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Arthur H. Westing

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Arthur H. Westing*

The Environmental Aftermath of Warfare in Viet Nam[†]

INTRODUCTION

The Second Indochina War of 1961–75 is noted for the widespread and severe environmental damage that was inflicted upon its theatre of operations, especially in the former South Viet Nam.¹ This article reviews the character and extent of the initial ecological disruption brought about by military actions (primarily those during the late 1960s and very early 1970s) and describes the nature and pace of recovery and some of the related reconstruction efforts made during the first five or so postwar years. The emphasis is upon Viet Nam and especially upon the former South Viet Nam, the region which was most severely disrupted from an environmental standpoint.

As far as is possible, the present analysis dwells upon the natural environment and renewable natural resources. One must recognize, however, that the region in question has long been a heavily populated one, supporting an agrarian society that depends for its survival upon exploiting the natural resources of the region on a continuing basis. The natural and human environments are thus inextricably intertwined there, and matters of postwar recovery and reconstruction must often be treated in tandem.

After briefly describing the land and population of Viet Nam and the strategy and consequences of the Second Indochina War (including a minor digression on dioxin), this article reviews the postwar status of Viet Nam's major renewable natural resources: inland forests, coastal mangroves, fisheries, wildlife, and food and industrial crops. In conclusion, we examine the lesson to be learned from the Viet Nam debacle.

The Land and Population of Viet Nam

Viet Nam is a mountainous country dominated by two powerful rivers, the Red River in the north, and the Mekong River in the south. Two deltas and the narrow coastal plain that connects them are devoted in

*Senior Research Fellow, Stockholm International Peace Research Institute, and Adjunct Professor of Ecology, Hampshire College, Amherst, MA.

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1. See Westing, *Ecological Consequences of the Second Indochina War*, 1976 SIPRI Y.B. (1976). See also, Westing, *Warfare in a Fragile World: Military Impact on the Human Environment*, 1980 SIPRI Y.B. (1980).

large part to rice cultivation. Overall, some 25 percent of Viet Nam's land surface is in agricultural use; about 67 percent is considered forest land; and perhaps 1 percent is covered by inland waters. Table 1 summarizes land disposition in the country.

The population of Viet Nam in 1981 was approximately 55.0 million, and growing rapidly (see Table 2). There are three large cities—Ho Chi Minh City with 3.4 million inhabitants, Hanoi with 2.6 million, and the nearby port of Haiphong with 1.3 million—and various smaller ones. Nonetheless, an estimated 81 percent of Viet Nam's population is rural, and most of these people are farmers. Approximately 88 percent of the total population is ethnically Vietnamese, living mostly on the deltas or coastal plain, whereas the remaining 12 percent belong to some sixty

TABLE 1
Land Disposition in Viet Nam, 1979^a

Category	Area (million ha)	Percentage of Total Land Area
Agriculture	8.4	25
Rice (paddy and upland)	5.5	17
Other cereals (maize, etc.)	1.4	4
Other foods	1.0	3
Annual industrial crops	0.3	1
Rubber	0.1	0
Other perennial industrial crops	0.1	0
Savanna and pasture	2.0	6
Forest ^b	22.0	67
Inland	21.4	65
Coastal	0.6	2
Miscellaneous land	0.3	1
Inland waters ^c	0.4	1
Total^d	33.1	100

^aViet Nam General Statistical Office, *Statistical Data of the Socialist Republic of Viet Nam 51-79* (1979); Socialist Republic of Viet Nam: *Basic Data 51, 68* (Foreign Languages Publishing House 1978); Umbrecht, Lankester, & Pantulu, *supra* note 11, at 132; FAO, *FAO Production Yearbook 52* (1979); and V. Lap, *Vietnam: Geographical Data* (1979).

^bThe forest category includes 2.1 million ha of lands not at present covered by trees (14 percent of the forest category and 9 percent of all Viet Nam). It also includes 11.1 million ha of commercial forest.

^cInland waters include 0.1 million ha devoted to pisciculture. Viet Nam General Statistical Office, *supra* item a, at 51.

^dNorth Viet Nam, 15.8 million ha; South Viet Nam, 17.3 million ha. *Id.* at table 1.

different and more or less primitive, ethnically distinct tribes largely living a semi-nomadic existence in the mountains.²

Viet Nam was under French colonial domination and exploitation from the mid-19th century to 1954; was under harsh and even more intensely exploitative Japanese occupation from 1940 to 1945; fought a vicious and draining war of independence from 1946 to 1954; soon again a devastating war from 1961 to 1975; and has had a number of disrupting military involvements since then. The result of a century or so of exploitation, capped by its recent environmental holocaust, is that Viet Nam

TABLE 2
The Population of Viet Nam

Year	Total ^a (million)	Rural ^b (million)	Percentage Rural of Total	Ho Chi Minh City (Saigon) ^c (million)
1960	30.0 ^d	25.5	85	1.4
1975	47.6 ^e	37.4	79	4.2
1976	49.2	39.0	79	3.6
1977	50.4	40.3	80	3.5
1978	51.4	41.3	80	3.5
1979	52.5 ^f	42.4 ^g	81	3.4
1980	53.7			
1981	55.0			
1982	56.3			

^a1960 data from G. HUNG, ECONOMIC DEVELOPMENT OF SOCIALIST VIETNAM 1955-80, at 4-5 (1977); 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM 15 (1979); the values for 1980-82 are extrapolations from the 1979 datum, using a continuous compound growth rate of 2.4 percent (based on the populations for 1975-79) which leads to a doubling time of 29 years (see also item f *infra*). An estimated one million persons emigrated from Viet Nam during 1975-80. Fraser, *Vietnam's First Census*, 8 INTERCOM 8 at 8 (1980).

