



LONG-TERM CONSEQUENCES OF THE VIETNAM WAR

ECOSYSTEMS

**REPORT TO THE
ENVIRONMENTAL CONFERENCE ON
CAMBODIA • LAOS • VIETNAM**

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This is one in a series of reports produced in connection with the Environmental Conference on Cambodia, Laos and Vietnam which was held in Stockholm during 26-28 July 2002. The purpose of the conference was to review the long-term consequences of the Vietnam War, which also afflicted Laos and Cambodia.

Over a quarter-century has elapsed since the war's formal conclusion in 1975, and more than half the current population was born after that date. This means that an entire generation has now grown up in an environment exposed to the massive impact of modern warfare, so that it is now possible to study the long-term implications. Among its other effects, the Vietnam War left a legacy of environmental contamination and destruction that has yet to be thoroughly examined.

That legacy was the focus of the Stockholm conference, and the review of the war's long-term consequences was conducted by subcommittees for each of four main areas: ecosystems; public health; economic and social impacts; ethical, legal and policy issues.

The reports of the subcommittees, all of which are available on the conference web site, may be regarded as initial attempts to deal with highly complex issues for which significant categories of data are often lacking. Furthermore, the resources available for the project were extremely limited.

Accordingly, much remains to be done. It is hoped that the work of the subcommittees will stimulate further study and analysis of the Vietnam War's long-term consequences. The subcommittee reports and related information are available on the conference web site at:

www.nnn.se/environ.htm

The Environmental Conference on Cambodia, Laos and Vietnam was an initiative of Föreningen Levande Framtid ("Living Future Society"), a Swedish non-profit organization which assembled a steering committee of scientists and other experts to plan and organize the project.

The conference was made possible by financial contributions from Oxfam America, Oxfam Netherlands (NOVIB), Allan & Nesta Ferguson Charitable Trust (England), Swiss-Vietnam Association, American Friends Service Committee, Ford Foundation, Norwegian Red Cross Society, Swiss Red Cross Society, Umverteilen Foundation (Germany) and Sea Otter Productions (Sweden).



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Cover illustration: Vo Quy

“The immense destruction brought about by indiscriminate bombing and by the large-scale use of bulldozers and herbicides is an outrage that is sometimes referred to as ‘ecocide’. It is shocking that only preliminary discussions of this matter have thus far been possible in the United Nations. . . . We fear that the active use of these methods is coupled with a passive resistance to discuss them.”

— *from opening address of Swedish Prime Minister Olof Palme to the 1972 U.N. Conference on the Human Environment*



Photo: E.W. Pfeiffer

C-123 plane depositing some of the 72 million liters of herbicides sprayed on the fields and forests of Indochina during the Vietnam War.

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THE VIETNAM WAR involved an unprecedented assault on the environment. Vast quantities of bombs, cluster bomb units (CBUs or “bomblets”), napalm, landmines, toxic chemicals, etc. have had lasting effects on soils, water systems, biological diversity, and perhaps even climate. Life forms at many levels of the evolutionary scale have been significantly affected, from primitive plants and animals to human beings.

The extent and intensity of the assault were unprecedented. On an area less than eight percent that of the United States, the amount of high explosives employed was almost double the amount expended by the USA during World War II. Left in the earth were many millions of large bomb craters, unexploded landmines, bomblets, and other ordnance which continue to take a heavy toll of life and limb.

Over 72 million liters of herbicides destroyed roughly ten percent of southern Vietnam’s valuable forests, including nearly one-third of the coastal mangroves which play vital roles in coastal ecology and in sustaining fish stocks. Toxic chemicals contained in the herbicides, arsenic and dioxin in particular, are expected to continue posing a significant health threat long into the future.

Altogether, the damage to the environment was so intense and widespread that it gave rise to the term “ecocide”. Nearly three decades later, many of the affected ecosystems have still not recovered. The long-term consequences include loss of habitat and biological diversity, severe and persistent problems of public health, enormous economic losses, and severe constraints on human development.

The affected populations have made some progress in restoring the environmental damage from the war. But much more remains to be done, and available resources are very limited. Breaking the war-related cycle of poverty is crucial to the well-being of the present and future generations of Cambodia, Laos and Vietnam. It is an enormous task that will require substantial resources, long-term commitments and appropriate corrective measures.

ASSAULT ON THE ENVIRONMENT

Warfare is a human pastime, the very purpose of which is to subdue an enemy by inflicting overpowering levels of death, destruction, and disruption. Thus, damage to the human environment in time of war— both intentional and collateral— is as old as warfare itself.

The level of savagery is largely independent of the belligerents' level of technological sophistication. Nonetheless, the Vietnam War* of 1961-1975 stands out as the archetypal example of war-related environmental abuse. This negative image is the result of at least five major factors:

- (a) the protracted, systematic fury inflicted by one of the belligerents upon the environment of an enemy dependent for its survival on a rural economy based on natural resources
- (b) the coincidence of this war with the growing awareness of concern over massive assaults being visited upon the global biosphere in general
- (c) the frightening medical consequences of some of the attacks on the environment
- (d) the hostile atmospheric manipulations carried out by one of the belligerents, and
- (e) perhaps, as well, more generalized moral or ethical objections to this particular war and the way it was pursued by the United States.

The theater of operations of the Vietnam War encompassed portions of Cambodia (18 million hectares, population seven million at the time), Laos

*The Vietnam War is also known as the Second Indochinese War and, in Vietnam, as the American War.

(24 million hectares, population three million), North Vietnam[†] (16 million hectares, population 19 million), and South Vietnam (17 million hectares, population 18 million). Thus, the total for all three countries was 76 million hectares (188 million acres) and 47 million people, the vast majority of whom lived in rural areas. Environmentally, the most disruptive means of U.S. warfare consisted of high-explosive munitions, chemical anti-plant agents, and land-clearing tractors (“Rome plows”).

High-explosive munitions

The United States employed some 14 million metric tons of bombs and other high-explosive munitions during the Vietnam War, a truly formidable amount (twice what it had expended during World War II and, in terms of energy released, the equivalent of 328 Hiroshima A-bombs). Of the munitions expended in the region, five percent were used in Cambodia, 16 percent in Laos, eight percent in northern Vietnam, and 71 percent in southern Vietnam — nearly all in rural areas, where 90 percent of the population lived.

