 2000). Also, at US insistence, the 1997 Kyoto Protocol to the 1992 Framework Convention on Climate Change includes a military exemption provision (Westing 2000).

4. Conclusion

Military activities, during both war and (ironically) peace, have extensive adverse impact on the environment. It is also becoming increasingly clear that a militarized economy, region, or indeed world, works in direct opposition to urgently needed initiatives on sustainable development. However, although the inverse relationship between militarism and human security was recognized in the UN's Rio Declaration of 1992, no substantive development has been made since. The spectacular failure of the World Summit on Sustainable Development in Johannesburg in 2002, instead, indicates a willful attempt on behalf of some governments to sideline the issue despite broad and popular grassroots and NGO demands that it be addressed.

Movement toward the weaponization of space, increased military expenditures, and an economic agenda that places ever greater loads on the ecosphere, all indicate a trend towards more rather than less environmental exploitation. The creation of environmental refugees and the growing ecological debt of Northern nations towards the Global South are only two examples of the environmental injustice inherent to the current path being tread. Achieving sustainable development requires, perhaps most critically, recognizing and addressing the intimate relationship between militarism and the global economy.

5. Recommendations

1. That there be policies in place to evaluate and minimize environmental damage in planning and carrying out military action.

2. That cost - benefit analysis of military intervention be undertaken, to review effects over the short and long term time period, remembering that unpolluted land air and water are necessary for survival for human beings, animals and plants.

3. That resources presently being used for military purposes be re-allocated to human need.

4. That alternatives to military action be sought wherever possible, not only to reduce the direct human cost, but also the indirect costs through environmental degradation and use of non-renewable resources.

5. That international law recognize the connections between destruction of the environment and the impact of human rights.

6. That the nations liaise and coordinate with military partners, international organizations to prevent environmental damage as a consequence of military action.

7. That the nations support international law and the United Nations as being the best option for increasing world stability and sustainable development.

8. That governments have in place policies to assist in establishing environmental and sustainable development priorities for reconstruction in the immediate aftermath of conflicts.

Appendix

Acronyms and Abbreviations

AMAP	Arctic Monitoring and Assessment Programme
APM	Anti-Personnel Mines
ASAT	anti-satellite
ATRC	Arms Trade Resource Center
BBC	British Broadcasting Corporation
BC	British Columbia
CDI	Center for Defense Information
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFCs	chloroflourocarbons
CO	carbon monoxide
CS	*o*-chlorobenzalmalononitrile
Db	decibel
DU	Depleted Uranium
ELI	Environmental Law Institute
ENMOD	Environmental Modification
EPA	Environmental Protection Agency
ERA	Environmental Rights Action
ESA	Endangered Species Act
FAS	Federation of American Scientists
FoEI	Friends of the Earth International
FY	Fiscal Year
GDP	Gross Domestic Product
GPS	Global Positioning System
HAARP	High Frequency Active Auroral Research Project
HCV	High Conservation Value
HEF	High Explosive Fragmentation
HRW	Human Rights Watch
Hz	hertz
ICBM	Inter-Continental Ballistic Missile
ICRIN	International Chernobyl Research and Information Network
IED	Institute for Economic Democracy
INF	Intermediate-range Nuclear Forces
IOMC	Inter-Organization Programme for Sound Management of Chemicals
IPA	International Peace Academy
IPB	International Peace Bureau
IPPNW	International Physicians for the Prevention of Nuclear War
JACADS	Johnston Atoll Chemical Agent Disposal System
LEO	Low-Earth Orbit
LFA	Low Frequency Active sonar
MIIS	Monterey Institute of International Studies
MMOU	Multinational Memorandum of Understanding
MMPA	Marine Mammal Protection Act
MT	megaton
NATO	North Atlantic Treaty Organization
NO	nitric oxide
NRDC	Natural Resource Defence Council
OPCW	Organization for the Prohibition of Chemical Weapons
PCBs	polychlorinated biphenyls
PGS	Physicians for Global Survival (Canada)
PNAS	Proceedings of the National Academy of Sciences of the United States of America
PRIO	International Peace Research Institute, Oslo
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
RD	Xhexahydro-1,3,5-trinitro-1,3,5-triazine
SIPRI	Stockholm International Peace Research Institute
SPEC	Society Promoting Environmental Conservation
Tg	ton
TNC	Transnational corporation
TNT	2,4,6-trinitrotoluene
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNHCR	United Nations High Commissioner for Refugees
US	United States
VX	*S*-(2-diisopropylaminoethyl) *O*-ethylmethylphosphonofluoridate
WGI	World Game Institute
WHO	World Health Organization
WILPF	Women's International League for Peace and Freedom
WMD	Weapons of Mass Destruction

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