^b1960 datum based on 85 percent of total estimate. N. VIEN, VIETNAM: FIVE YEARS AFTER 7 (1980); 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, *supra* item a, at table 3.

^c1960 datum interpolated from 2 EUROPA Y.B. 1962 at 1369 and 2 EUROPA Y.B. 1963 at 1194; 1975 datum from UMBRIGHT, LANKESTER, & PANTULU, *supra* note 11, at 90; 1976-79 data from VIET NAM GENERAL STATISTICAL OFFICE, *supra* item a, at 7 (1976); 12 (1977); table 1 (1978); and 11 (1979).

^dNorth Viet Nam, 15.9 million; South Viet Nam, 14.1 million. G. HUNG, *supra* item a.

^eNorth Viet Nam, 24.3 million; South Viet Nam, 23.3 million. DEMOCRATIC REPUBLIC OF VIET NAM 12 (Foreign Languages Publishing House 1975). The growth in population for all Viet Nam during 1960-75 can be calculated to have continuously compounded at the rate of 3.1 percent (doubling time of 22 years).

^fNorth Viet Nam, 26.3 million; South Viet Nam, 26.2 million. VIET NAM GENERAL STATISTICAL OFFICE, *supra* item a, at table 1. The 1975-79 growth rate for North Viet Nam can be calculated to have been 2.0 percent (doubling time 35 years); for South Viet Nam, it was 2.9 percent (doubling time 24 years); for all of Viet Nam, see item a, *supra*. An estimated 41 percent of the population of Viet Nam is under the age of 15 years. Fraser, *Notes on Population and Family Planning in Vietnam*, 25 J. FAMILY WELFARE No. 3, at 71 (1979). Over one percent of the population is in the armed forces. See *supra* note 4, U.S. ARMS CONTROL AND DISARMAMENT AGENCY, at table 2.

^gOf the rural population, 37.6 million, or 88 percent, were engaged in agriculture in 1979 (i.e., 71 percent of the total population). Fraser, *supra* item a, at 9. More than 300,000 of the rural population are engaged in fishing. U.N. DEVELOPMENT PROGRAMME, *supra* note 5, at 6.

2. SOCIALIST REPUBLIC OF VIET NAM: BASIC DATA 39 (Foreign Languages Publishing House 1978).

today stands among the poorest and least economically developed nations in the world. Its renewable natural resource base has been devastated, its infrastructure severely disrupted, and its overall economy shattered. In South Viet Nam there was additionally a dearth of able leaders and other administrators at the end of the Second Indochina War, owing to their systematic assassination by the United States as a part of its so-called Phoenix Program.³ Its largely agrarian society must cope with an agricultural and associated water conservancy system that was widely damaged by a combination of military actions and forced abandonment and neglect. As a result, Viet Nam is now only about 85 percent self-sufficient in staple foods, and its gross national product per capita is below \$300 (1980 value).⁴ In the words of a recent United Nations report, “. . . almost everywhere there is a lack of equipment, spare parts, and repair and maintenance facilities. As a result, it is almost impossible to provide basic everyday services reliably and properly; similarly, the productive capacity of industry is very low and continually deteriorating.”⁵

THE SECOND INDOCHINA WAR

The Second Indochina War of 1961–75 consisted of more or less distinct conflicts complicated by massive U.S. involvement. The ecological and related consequences of the war have been described elsewhere,⁶ and a number of very useful bibliographies are available.⁷

Strategy and Consequences

The Second Indochina War can be summarized as an unsuccessful attempt by the United States to prevent the government of the Republic of [South] Viet Nam from being replaced by the National Front for Liberation of South Viet Nam *cum* Revolutionary Government of South

3. HOUSE COMM. ON GOVERNMENT OPERATIONS, 92d CONG., 1st SESS., U.S. ASSISTANCE PROGRAMS IN VIET NAM 175–242 (1971).

4. See U.S. ARMS CONTROL AND DISARMAMENT AGENCY, WORLD MILITARY EXPENDITURES AND ARMS TRANSFERS 1969–78, ACDA PUBLICATION No. 108, Table 1 (1980). See also R. I. SIVARD, WORLD MILITARY AND SOCIAL EXPENDITURES at Table 4 (1980).

5. UNITED NATIONS DEVELOPMENT PROGRAMME, COUNTRY PROGRAMME FOR VIET NAM: UNDP ASSISTANCE REQUESTED BY THE GOVERNMENT OF VIET NAM FOR THE PERIOD 1982–1986, UNDP DOC. No. DP/GC/VIE/R.2 at 21 (1981).

6. Westing (1976), *supra* note 1, at ch. 3; see also, Westing, *Environmental Consequences of the Second Indochina War: a Case Study*, 4 *AMBIO* 216 (1975); Pfeiffer, *Post-War Vietnam*, 15 *ENVIRONMENT* 9 at 29 (1973); U.S. CHEMICAL WARFARE AND ITS CONSEQUENCES: DOSSIER (Vietnam Courier 1980); and VIET NAM: DESTRUCTION, WAR DAMAGE 23 (Foreign Languages Publishing House, 1977).

7. See R. BURNS & M. LEITENBERG, *WAR IN VIETNAM* (2d ed. 1983). See also, Westing, *Herbicides as Weapons: a Bibliography*, 3 *POL. ISSUES SERIES* 1 (1974); and Westing & Lumsden, *Threat of Modern Warfare to Man and His Environment: An Annotated Bibliography*, UNESCO REPORTS & PAPERS IN THE SOCIAL SCIENCES 40 (1979).