These attacks left some 10-15 million large bomb craters as a semi-permanent feature of the landscape in Vietnam, alone. Also left behind

[†] The division of Vietnam into “North” and “South” was a temporary provision of the 1954 peace agreement that ended the First Indochina War (in Vietnam, the “French War”). The division ceased to have any legitimacy under international law after the reunification scheduled for 1956 was not allowed to take place. See www.nnn.se/environ/ethics.htm



*A portion of the craters resulting from a single B-52 bombing run.
In Vietnam alone, some 10-15 million large bomb craters were left in the landscape.*

were many millions of unexploded landmines, bomblets and other unexploded ordnance (UXO) which continue to threaten life and limb throughout the region.

Chemical anti-plant agents

Of the 72 million liters of chemical anti-plant agents sprayed by the United States, less than 0.1 percent was in Cambodia, two percent in Laos, and a negligible amount in northern Vietnam. The remainder, nearly 98 percent, was used in southern Vietnam. Of that amount, 86 percent was directed against forested areas to deny cover to opposing forces; the remaining 14 percent was directed against agricultural lands, primarily for the destruction of rice (both paddy and upland cultivation). These attacks on agriculture were part of a systematic large-scale program of crop destruction and food denial conducted by the USA by a variety of means.

Approximately 14 percent of the total woody vegetation of southern Vietnam was attacked with herbicides. About 13 percent of its inland forests (including rubber plantations) and about 30 percent of its coastal mangrove forests were also attacked, the latter with especially devastating results. Losses of merchantable timber from hostile actions in the inland forests have been estimated at roughly 75 million cubic meters, of which about 20 million can be attributed to the herbicide attacks (although it may be noted that some reports have suggested somewhat higher levels of wartime damage).

Overall, the herbicidal attacks were inflicted upon some ten percent of South Vietnam's total land area (although again it may be noted that some reports have suggested substantially higher values of 24-27 percent).

One of the major chemical anti-plant agents employed, called Agent Orange*, contained trace amounts of the highly toxic substance, dioxin. All told, some 170 kilograms of dioxin were dispersed over the landscape, primarily in rural South Vietnam. To this day, traces of dioxin (TCDD) can still be found in the soil of the most intensively affected areas, for example on the perimeters of some U.S. military installations and at the 50 or more sites where unintended emergency dumping of Agent Orange occurred. Another widely employed herbicide, "Agent Blue", consisted largely of an organic arsenic compound (dimethyl arsenic, or cacodylic acid).

Land-clearing tractors. Three percent of South Vietnam's total forested area, 325 thousand hectares, was scraped bare by the USA with "Rome plow" tractors.

Violation of ethical and legal norms

The assault on the environment of the three affected countries during the Vietnam War violated widely held ethical principles and established legal norms, and evoked a strong response from the international community. The most serious violation was the employment of chemical weapons by the USA, primarily in southern Vietnam. This was seen as a clear breach of the 1925 Geneva Protocol on Chemical and Biological Warfare (LNTS 2138). As of mid-2002, this international agreement, which was developed in response to World War I, had been adopted by 133 of the 193 nation-states of the world (69 percent).

Although the United States was not itself a party to that landmark treaty at the time of the Vietnam War, it defended its use of chemical weapons on the grounds that they were not lethal

to human beings. This included the several anti-plant agents and the anti-personnel agent known as 'CS' (*ortho-*



Photo: Hatfield Consultants Ltd.

One of the estimated 10-15 million larger bomb craters from the war.

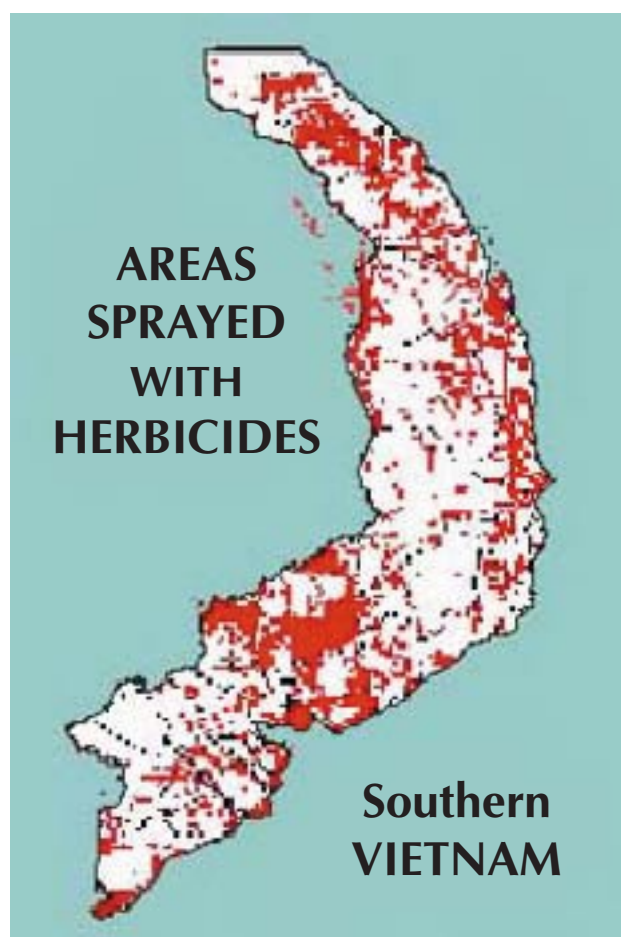
*Agent Orange, which got its name from identifying orange stripes painted on the barrels, was a 50/50 mixture of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,4-dichlorophenoxyacetic acid (2,4-D). Included in the mixture as an unintentional by-product were trace levels of the dioxin TCDD (2,3,7,8-tetrachlorodibenzo-*para*-dioxin), a substance known to be highly toxic to humans.

chlorobenzalmalononitrile). In 1969, however, a substantial portion of the world community of nations rejected the USA's interpretation, maintaining that those agents were indeed covered by the Geneva Protocol (cf. United Nations Resolution No. 2603[XXIV]A). The United States conceded on this point in 1975 when it became a party to the treaty; its acceptance was qualified by a minor statement on non-combat military uses of herbicides, but this was not a formal reservation.

Another violation of widely held ethical norms was the extensive, severe and long-term environmental damage that the USA inflicted on much of the region comprised of Cambodia, Laos and Vietnam. The affront to these norms, which were just emerging at the time, led to an important qualitative extension of the law of war that was spearheaded by the International Committee of the Red Cross in Geneva. The change took the form of the 1977 Protocol I on International Armed Conflict (UNTS 17512), which for the first time specified constraints on abuse of the environment *per se* (see especially Article 35.3). As of mid-2002, the Protocol had been adopted by 157 of the 193 states (81 percent); the United States is not one of them.

Yet a third affront to ethical norms was a decade-long effort to manipulate the environment, in this case the atmosphere, for military purposes. The program involved cloud-seeding, primarily over Laos, in order to produce heavy rains. This clandestine operation led to yet another extension of the law of war— this time spearheaded by the now-defunct Soviet Union—in the form of the 1977 Environmental Modification Convention (UNTS 17119). However, this treaty has major weaknesses that appear to be recognized by the world community, as indicated by the modest number of states that have adopted it— only 66 of 193, or 34 percent, as of mid-2002. The USA is one of the signatories, but its government has informed its military commanders that the constraints specified in the treaty are essentially meaningless.

Although not of the same character as the three international responses to the Vietnam War



Areas of southern Vietnam sprayed with herbicides at least once during 1965-1971.

(Source: US Dept. of the Army)

referred to above, it may be of interest to note an episode from the 1972 United Nations Conference on the Human Environment. At the insistence of the USA, military disruption of the environment was not included on the conference agenda. But in opening the conference, the prime minister of host country Sweden felt obliged to take the United States to task for its environmentally destructive conduct in Indochina, an action that aggravated diplomatic tensions between the USA and Sweden.

The remainder of this report focuses on the consequences of the war for the inland and coastal ecology of Vietnam, the only one of the three affected countries for which significant amounts of data are currently available.

— Arthur H. Westing

INLAND PLANT ECOLOGY

Vietnam has a tropical monsoon climate with two relatively distinct seasons. Its total land area of some 33 million hectares includes a variety of land forms that range from deltas to high mountains. The country is primarily mountainous, with a backbone formed by the Truong Son mountains that run north-south for a distance of some 1,000 kilometers. The highest peaks, located in the north, are over 3,000 meters above sea level. As a result of these wide variations in latitude, altitude, climate and land forms, Vietnam possesses great ecological and biological diversity.

The forest lands (including open areas) that occupy three-quarters of Vietnam's total land area grow under a variety of topographic conditions, including those associated with mountains, hills and valleys. Forests constitute an integral component of the land and water resources, and are vital to the 24 million people in various ethnic groups who are substantially dependent on forest resources for their livelihoods.

Those resources are abundant: Vietnam has over 10,000 described species of higher plants in 337 genera and 96 families. Among these are over 1,000 species of large trees, including more than 40 rare and valuable timber species.

Non-woody forest products comprise an economically vital component of the tropical forests of Vietnam. Among a wide range of bamboo species, approximately 40 have commercial value. It is estimated that there are some forty species of rattan, the annual harvest of which is now about 50,000 metric tons. Of the more than 1,800 known medicinal plants in Vietnam, two-thirds are found among the natural vegetation—a truly valuable storehouse of natural medicines.

There are an estimated 600 species which provide tannin, 160 so-called essential (volatile aromatic) oils, and 260 other oils. Many of these non-woody forest products are in great demand in local and export markets.

In short, Vietnam is characterized by several types of rain forest supporting an immense range of unique ecosystems that provide a diversity of forest resources.

Decline of natural forest

By 1999, the total area covered by forest was 10.91 million hectares, corresponding to 33 percent of Vietnam's total land area. Of this amount, 9.44 million hectares consisted of natural forest, and 1.47 million hectares were plantation forest. In terms of use, 4.04 million hectares (37 percent) consisted of production forest, 1.52 million hectares (14 percent) for special uses such as national parks, nature reserves, etc., and 3.61 million hectares (49 percent) for the protection of watersheds and the prevention of soil erosion. The last-named category also includes forest land that has been set aside for national defense and other purposes.

In terms of species dominance, approximately 77 percent of the 9.44 million hectares in a natural state consisted of tropical and semi-tropical forest, one percent of deciduous forest, two percent of coniferous forest, eleven percent of bamboo forest, and five percent of mixed forest.

As indicated by the table on page 6, there was a steady and quite rapid decline in natural-forest cover between 1943 and 1990. Since 1990, the loss of natural forest has proceeded at a

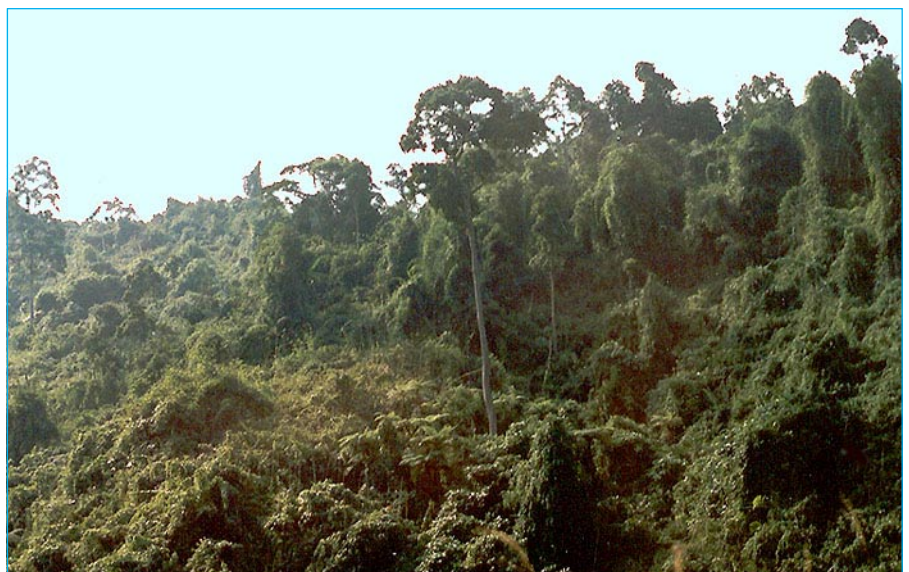


Photo: Hatfield Consultants Ltd.

Natural triple-canopy forest of Vietnam

much slower rate— an annual average of 36,000 hectares during 1990-1995. At the same time, the area of planted forest increased at an average annual rate of 61,000 hectares. Between 1995-1999, the total area of both natural and planted forest increased rapidly.