TABLE 3

Hostile Actions by the United States Against Viet Nam During the Second Indochina War^a

Region	Munitions Fired		Herbicides Sprayed		Land Cleared	
	(million tons)	(kg/ha)	(thousand m ³)	(l/ha)	(thousand ha)	(m ² /ha)
North Viet Nam	1.1	70	0	0	0	0
South Viet Nam ^b	10.2	590	72.4	4.2	325	190
Military Region I	3.3	1,170	12.3	4.4	70	250
Military Region II	2.1	270	15.2	2.0	50	60
Military Region III	4.3	1,430	38.4	12.7	200	660
Military Region IV	0.5	130	6.5	1.7	5	10
All Viet Nam	11.3	330	72.4	2.1	325	100

^aThe data are derived from SIPRI Y.B. (1976), *supra* note 1; munitions at Table 2.2; herbicides at Table 3.5; land cleared (by Rome plough tractors) at 46-50; and the regional areas from Table 1.1.

^bThe former military regions of South Viet Nam are depicted in SIPRI Y.B. *id.*, at chapter 4.

Viet Nam or, eventually, from being annexed by the Democratic Republic of [North] Viet Nam, with ancillary U.S. military involvement against Laos and Kampuchea.⁸ The U.S. strategy against North Viet Nam involved heavy bombing and naval shelling in order to destroy systematically industry, transportation networks, and all manner of public buildings.

The U.S. strategy against South Viet Nam involved truly massive rural area bombing, chemical and mechanical forest destruction, large-scale crop destruction, destruction of food stores, the destruction of hospitals, and large-scale population displacements—in short, the massive, intentional disruption of both the natural and human ecologies of the region (see Table 3).

The loss of life in Viet Nam during the war was enormous: an estimated 1.5 million Vietnamese were killed, representing 4 percent of the population (3 percent in North Viet Nam and 5 percent in South Viet Nam).⁹ Moreover, non-fatal casualties must have exceeded three times that number. Wartime population displacements in Viet Nam involved some 10 million people at one time or another, primarily in South Viet Nam (i.e., over half of its population).¹⁰

Of the major cities in North Viet Nam, Haiphong and essentially only the outskirts of Hanoi were bombed. All five of North Viet Nam's in-

8. Westing (1976), *supra* note 1, at 18.

9. *Id.* at 36.

10. Casella, *Dateline Vietnam: Managing the Peace*, 30 FOREIGN POLICY 170 (1978).

dustrial centers were demolished.¹¹ All 29 provincial capitals were bombed, and 12 of them razed; 96 of its 116 district capitals were bombed, and 51 of them razed; and about 2,700 of its 4,000 or so rural villages were bombed, and 300 of them razed. Virtually every railway and highway bridge was destroyed, as were many hundreds of public buildings. In the process, many hundreds of water conservancy works and irrigation dikes and much farmland and livestock were damaged or destroyed. Countless unexploded munitions remained at the end of the war, continuing to cause scores of casualties annually, many of them fatal.

About 9,000 of approximately 15,000 rural villages in South Viet Nam were damaged or destroyed, and millions of people were driven into Saigon, Danang, Hue, and other urban areas.¹² Saigon swelled from a prewar population of 1.4 million to 4.2 million (Table 2). When the war ended, South Viet Nam was burdened with more than 600,000 war orphans, several hundred thousand war widows, about 400,000 invalided war cripples, some 3 million unemployed, about 600,000 prostitutes, and an estimated 500,000 drug addicts.¹³ As in North Viet Nam, there remains a legacy in South Viet Nam of unexploded munitions that each year kill and maim scores of those who must work the land. Millions of South Vietnamese at the end of the war suffered from such serious ailments as malaria, tuberculosis, leprosy, bubonic plague, poliomyelitis, venereal diseases, and psychiatric disorders.¹⁴

Throughout Viet Nam, some 360,000 disabled war victims of laboring age (both military and civilian) currently receive governmental compensation, 140,000 of whom are totally disabled, and the remainder partially disabled.¹⁵ These numbers do not by any means represent all such war casualties. Moreover, throughout Viet Nam today 1.1 million war orphans, who have lost both parents, exist and many of them have nutritionally based and other disabilities. The number of rehabilitation centers in the country is far from adequate, and the available ones are understaffed with trained personnel and inadequately equipped.

Finally, the Second Indochina War resulted in massive damage to field and forest, especially in South Viet Nam, the subject of the following sections. This war was remarkable in that a great power attempted to subdue a peasant army through the profligate use of technologically ad-

11. N. K. VIEN, VIETNAM: FIVE YEARS AFTER 7 (1980). *See also*, VIET NAM: DESTRUCTION, WAR DAMAGE, *supra* note 6, at 28-31; and V. UMBRIGHT, C. LANKESTER, & V. PANTULU, REPORT OF THE SPECIAL MISSION ON INTERNATIONAL ASSISTANCE FOR THE RECONSTRUCTION OF VIET NAM 16 (1978).

12. UMBRIGHT, *id.* at 15-16. *See also*, VIEN, *id.* at 6-7, and VIET NAM: DESTRUCTION, WAR DAMAGE, *supra* note 6, at 23-27.

13. M. BJELIC, REPORT ON THE MISSION CONCERNING REHABILITATION OF WAR VICTIMS AND OTHER DISABLED PERSONS IN THE SOCIALIST REPUBLIC OF VIETNAM 5 (1978).

14. WORLD HEALTH ORGANIZATION, REPORT ON THE REPUBLIC OF SOUTH VIETNAM (1976).

15. BJELIC, *supra* note 13, at 5.

vanced weapons and techniques. A number of these weapons and techniques were inescapably anti-ecological, especially those employed against the land and people of South Viet Nam. The result in South Viet Nam was the widespread, long-lasting, and severe disruption of forest lands, of perennial croplands, and of farmlands, that is to say, of millions of hectares of the natural resource base essential to an agrarian society.

The Dioxin Question

During the Second Indochina War, a substantial quantity of dioxin (2,3,7,8-tetrachlorodiben/*o*-*para*-dioxin, or TCDD) was inadvertently disseminated into the South Vietnamese environment as an impurity of so-called Agent Orange, the most widely and heavily used of the several anti-plant chemical warfare agents employed by the United States.¹⁶ Dioxin is briefly singled out here owing primarily to its notoriety as a highly potent human toxin and teratogen, and its apparent mutagenic and carcinogenic effects on humans.

It is not possible to establish the exact quantities, locations, and dates of dioxin application. A conservative early estimate of the total quantity of dioxin applied was 110 kg,¹⁷ whereas a recent estimate based on somewhat more complete information is 170 kg.¹⁸ An estimated 90 percent of the dioxin was disseminated during 1966–69. It was applied to about 1 million hectares of South Viet Nam, approximately 90 percent as part of the anti-forest program. About two-thirds of the affected area received approximately 110 mg/ha of dioxin, although multiple applications caused some areas to be subjected to two to five times this amount. The several provinces surrounding Ho Chi Minh City, that is, the former Military Region III (including War Zones C and D and the Iron Triangle) received more than half the total amount.

The amount of dioxin that remains in the environment following application to an area diminishes with time, owing primarily to degradation and dissipation. About half the amount of aeri ally applied dioxin decomposes within a few days, with the remainder becoming more permanently incorporated into the ecosystem, that is, into the soil and biota.¹⁹ Once thus incorporated, dioxin's subsequent disappearance can be assumed to follow an exponential decay curve (i.e., follow first-order kinetics) and

16. See Westing (1980), *supra* note 1, at ch. 3. See also, Westing, *Ecological Considerations Regarding Massive Environmental Contamination with 2,3,7,8-tetrachlorodibenzo-*para*-dioxin*, 27 *ECOLOGICAL BULL.* 285 (1978).

17. Westing (1976), *supra* note 1, at 26.

18. A Young, unpublished lecture, U.S. Air Force (May 28, 1980).

19. Crosby, *Photodecomposition of Chlorinated Dibenzo-*p*-dioxin*, 173 *SCIENCE* 749 (1971); and Crosby & Wong, *Environmental Degradation of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD)*, 195 *SCIENCE* 1337–38 (1977).

is thus expressible in half-lives. On the basis of some published field data, this environmental half-life for dioxin has been calculated to be 2.9 years.²⁰ More recent field data²¹ permit a similar calculation to be made that gives a value of 3.5 years. In the case of Viet Nam, if one makes the simplifying assumption that the estimated 170 kg of dioxin had all been introduced in 1968, then perhaps 8 kg remained at large in 1980, 3 kg will be present in 1985, and 1 kg in 1990.

Dioxin is apparently non-toxic to plants and thus can be assumed to have had little if any effect on the natural or cultivated vegetation of Viet Nam. Moreover, in the amounts involved, its effect on indigenous wildlife populations appears at worst to have been transitory and, therefore, probably negligible. However, it is possible, if not likely, that occasional heavy localized applications of dioxin resulted in some wildlife and livestock losses, especially perhaps of poultry.²²

The question of whether the applied dioxin had a health impact on the indigenous human population of Viet Nam is still under active investigation there.²³ The possibility of long-term health effects on U.S. troops that had been exposed during the war is also a matter of continuing concern.²⁴ The fact that dioxin is mobile in the environment and can move up a food chain that culminates in humans, perhaps concentrating somewhat in the process,²⁵ lends credence to the possibility of dioxin-related human health problems in Viet Nam.

THE POST-WAR STATUS OF VIET NAM'S RENEWABLE RESOURCES

To a major extent, Viet Nam must depend upon the renewable natural resources that can be derived from its forests, fields, and waters (both inland and nearby ocean) for its industrial raw materials and as items for export in exchange for imported oil and other crucial basic commodities which the country lacks. The following sections summarize several major renewable resources.

Inland (Upland) Forests

Forest lands cover two-thirds of Viet Nam (Table 1) and trees must be counted among the nation's most important natural resources.²⁶ The for-

20. Westing, *supra* note 16, at 290.

21. Young, *supra* note 18.

22. Westing, *Herbicide Damage to Cambodia*, HARVEST OF DEATH: CHEMICAL WARFARE IN VIETNAM AND CAMBODIA 196-97 (J. NEILANDS, ed. 1972).

23. Hay, *Vietnam's Dioxin Problem*, 271 NATURE 597-98 (1978).

24. STAATS, U.S. GROUND TROOPS IN SOUTH VIETNAM WERE IN AREA SPRAYED WITH HERBICIDE ORANGE, USGAO REP. FPCD-80-23 (1979).