Wartime damage

During the American War, the forests of southern Vietnam covered an area of roughly 10.4 million hectares, 60-70 percent of it in the Central Highlands. The United States sprayed over 72 million liters of herbicides on forests (61 million liters) and fields (10 million liters), thereby inflicting environmental damage of varying severity on approximately ten percent of southern Vietnam’s total land area. (As noted previously, some reports suggest that this figure may have been as high as 24-27 percent.)

The chemicals were sprayed from the 17th parallel, south to Cape Cau Mau. Most forest types of southern Vietnam were affected. These chemical herbicide attacks, the most extensive in history, substantially depleted the forests that are so important to the sustainable development of Vietnam.

Inland forests, including rubber plantations, were heavily affected by the herbicide attacks, accounting for about 77 percent of total spraying missions. Coastal forests accounted for an additional nine percent, with the remaining 14 percent directed to agricultural lands. In addition, many forest areas were subjected to intense bombing, clearing by tractors and, in some instances, attacks with incendiary bombs.



Photo: Hatfield Consultants Ltd.

Healthy forests are essential to the welfare of many ethnic minorities.

With regard to altitude, distribution of the spraying was approximately as follows:

- below 300 meters, 16 percent
- 300-700 meters, 42 percent
- 700-1000 meters, 30 percent
- above 1000 meters, 12 percent.

Initial research findings indicate that about 1.4 million hectares of forest land were affected, with countless trees defoliated and destroyed. (Some reports suggest that total area was greater than 2.0 million hectares.) Immediate losses of merchantable timber due to herbicidal attacks were estimated at about 20 million cubic meters (again, some estimates of overall war losses are as high as 90 million cubic meters).

There was also great loss of non-woody forest products. Areas of inland forest where the forest canopy was destroyed have been invaded by secondary tree species or such grasses as *Pennisetum polystachyon* and *Imperata cylindrica*. These invasions have prevented normal forest regeneration. Forest spraying at elevations above

CHANGES IN THE FOREST COVER OF VIETNAM, 1943-1999

1000s hectares

	1943	1976	1980	1985	1990	1995	1999
Natural forest	14,000	11,077	10,486	9,308	8,430	8,252	9,444
Plantation	0	92	422	584	745	1,050	1,471
Total hectares	14,000	11,169	10,608	9,892	9,175	9,302	10,915
% of total area	43.0	33.8	32.1	30.0	27.2	28.1	33.2

Source: Vietnam Ministry of Agriculture and Rural Development. No accurate data available for period from 1943-1976.

700 meters and in areas of steep slopes, especially those with a gradient of more than 25 degrees, had a very serious impact on the absorption capacity of 28 watersheds, with heavy flooding as a result.

Postwar activities

During the period from 1976 to 1995, the natural forests of Vietnam decreased from 11.08 million to 8.25 million hectares, while planted forests increased from 0.09 million to 1.04 million hectares.

Since 1995, there has been a substantial growth of awareness regarding the need for forest rehabilitation; the combined efforts of the national government and the general public have yielded positive results. For example, the National Program for Forest Protection and Reforestation during the five-year period from 1993 to 1998 resulted in the following advances on a total of 1.46 million hectares:

- establishment of plantations and the management of protected forests on 640,000 hectares
- preservation of natural regeneration on 700,000 hectares
- establishment of cash crops on 89,000 hectares of sloping land
- establishment of household farms on 31,000 hectares.

Another national program, "Five Million Hectares of Aforestation" has two aims: the greening of barren lands for watershed protection and the effective conservation of ecosystems, biodiversity and environmental conditions; and returning barren lands to efficient production in order to alleviate poverty and promote sustainable development, especially in mountainous rural areas. As a result of such activities, forest cover in Vietnam has increased from 28 percent in 1994 to 33 percent in 1998.

Despite the passage of more than 25 years since the conclusion of the Vietnam War, its impact on affected forests continues. Areas hard-hit by spraying and bombing are still dominated by such undesirable grasses as *Pennisetum polystachyon* and *Imperata cylindrica*. Examples of such areas include the Aluoi Valley, Sa Thay, Ma Da, and the Boi Loi Woods. Another problem is

that natural forests in upland areas are under mounting pressure from commercial logging, and forests of high quality continue to be lost.

It is now clear that the natural restoration of such sites with high-quality trees will be a lengthy process, perhaps taking up to 80 or 100 years. Initial attempts to plant native trees have not been very efficient or effective. Complicated and costly measures will be necessary in order to increase the pace of restoration.



Photo: Hatfield Consultants Ltd.

Removal of the forest has led to widespread erosion, polluting streams and blocking transportation.

Research priorities

Compilation of existing documentation (basic data, aerial photographs, satellite imagery, etc.) from the wartime period, 1961-1975.

Comprehensive surveys of sprayed areas, with a particular focus on areas that were also bombed or otherwise disrupted, in order to produce the documentation required for land-use planning.

Investigation of applicable silvicultural techniques, appropriate tree species (including exotics), and innovative agro-forestry approaches that are suitable for local economic and social conditions.

Needed corrective measures

Rehabilitating the environment and improving the means of livelihood for ethnic minority groups in areas seriously affected by the war.

Forest conservation and replanting in destroyed areas; minimum cost estimated at USD 500-800 per hectare.

— Phung Tuu Boi

INLAND ANIMAL ECOLOGY

Prior to World War II, Vietnam was recognized as one of the world's most attractive big-game hunting regions, and its natural environment contains a great wealth of animal life. Recorded to date are 276 mammal species, 830 birds, 180 reptiles, 80 amphibians, 472 freshwater fish, 2038 saltwater fish, and many thousand species of invertebrates. These categories display a high degree of variation, with many local species that are of great scientific and economic value.

Of special interest are such inland species as the elephant (*Elephas maximus*), Javan rhinoceros (*Rhinoceros sondaicus*), banteng (*Bos javanicus*), kouprey (*Bos sauveli*), gaur (*Bos gaurus*), tiger (*Panthera tigris*), gibbon (*Hylobates concolor*), douc langur (*Pygathrix nemaeus*), sarus crane (*Grus antigone*), giant ibis (*Pseudibis gigantea*), white-shouldered ibis (*Pseudibis davisoni*), white-winged wood duck (*Cairina scutulata*), several lophura pheasants (*Lophura spp.*), crested argus (*Rheinardia ocellata*), crocodile (*Crocodilus siamensis*), and python (*Python molurus*).

Vietnam is located in a region of the world that has yet to be studied systematically, which explains why many interesting species have only recently been discovered. These include four large mammals (*Megamuntiacus vuquangensis*, *Pseudoryx nghetinhensis*, *Muntiacus truongsongensis*, *Nesolagus temminsi*) and four new bird species (*Lophura hatinhensis*, *Garrulax ngoclinensis*, *Actinodura sodangorum*, *Garrulax kongkakingensis*).

Wartime damage

During the Vietnam War, over two million hectares of southern Vietnam's total land area were damaged by various combinations of defoliants, high-explosive munitions, napalm, and land-clearing tractors. The inland tropical forests were especially hard hit. Many animals, including mammals and birds, were killed directly or indirectly by these weapons.

However, the most serious impact was the destruction of ecosystems—including the contamination of soil and water by dioxin and other

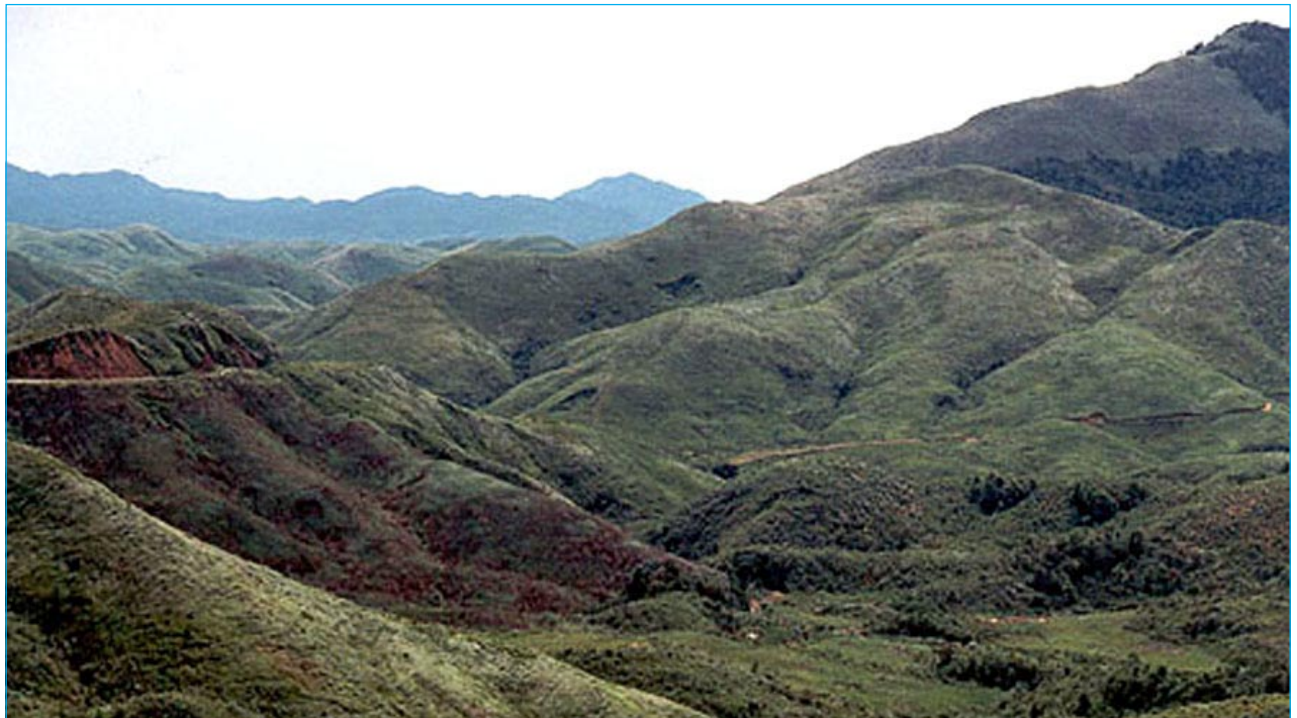


Photo: Hatfield Consultants Ltd.

The massive destruction of forests resulted in the disappearance of vital habitats for many animal species. An extensive reforestation program has been implemented since the end of the war. But to plant thousands of hectares of forest is not a simple matter in areas where the soil has been leached and compacted, and where the former life-giving microclimate has been altered by loss of tree cover. In the upper right corner can be seen a small remnant of the original, natural forest.

toxic chemicals— which had provided habitat for forest animals.

Initial investigations showed that forest ecosystems in many of the areas that were repeatedly sprayed were completely destroyed. This includes the dense forests in Ma Da, Phu Binh, Sa Thay, A Luoi, and those along Route 19, which have been replaced by persistent grasses of little value.

Almost three decades have now elapsed since the end of the war, but there are as yet no indications that the destroyed habitats are regenerating naturally. The animal populations are sparse, and very different from those before the war. Thus, the chemical anti-plant agents employed by the United States disrupted natural conditions, converting rich forest ecosystems of great biodiversity into exhausted remnants. Due to the loss of their habitats, many animal species,

especially the larger mammals and birds, have become rare or endangered; some are on the verge of extinction.

Postwar activities

Studies have been conducted of natural habitats and the wildlife they support, both in areas that were subjected to military action and in other areas that were not. This has made it possible to evaluate the impact of the war in, for example, Ma Da, Binh Phuoc, the Tay Nguyen high plateau, the Aluoi Valley and the mangroves of the Mekong Delta.