25. Westing, *supra* note 16, at 289.

26. UMBRIGHT, *supra* note 11, at 123-90; Westing, *Forestry and the War in South Vietnam*, 69

TABLE 4
Forestry and Forest Products in Viet Nam^a

Year	Sawnwood Production ^b (million m ³)	Sawnwood Per Unit Area ^c (m ³ /ha)	Sawnwood Per Capita ^d (m ³ /cap)	Paper Production ^e (thousand tons)	Lumber Export ^f (million m ³)
1960	2.5 ^g	0.23	0.083		
1975	1.3	0.11	0.026	42	0.00
1976	1.7	0.15	0.034	75	0.02
1977	1.7	0.15	0.033	71	0.05
1978	1.7	0.16	0.034	69	0.06
1979	1.8	0.16	0.033	54	0.07

^aIn addition to the timber (roundwood) removals, fuel wood (firewood plus charcoal) is cut at the annual rate of perhaps 0.36 m³/cap, i.e., for a nationwide total now of approximately 19 million m³/year, FAO, FAO YEARBOOK OF FOREST PRODUCTS 223 (1978); or perhaps somewhat more. See UMBRICH, LANKESTER & PANTULU, *supra* note 11, at 147. However, apparently only of the order of 2 million m³/yr of this is derived from Viet Nam's commercial forests. *Forestry and the War in South Vietnam*, *supra* note 26, at 780; and *Postwar Forestry*, *supra* note 26, at 154.

^b1960 datum combined from *Forestry and the War in South Vietnam*, *id.*, at 780, and *Postwar Forestry*, *id.*, at 154. 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM, table 19 (1979) and table 13 (1978).

^cBased on a commercial forest area of 11.1 million ha.

^dBased on population figures from Table 2.

^eFrom VIET NAM GENERAL STATISTICAL OFFICE, *supra* item b, at table 19 (1979) and table 13 (1978). A modest fraction of Viet Nam's paper is not derived from bamboo or other tree fibre.

^fFrom VIET NAM GENERAL STATISTICAL OFFICE, *supra* item b, at 86 (1979) and table 38 (1978).

^gNorth Viet Nam, 1 million m³; South Viet Nam, 1.5 million m³.

ests, which are divided more or less evenly between North and South Viet Nam, now provide the nation with almost 2 million cubic meters per year of timber plus large amounts of fuel wood (Table 4). This section deals with the inland (upland) forest, comprising 97 percent of the total, whereas the next section deals with the coastal mangrove forest, which accounts for the remaining 3 percent.

The inland forests of Viet Nam—11.1 million ha of which are considered to be commercially exploitable²⁷—support some 200 commercial species, a dozen or more of which are of exceedingly high quality and suitable for the world market.

Because of a variety of factors, the forests of Viet Nam are considered to be in generally poor condition. They were casually exploited for many

I. FORESTRY 777-83 (1971); Westing, *Letter to the Editor*, 70 J. FORESTRY 129 (1972); Westing, *Letter to the Editor*, 73 J. FORESTRY 755 (1975); Westing, *Postwar Forestry in North Vietnam*, 72 J. FORESTRY 153 (1974); Uibrig & Pfaff, *Zur Entwicklung von Waldinventur und Forstprojektion im Norden der Sozialistischen Republik Vietnam*, 11 BEITRÄGE FÜR DIE FORSTWIRTSCHAFT 75 (1977); and Thomasius II, *Wälder der Sozialistischen Republik Vietnam*, 124 PETERMANN'S GEOGRAPHISCHE MITTEILUNGEN 1, at 23 (1980).

27. Thomasius II, *id.* at Table 1, and Westing (1976), *supra* note 1, at 5.

decades during the French colonial period, and ruthlessly exploited by the Japanese during World War II. They were badly damaged during the Second Indochina War. Perhaps most importantly, they have been severely degraded as a timber resource by centuries of shifting slash-and-burn agriculture by Viet Nam's sixty or more primitive hill tribes. Recent population increases among these national minority groups and a declining area of land available to them have inevitably led to a slash-and-burn rotation too brief for adequate rejuvenation of the exploited land. An estimated 10,000 ha are cleared in this way in North Viet Nam each year,²⁸ and presumably as much again in South Viet Nam.

The almost 6 million ha of commercial forest in South Viet Nam were especially hard hit during the Second Indochina War by a combination of chemical attack, bombing, and tractor clearing (so-called Rome ploughing).²⁹ Over a period of about a decade, the United States expended about 10 million tons of high-explosive bombs, shells, and other explosives against South Viet Nam (Table 3). The damage that can be attributed to this assault on the rural reaches of South Viet Nam is best presented in two stages, complete obliteration, and severe damage. The first category consists of that land, to a very large extent forest, which was converted to craters by the high-explosive munitions. Such crater-obiterated areas add up to just over 100,000 ha, perhaps 1 percent of the entire South Vietnamese forest. Among many small artillery craters, an estimated 10 to 15 million large bomb craters were created in South Viet Nam, and these have for the most part become a semi-permanent feature of the regional geomorphology. The second category consists of that land which was subjected to flying metal fragments (shrapnel). The zone subjected to such abuse at an intensity lethal to 50 percent or more of exposed personnel amounts to almost 5 million ha, representing over 40 percent of the total forest lands of South Viet Nam. This last defined area is one in which many of the trees present were injured by shrapnel, an event that, in the tropics particularly, leads to fungal entry and decay, inevitably followed by a significant proportion of tree mortality.

The damage caused by chemical anti-plant agents to the forests of South Viet Nam is also best presented under two headings: virtually complete obliteration and partial damage.³⁰ The first category comprises the upland forest land that was sprayed four or more times. This category of virtual obliteration covers about 50,000 ha. The second category com-

28. Westing, *Postwar Forestry*, *supra* note 26.

29. Westing (1976), *supra* note 1. See also, UMBRICH, *supra* note 11, at 23-90; Bengtsson, *Ecological Effects of Chemical Warfare and Bombing in Vietnam*, R-3 SWEDISH AGENCY FOR RESEARCH COOPERATION WITH DEVELOPING COUNTRIES (1976); and C. MEYENFELDT, *RESTORATION OF DEVASTATED INLAND FORESTS IN SOUTH VIETNAM* (1978).

30. Westing (1976), *supra* note 1, at 24-45.

prises upland forests that were sprayed one to three times. This area has been calculated to cover some 1.3 million ha (12 percent of South Viet Nam's total forest). The first of these categories is estimated to have experienced between 85 and 100 percent tree mortality, whereas the second experienced between 10 to 50 percent.

The environmental disruption attributable to the 200 or so huge Rome plough land-clearing tractors is easy to summarize.³¹ This bizarre category of complete tree removal and topsoil disturbance amounted to some 325,000 ha, that is, approximately 3 percent of the total South Vietnamese forest lands.

Combining the several separate estimates of damage presented above by simple addition would inflate the extent of damage since some of the areas were subjected to more than one category of insult. The summations are therefore reduced by 10 percent to allow for such overlap. Thus, complete or essentially complete devastation of South Viet Nam's upland forests occurred to an estimated 417,000 ha, representing about 4 percent of its total forest lands. The partially damaged forest lands are estimated to have covered at least an additional 5.6 million ha, or just over half of forest land area.

In terms of primary forest products, the military damage described above has been estimated to have resulted in as much as 75 million m³ of destroyed timber, assuming that each hectare of commercial forest had an average prewar merchantable stocking of 90 m³.³² This amounts to about 14 percent of the standing merchantable timber crop of South Viet Nam, or to about 8 percent for all of Viet Nam. Moreover, with the assumption of a growth rate of 0.6 percent per year, it will take perhaps thirteen years for Viet Nam's 11.1 million ha of commercial forest to make up this loss without any concomitant harvesting, or, somewhat more realistically, about 40 years with continuing harvest of 4 million m³/yr (the approximate current value of timber plus fuel wood removals; see Table 4). The effects of particulate erosion and nutrient dumping (loss to the soil of nutrients in solution) will reduce the annual increment in the badly damaged areas, thereby extending the overall recovery period somewhat, as will increased removals. Conversely, artificial regeneration (planting) will shorten it.

In the upland forests of South Viet Nam which had been heavily damaged during the war, the land is now again fully occupied with vegetation except for some steep areas in which erosion and forest fires had exposed bedrock. The replacement vegetation is in many of the heavily damaged areas comprised almost entirely of herbaceous grasses and in others of

31. *Id.* at ch. 4, Table 1.1, and Map 1.2.

32. Westing (1980), *supra* note 1, at 83.

shrubby bamboos. Standing dead tree trunks, killed during the war, are still widely in evidence and regularly harvested, some for timber but mostly for fuel. In some parts of the country, for example in Tay Ninh province, large areas of destroyed forest have recently been or are in the process of being converted to agriculture as part of the new frontier or new economic zone program.

Viet Nam's prewar merchantable cut of 2.5 million m³/yr was reduced to just over half that level at the end of the war and has crept up only slightly since then (Table 4). This decrease has been in part the result of wartime decimation in highly accessible timber stands (e.g., in the former War Zones C and D) as well as of the destruction of forest industries, half of which were damaged or destroyed.³³ Lack of spare parts and fuel for logging, transporting, and milling equipment has further hampered postwar recovery of the industry. Moreover, unexploded munitions and craters have hampered logging considerably. The rural road system needed for timber transportation is in a bad state of repair. Metal fragments in the logs seriously impede sawmilling.³⁴ The increasing demands of a growing population for fuel wood and for some of the forest land itself for agriculture have also contributed to the reduced harvest.

Natural processes of forest growth and of ecological succession are helping to heal the wounds of war in Viet Nam's upland forests. Pioneer vegetation became established quite quickly in most of the heavily damaged areas, thereby arresting further erosion and nutrient dumping. However, the tenure of this pioneer vegetation of herbaceous or woody grasses which precedes the re-establishment of the desirable, dicotyledonous trees, is measured in decades. Artificial regeneration is thus often called for, despite the trouble and long-delayed return on investment involved. Indeed, even before the end of the war Viet Nam initiated a modest reforestation program of several thousand hectares per year, much of it to counter erosion brought on by bombing damage.³⁵ Today, a number of new nurseries have been established in both North and South Viet Nam in which some ten species of native and exotic trees, including teak and pine, are being raised for outplanting.³⁶ Current national plans call for the reforestation of 1.5 million ha and, according to one source, about 100,000 ha have been replanted annually since the end of the war.³⁷

In conclusion, the inland forests of Viet Nam are in rather poor condition today for a number of reasons. Shifting slash-and-burn agriculture

33. UMBRIGHT, *supra* note 11, at 129.

34. *Id.* at 152, and Westing, *Letter to the Editor* (1972) *supra* note 26.

35. Westing, *Postwar Forestry in North Vietnam*, *supra* note 26.

36. Kohlstock, *Erfahrungen und Schlussfolgerungen aus der Planmässigen Pflanzenanzucht für Grossflächige Kiernaufforstungen in der SR Vietnam*, 13 BEITRÄGE FÜR DIE FORSTWIRTSCHAFT 111 (1979).

37. Shehedrov, *Vietnam Looks Confidently to the Future*, 12 INT'L AFFAIRS 25 (1979), and Tram, *Tree Planting: An Example Set by President Ho Chi Minh*, 15 VIETNAM COURIER 8 (No. 9, 1979).

continues to be the nation's most serious forestry problem. The annually intensifying demand for fuel wood by a rapidly growing population and the need for an ever greater area of cultivated land are further serious threats to the integrity of this important renewable resource. The massive war damage to the inland forest from which it will take several decades to recover thus adds a substantial burden.