Immediately following the war, the Vietnamese people began an ambitious tree-planting program to regreen the war-scarred land, starting with the mangrove forests and then moving inland. To plant thousands of hectares of forest is not a simple task— especially in areas where the

ENDANGERED SPECIES OF VIETNAM

Among the endangered birds and mammals of Vietnam are these 21 species:

Douc langur	<i>Pygathrix nemaeus</i>
Delacour's langur	<i>Semnopithecus francoisi delacouri</i>
Tonkin snub-nosed monkey	<i>Rhinopithecus avunculus</i>
Malayan sun bear	<i>Ursus malayanus</i>
Clouded leopard	<i>Neofelis nebulosa</i>
Tiger	<i>Panthera tigris</i>
Indochinese eld's deer	<i>Cervus eldii</i>
Kouprey	<i>Bos sauveli</i>
Gaur	<i>Bos gaurus</i>
Asian elephant	<i>Elephas maximus</i>
Javan rhinoceros	<i>Rhinoceros sondaicus</i>
Vietnamese pheasant	<i>Lophura hatinhensis</i>
Milky stork	<i>Mycteria cinerea</i>
Lesser adjutant stork	<i>Leptoptilos javanicus</i>
Greater adjutant stork	<i>Leptoptilos dubius</i>
Black ibis	<i>Pseudibis papillosa</i>
Giant ibis	<i>Thaumatibis gigantea</i>
Imperial pheasant	<i>Lophura imperialis</i>
Edward's pheasant	<i>Lophura edwardsi</i>
Green peafowl	<i>Pavo muticus</i>
Crested argus	<i>Rheinartia ocellata</i>



Douc langur



Vietnamese pheasant



Crested argus



RECENT DISCOVERIES

Much of Vietnam remains relatively unexplored. It was only recently that scientists discovered these two large mammals: *Pseudoryx nghetinhensis* (above) and *Megamuntiacus vuquangensis* (right).

soil has been leached and compacted, and where the formerly cool, moist, life-giving microclimates have become hot and dry due to loss of forest cover.

Great efforts have also been made to select and establish a wide range of nature reserves in order to protect most major types of wildlife habitat remaining in the country after the war. There are now over one hundred conservation sites with a combined area of approximately two million hectares, representing six percent of Vietnam's total land area; these include fourteen national parks, a Ramsar wetlands site, and a UNESCO biosphere reserve. The last-named is the Can Go mangrove forest; it was completely destroyed by herbicides during the war, but has now been successfully rehabilitated.

Research priorities

Surveys of areas affected by herbicides in order to monitor natural conditions, long-term effects on animal life, and the gradual re-establishment

of animal species. Such surveys are also needed for restoration and land-use planning.

Systematic surveys of flora and fauna in dense primary forests that were not sprayed with herbicides.

Development of appropriate methods for the management of those areas that have been selected for special protection in order to preserve their ecosystems and endangered species.

Needed corrective measures

Environmental restoration in areas that have been seriously affected by herbicides.

Clearing of landmines and other UXO, especially in areas occupied by minority groups.

Helping minority groups to improve their living standards in order to reduce the pressures they now exert on forests and endangered species.

Training of young scientists in habitat restoration and in the conservation of ecosystems, flora, and fauna

— Vo Quy



Photos: E.W. Pfeiffer

Before and after: results of herbicide-spraying on mangroves of Mekong Delta.

COASTAL ECOLOGY

Vietnam has 2,300 kilometers of coastline along the South China Sea and Gulf of Thailand. There are two main deltas, those of the Red River in the north and the Mekong River in the south. The midsection of the country has a rocky or sandy shoreline along the steep slopes of the Truong Son Mountains.

The northeast monsoon creates ocean movements that draw the warm waters of the Japan Current into the South China Sea. The monsoon also carries the north's cool autumn and winter climate southward to Hai Van Pass in Da Nang Province. South of Da Nang, the northeast monsoon results in the dry season, and the intrusion of additional saltwater into estuaries. However, there are no low temperatures to set in motion any vertical circulation of inland waters (autumn overturn).

The southwest monsoon brings a rainy season that lasts for over half the year. This is a time of water runoff and the most rapid vegetation growth in wetland forests, upland tropical forests, and on croplands.

In combination with upstream snowmelt, the rainwater runoff results in annual flooding of the delta floodplains, and greatly expands the Mekong River's discharge plume into the sea. At the interface where freshwater mixes with saltwater, soluble humic-acid matter forms into small particles that provide an abundant source of food for the young of fish, shrimp, and filter-feeders such as shellfish.

In the northern part of the country, the earthen dikes built to prevent flooding by the Red River have for centuries prevented sedimentation on the floodplains. The riverbed is filling

up with silt, and the construction of Dinh Vu Dam some twenty years ago has accelerated the sedimentation of Haiphong harbor. The planting of mangroves on coastal wetlands and of Australian pine (*Casuarina equisetifolia*) on sand dunes is now being promoted on suitable sites. Recently, the market economy has created strong demand for the cultivation of tiger shrimp (*Penaeus monodon*).

In the south, the mangroves form a tidal zone on the fringe of the Mekong Delta, while the rear mangroves occupy the inland swamps. These alternate with barren sand bars that are the remnants of previous stages in the seaward sedimentation process.

Rice cultivation is the principle agriculture of Vietnam, and the best growing conditions are on the high tidal flats. With increasing population pressure, the rice fields have been expanding onto the low tidal flats, into the rear mangroves along their less flooded fringes, and along the inland border of the mangroves where there is freshwater during the rainy season.

Houses and fruit-tree gardens have been established on natural riverbanks and on artificial levees along canals. The construction of canals, gates, and dams for new rice fields prevents the natural intrusion of saltwater. The recent large-scale investment in shrimp-farming in brackish water has led to the disruption of coastal ecosystems in general, and of tidal ebb and flow in particular.

For the past 300 years, canals have been built to connect the nine branches of the Mekong Delta with adjacent rivers in order to form a network of waterways for transportation, as well as

an irrigation and drainage system for agriculture. The inward tidal flows create “no-flow” points within the network of waterways.

In the wetland depressions, the no-flow sites have functioned as natural nurseries where particulate matter and juvenile marine organisms collect. Now, the no-flow sites are also collecting pollutants from upstream sources and the residue of oil spills from offshore tanker accidents.

The annual rainy season of eight months is the prime time for juvenile marine organisms to migrate to their nurseries in the brackish pools of the mud flats and lagoons, and for mature individuals to move toward their spawning grounds offshore.

Wartime damage

The military defoliation of inland regions during 1961-1971 damaged or destroyed huge areas of upland forest in the river drainage basins, leading to extensive soil erosion. Dioxins and other pollutants from the entire Mekong River watershed ended up in sediments deposited in the wetland and rear mangroves of the estuaries.

Military defoliation operations along the coast during that period completely destroyed about 41 percent of the true mangroves, and about 14 percent of the rear mangroves. This had the effect of rapidly increasing the amount of organic matter and other detritus in the brackish tidal pools where marine organisms establish their nurseries.