Coastal Mangrove Habitat

The mangrove habitat of Viet Nam covers about 400,000 ha (not including rear mangrove), more than three-quarters of it in South Viet Nam. In contrast to inland habitats, this extraordinarily productive estuarine habitat supports a relatively restricted biota. The plant species have in common the ability to become established and survive in a mucky soil which is periodically inundated with salt water. The dominant vegetation consists of several species of small dicotyledonous trees, most 3 to 15 m high and primarily in the genera *Rhizophora*, *Avicennia*, *Bruguiera*, and *Sonneratia*; the shrubby palm *Nipa* is also often in evidence. The vegetation in turn is home to a variety of birds, mammals, and other animals. This endlessly channel-dissected habitat is also of major importance as the breeding and/or nursery grounds for numerous salt-water and fresh-water fish and crustaceans; indeed, it serves this function for the majority of Viet Nam's offshore and river fish. The mangrove vegetation serves as well to stabilize the shoreline.

The mangrove habitat is of major regional importance as a source of small timbers for pilings and construction, firewood, charcoal (from *Rhizophora*), thatch (from *Nipa*), tannin (from *Ceriops* and *Rhizophora*), fish, crustaceans, honey, and other products.

During the Second Indochina War, an estimated 124,000 ha (or 41 percent) of South Viet Nam's mangrove habitat was utterly destroyed by chemical attack, mostly between 1965 and 1970. The anti-plant chemical warfare agents employed left this vast area virtually lifeless. In addition to the biotic carnage, these attacks permitted serious erosion to occur, both sheet erosion and shoreline erosion. There was some concern among the international scientific community in the early 1970s that biotic recovery would take more than a century.

Examination of the attacked mangrove areas in 1980, a full decade or more after their annihilation, revealed that some scattered patches of perhaps 5 to 50 ha in size have to date remained barren of vegetation. In the aggregate these bare patches amount to perhaps 5 to 10 percent of the zone of original destruction. The reason these patches have thus far remained bare is not altogether certain, although in at least some instances it may be the result of a modestly depressed elevation. Attempted replantings in these bare patches have proved unsuccessful, except where

the drainage has been improved by ditching and the patches have become naturally revegetated or at least amenable to planting.

A few small areas adjacent to undamaged *Rhizophora* stands (by far the most important of Viet Nam's mangrove species) have during the post-destruction decade become naturally revegetated with *Rhizophora*. Such natural regeneration appears to have occurred in about one percent of the destroyed zone. After the deactivation of unexploded munitions and the removal of existing vegetation, a further 10 percent of the destroyed area has now been replanted with *Rhizophora*. Present plans are for several thousand hectares per year to be planted for several more years. *Rhizophora* trees are ready for fuel wood harvest at an age of 30 to 40 years, at which time one tree yields 0.5 m³ of wood that can be converted to about 90 kg of top quality charcoal. A considerable scattering of *Nipa fruticans* has also been planted along channels in Minh Hai province as has a modest amount of *Cyperus* (two species) for use in basketry, the palm and rushes together certainly amounting to less than 1,000 ha.

Some 5,000 ha, or about four percent, of destroyed mangrove habitat has in recent years been converted to rice, and another few thousand hectares to other food crops.

The remaining 93,000 ha, or about 75 percent, of the originally destroyed mangrove habitat became occupied by a variety of low-growing and locally undesirable plant species within a few years of being denuded. It is assumed that it will take one or more decades before the present vegetation over this large area begins to give way to any considerable extent to the desirable *Rhizophora* species, and even longer in the contiguously large destroyed areas unless, of course, expensive artificial regeneration is resorted to.

Inshore ocean fishing, out no further than 12 to 15 km off the destroyed mangrove areas, has reportedly continued to decline during the past decade. Indeed, the recent overall decline in Viet Nam's marine fishery is attributed in part to the loss of mangrove habitat. Clams disappeared in the destroyed mangrove areas and have returned only—and in reduced numbers—in those areas in which *Avicennia* or *Rhizophora* has become established.

With about one-third of it literally destroyed, the mangrove habitat was the ecological system in Viet Nam most seriously affected by the Second Indochina War. Moreover, subsequent conversion to agriculture and other uses can be expected to more or less permanently reduce Viet Nam's mangrove habitat, perhaps by 10 percent. The question thus arises to what extent such long-term shrinkage will lead to special extinctions. The number of species within any particular taxon that an isolated habitat can support is related to its area. If a habitat is reduced in size, as was the

case with Viet Nam's mangroves, the resulting excess of species will in due course die out.

Prewar data on species numbers are not on hand for Viet Nam's mangrove habitat. Literature on comparable habitats in parts of the East Indies,³⁸ and the Galapagos³⁹ allows us to estimate that a 10 percent reduction in Viet Nam's mangrove habitat is likely in time to lead to four percent and three percent reductions respectively in the number of bird and plant species that can be supported. If any of the species lost from the area are endemic ones they will, of course, be lost to nature.

In conclusion, roughly one-third of Viet Nam's total mangrove habitat has been lost for perhaps half a century or more, and is thus unavailable throughout this protracted period for exploitation for charcoal and other products so crucial to a growing population and a struggling economy.

Fisheries

The marine and inland fishery resources of Viet Nam provide an important source of protein-rich food.⁴⁰ Perhaps 75 percent of the catch is consumed as fresh fish, 5 percent as dried fish, and the remaining 20 percent in the form of fish sauce. Viet Nam has close to 350,000 fishermen, 70 percent of whom are engaged in ocean fishing.