The denuded wetlands became free-fire zones during the war, thus denying the local populace access to their traditional natural resources and small-scale rice production, while at the same time leading to steady deterioration of coastal habitats, in general. An alternate source of income was soon discovered in the harvesting

of brackish-water shrimp, which had become more abundant due to the increased supply of detritus. Local residents began to impound small pools of water to increase production, but this also impeded the natural ebb and flow.

With the tree canopy removed, clam populations in mud flats were exposed to direct sunlight and died off. They were replaced by populations of *Upogebia* spp., a type of shellfish whose burrow has a mound of mud around the entrance. On these slight elevations above the water surface grows the giant fern, *Acrostichum aureum*, which acts as a sediment trap. In this way, the mud flats that once served as nurseries for the juveniles of marine organisms rapidly fill up with sediment. This appears to be an irreversible degeneration of the habitat.

Generally, the loss of nurseries for marine organisms along Vietnam’s entire seacoast with the South China Sea has led to reductions in populations of marine fishes. The loss of valuable resources from the estuaries has led to overexploitation by the local populace, which in turn has impeded the regeneration of mangroves and thereby aggravated problems of poverty and hunger. Many individuals and families thus affected have migrated to the cities, where they have settled as squatters along the canals. Their marginalization in this era of globalization is a tragedy for them and a severe impediment to urban development.

Postwar activities

Soon after the war, the local populace began to harvest the trunks and roots of dead trees to sell as firewood. The demands on coastal lands were substantial: rice fields were established wherever possible; evaporation saltbeds were established on barren land; and *Rhizophora* mangroves were



Photo: E.W. Pfeiffer

Mangrove after spraying.

replanted on tidal mud flats. Natural regeneration of pioneer plants occurred along river banks, especially in rivermouth sediments.

The depleted monkey population recovered naturally, and small clupeid fishes returned to spawn. In the 1980s, the farming of peneid shrimp in the Rung Sat mangroves was expanded by enlarging the water impoundments in tidal inlets. This has had the effect of further reducing the available amount of mangrove habitat, which is essential to the welfare of numerous land and marine organisms, including both freshwater and saltwater fish. The decline of the estuaries' natural resources on which the local people depend has led them to overexploit the mangroves, and the expansion of aquaculture may have destabilized the local microclimate.

The largest of several new reservoirs was formed in 1986 by the Tri An electric power dam, which altered both natural downstream flows and the pattern of saltwater intrusions. This resulted in the disruption of ecosystem relations between salt and freshwater, vegetation, and animal life in the tidal flats. From the Rung Sat estuaries, the spring-tide fish run was nearly depleted at the Soai Rap outlet. There has been a steady decline of natural seeding of fish from the sea.

New techniques for treating polluted brackish waters and managing the hatching of tiger shrimp larvae have led to a huge expansion of semi-intensive shrimp-farming in mangroves—and even on sandy barren lands along the rocky coasts of central Vietnam.

Since 2001, shrimp-farming in the Mekong Delta has been increasing steadily and is expected to extend over 700,000 hectares by 2005. Since their inception a decade ago, shrimp hatcheries have been contaminating the waters of Nha Trang with bacterial and virus diseases. Epidemic shrimp diseases covering areas larger than 20,000 hectares are now often reported. Such diseases have occurred in the rear mangroves, and have been attributed to the leaching of insecticides originating from rice fields. Epidemic shrimp diseases are also occurring in mangrove areas dominated by semi-intensive farming.

During the past three years, significant damage has been caused by altered flood cycles and water levels, in both the Mekong Delta and the estuaries of the smaller rivers which empty into the sea along the central coast of Vietnam. Typhoons associated with *El Niño* have led to heavy flooding of deforested upstream areas in the Truong Son Mountains, and also to large-scale coastal erosion.

Research priorities

Monitoring the watersheds of shorter rivers in central Vietnam in order to provide a scientific basis for minimizing typhoon-related flood damage and coastal erosion.

Monitoring the entire lower basin of the Mekong River, especially the wetland forests with brackish-water fish nurseries, in order to provide a scientific basis for achieving sustainable use.

Determining the capacity of Cambodia's great Tonle Sap Lake to serve as a flood-control reservoir and as a sanctuary for inland freshwater fish.

Determining the persistence of dioxins and polychlorinated biphenyls (PCBs), and their accumulation in food chains.

Interdisciplinary research with emphasis on restoration and development of affected ecosystems.

Needed corrective measures

Empowerment of stakeholders, including those who have been displaced by the deterioration of natural ecosystems.

Restoration programs, including the design and implementation of new techniques to minimize the negative effects of shrimp-farming for global markets, and education of the local populace to avoid overexploitation of remaining resources.

Restoration of the natural nurseries of marine organisms in tidal wetlands as a complement to current emphasis on restoration of vegetation.

— *Bui Thi Lang*

CONCLUSION

Alterations of the earth's ecosphere are part of an ongoing process that is increasingly influenced by human activities, of which warfare is among the most destructive. Its negative impact is reflected at virtually all levels of evolution— from simple one-celled organisms to higher plants and human beings.

The concept of “ecocide” was a product of the Vietnam War. In addition to the human suffering it inflicted, the destruction caused by the war to plants, animals and their habitats was unprecedented in scale and intensity. Much of that destruction resulted from the intentional targeting of ecosystems that were thought to provide shelter and support to opposing forces.

These military attacks on the environment, which were conducted on a massive scale for many years, was highly systematic and led to the destruction of entire ecosystems in large areas of

Vietnam. Among the means employed were high-explosive munitions, napalm, landmines, chemical herbicides, mechanical land-clearing, and even cloud-seeding. They all resulted in immediate and long-term impacts on the soils, nutrient balance, hydrological regimes, plants, animals, and perhaps even the climates of Cambodia, Laos and Vietnam.

Perhaps the most profound ecological impact was on the forests of Vietnam. The loss of a significant proportion of southern Vietnam's forest cover triggered a number of related effects. For example, loss of timber led to reduced sustainability of ecosystems, decreases in the biodiversity of plants and animals, poorer soil quality, increased water contamination, heavier flooding and erosion, increased leaching of nutrients and reductions in their availability, invasions of less desirable plant species (primarily woody and herbaceous grasses), and possible alterations of both macro- and microclimates. Chemical agents used during the war also had devastating impacts on the agricultural sector, especially rice cultivation, and on fisheries— in the latter case, primarily through destruction of vital mangroves.

The environment of Vietnam is struggling to recover from the effects of these human interventions. Understanding the causes of environmental degradation is an important challenge that involves both wartime and postwar factors. For example, the illegal logging taking place today poses a significant obstacle to the development and maintenance of a strong, ecologically sustainable forestry sector. There is a need for monitoring and control mechanisms that will support and encourage environmental sustainability in combination with sound economic development.

Cycle of poverty

A significant proportion of the Vietnamese population is trapped in a cycle of poverty which is aggravated by environmental degradation, widespread health problems, rapidly increasing numbers and unfavorable economic conditions. These factors are strongly linked to the Vietnam War and its persistent consequences.



Photo: Dave McCracken

Tens of millions of hand and rifle grenades, mines, mortar shells and other UXO remain in the landscape, posing a constant threat to all life, and eliminating large areas of valuable land from production.

Restoration of the war-ravaged environment is a matter of particular urgency, since well-functioning ecosystems are essential to human health and the reduction of poverty. With regard to just one long-term consequence of the war, Alastair McAslan has observed that, "It is now universally recognized that mine action is not just about de-mining; it is about reducing the social, economic and environmental impact of mines. It is about people and societies, and their interaction with land contaminated by mines and UXO."

The dangers of landmines, other UXO and chemical contamination have effectively removed large tracts of valuable land from production. Ecosystems damaged by the war are no longer able to support local communities, which have thereby become impoverished.

In many areas, for example, application of herbicides has transformed what were once rich triple-canopy forests into grasslands of little economic or ecological value. With the forest cover removed, erosion has become widespread and the resulting landslides often block transport routes to markets, further aggravating the cycle of poverty.

Death and injury caused by landmines and other UXO can have devastating repercussions, especially when the victims are family breadwinners. Trauma, anxiety and other disorders all combine to intensify the grip of poverty on individuals, families and communities. So do the effects of contaminated food and water, malnutrition and disease. The close relationship between poverty and ill health is well-established.

Breaking this war-related cycle of poverty is crucial to the well-being of the present and future generations of Cambodia, Laos and Vietnam. It is an enormous task that will require substantial resources, long-term commitments, and corrective measures that are sensitive to both social and cultural factors.

There is also a need for research in a number of areas to provide a solid basis for suitable programs of preservation and restoration. Among the highest priorities for future research are: the collection and assessment of ecological data from the wartime period; comprehensive surveys of the flora and fauna in relatively untouched areas and comparable surveys in war-impacted areas; reforestation alternatives; agricultural assistance; studies of watersheds, flooding and erosion; fisheries enhancement; and the chemical contamina-



Photo: Hatfield Consultants Ltd.

tion of food resources which may be linked to specific Agent Orange "hot spots", such as those associated with some former U.S. military installations, emergency dump sites and spray-plane crash sites.

Needless to say, such research priorities must be meaningfully related to corrective measures for habitat rehabilitation, clearing of landmines and other UXO, improvements in the living standards of local populations, reforestation, soil stabilization, and the restoration of aquatic habitats with their associated organisms.

Finally, it is essential that those who are most directly affected by the long-term consequences of the Vietnam War be provided with sufficient resources to understand and implement programs for healing and restoring the ravaged environment. Only in this way will it be possible to overcome the terrible legacy of the war.

— L. Wayne Dwernychuk

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SUBCOMMITTEE ON ECOSYSTEMS

Dr. Arthur H. Westing

Dr. Westing is a forest ecologist who was among the first to study the environmental effects of the Vietnam War on the forests and fields of the then south Vietnam and is regarded as a pioneer in the field. In the course of that work during the 1970s, he became familiar with the ecological and public health implications of the chemical deforestation program. He now operates an environmental consultancy firm in the United States, but has followed developments in Vietnam since the days of his field work there.

Phung Tuu Boi

Mr. Boi is Director of the Nature Conservation and Community Development Center in Hanoi, and is also on the staff of the Forest Inventory and Planning Institute (FIPI). For the past three decades, he has studied the effects on forests of herbicides and defoliants used during 1961-1971 in the Vietnam War. He has also prepared forest development plans for sprayed areas in southern Vietnam.

Prof. Vo Quy

Professor Quy is currently President of the Center for Natural Resources and Environmental Studies at the National University of Vietnam in Hanoi. An ornithologist by training, "the smiling professor" began studying the effects of massive defoliation on the forest ecology of southern Vietnam during the war. Since then, he has played a leading role in a national program to conserve natural resources and promote biological diversity.

Dr. Bui Thi Lang

A forester's daughter who grew up in the wetland and upland forests of southern Vietnam, Dr. Lang is a marine biologist who played a key role in wartime studies of defoliation which established the presence of dioxin contamination in fish and mothers' milk. She has also led major studies of coastal mangrove swamps and the wetlands of the Mekong Delta. In addition, she has worked with social scientists on studies of urbanization, ecological problems and sustainable development in marginal housing areas along the tidal canals of Ho Chi Minh City.

Dr. L. Wayne Dwernychuk

Dr. Dwernychuk is an environmental scientist with Hatfield Consultants Ltd. in Canada (HCL), and has been actively involved in that organization's studies on the effects of Agent Orange and related issues in Vietnam. That work has included sample-collection in Vietnam, serving as principal technical author of two HCL reports on Agent Orange impacts, and publication on Agent Orange/dioxin in the scientific journal, *Chemosphere* (see References).

LONG-TERM CONSEQUENCES OF THE VIETNAM WAR

ECOSYSTEMS

The Vietnam War included an unprecedented assault on the environment. Vast quantities of bombs, cluster bombs, napalm, landmines, toxic chemicals, etc. have had lasting effects on soils, water systems, biological diversity, and perhaps even climate. Life forms at many levels of the evolutionary scale have been significantly affected, from primitive plants and animals to human beings.

The damage to the environment was so intense and widespread that it gave rise to the term "ecocide". Nearly three decades later, many of the affected ecosystems have still not recovered. The long-term consequences include loss of habitat and biological diversity, severe and persistent problems of public health, enormous economic losses, and severe constraints on human development.

This report to the Environmental Conference on Cambodia, Laos and Vietnam analyzes those consequences, suggests priorities for future research, and proposes a variety of measures to deal with the continuing aftermath of the war.

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