The annual marine catch increased for a brief period following the Second Indochina War, owing to an upsurge of fishing activity (Table 5). The catch has, however, been declining in recent years, partly due to wartime damage to the mangrove breeding and nursery grounds. Significant decreases in the number and variety of planktonic and benthic forms as well as in fish eggs had been noted in the destroyed mangrove areas in the early 1970s, and such declines were associated with declines in offshore fin-fish and shell-fish numbers.⁴¹ The decline in Viet Nam's marine fishery is also partly due to a paucity of equipment and to reductions in the fishing fleet. These reductions stem on the one hand from a lack of spare parts and fuel, and on the other from the loss of boats taken along by emigrants (the so-called boat people).

Viet Nam is now actively encouraging the establishment of fish ponds⁴² and otherwise attempting to develop inland fishing. Indeed, some 100,000 ha of inland waters are being given over to intensive pisciculture (Table 1). A considerable number of the bomb craters located in farming areas

38. Preston, *Canonical Distribution of Commonness and Rarity*, 43 *ECOLOGY* 185, 195 (1962).

39. *Id.* at 197.

40. UMBRIGHT, *supra* note 11, at 111.

41. D. DE SYLVA & H. MICHEL, EFFECTS OF HERBICIDES IN SOUTH VIETNAM. B. EFFECTS OF MANGROVE DEFOLIATION ON THE ESTUARINE ECOLOGY AND FISHERIES OF SOUTH VIETNAM 113-17 (1974).

42. Tram, *Uncle Ho's Fishponds*, 15 *VIETNAM COURIER* 9 (No. 9, 1979).

TABLE 5
The Marine Fisheries of Viet Nam^a

Year	Catch ^b (1,000 tons)	Catch per Capita ^c (kg/cap)	Fish Sauce Production ^b (million liters)	Fish Sauce per Capita ^c (liters/cap)
1960	550 ^d	18 ^e		
1975	550	11	83	1.7
1976	610	12	99	2.0
1977	590	12	120	2.4
1978	520	10	115	2.2
1979	490	9	91	1.7

^aThe coastline is 3,260 km. long (North Viet Nam, 970 km; South Viet Nam, 2,290 km) and the 1977 fishing fleet consisted of 47,000 boats, two-thirds of them motorized. See UMBRIGHT, LANKESTER, & PANTULU, *supra* note 11, at 114. In addition to the marine fishery, inland fishing adds perhaps 15 to 20 percent to the annual catch. *Id.* at 113, and UN DEVELOPMENT PROGRAMME, *supra* note 5, at 6.

^b1960 datum estimated from G. HUNG, ECONOMIC DEVELOPMENT OF SOCIALIST VIETNAM 1955-80, at 177 (1977); Smith, *Area Handbook for North Vietnam*, U.S. DEPARTMENT OF THE ARMY PAMPHLET No. 550-57, at 294, and PAMPHLET No. 550-55, at 331 (1967); 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM, at 32 (1979) and table 13 (1978). The catch values are in fresh (live) weight.

^cBased on population figures from Table 2.

^dNorth Viet Nam, 200,000 metric tons; South Viet Nam, 350,000 metric tons.

^eSouth Viet Nam exported approximately 100,000 metric tons/yr during this period. See UMBRIGHT, LANKESTER, & PANTULU, *supra* note 11, at 114. Ocean fish consumption in Viet Nam in 1960 averaged perhaps 15 kg/cap (North Viet Nam, 13 kg/cap; South Viet Nam, 18 kg. cap).

that penetrate the water table have been converted to fish ponds. An annual fish yield of 2 to 3 t/ha is expected from intensive freshwater pisciculture. Moreover, some current research efforts in the Mekong Delta are aimed at developing a shrimp culture industry as one means of utilizing portions of the reclaimed mangrove habitat, and a similar effort is being begun for crab culture.

In summary, Viet Nam's important marine fishery is in a continuing postwar decline of several years' standing, one reason for which appears to be linked to the major wartime disruption of the mangrove habitat.

Endangered Species

Several decades of war culminating in the Second Indochina War did much to disrupt the varied tropical habitats of Viet Nam and the once plentiful wildlife that depended upon them. The current status of a number of rare and endangered species is described in detail elsewhere.⁴³

43. Westing & Westing, *Endangered Species and Habitats of Viet Nam*, 8 ENV'T'L CONSERVATION 59 (1981).

A number of mammals, birds, and plants are threatened with extinction as a result, at least in part, of wartime disruption. The scientific community of Viet Nam is highly sensitive to the plight of the country's endangered species and to conservation issues in general. However, equipment, fuel, and other necessities are simply not available for systematic on-site investigations of natural habitats and the wildlife which they support, nor do they suffice for major rehabilitation programs. Moreover, the plethora of unexploded munitions that remains hidden in the wilds makes field operations highly dangerous.

Current national priorities serve to channel most of the efforts of the scientific community into improving agricultural productivity of both food and industrial crops, or into utilizing natural resources for domestic consumption and export. Some of the war-damaged natural habitats are not, therefore, being permitted to revert to nature but are, instead, being converted to agriculture. Reduction in the size of a natural habitat, or its fragmentation, as noted earlier, results in a reduction in the number of species that an area can support. Inevitably, a number of species of plants and animals will slip into oblivion, some noticed and others not. The hill tribespeople pose another continuing conservation problem, owing to their unwillingness to abide by the laws which would protect wildlife and natural habitats.

At present, Viet Nam has one major nature reserve, the 25,000 ha Cuc Phuong National Park, which was established in 1962 in a mountainous primeval forest area about 100 km southwest of Hanoi. This park is rich in species of plants and animals and is scenically majestic.⁴⁴ It is possible that a second such park will be established as a refuge for such native, and at least locally endangered, species as the douc langur, banteng, wild water buffalo, leopard, cloud leopard, hog deer, and Edwards's and imperial pheasants.

Agriculture

The Second Indochina War brought about agricultural disruption in a variety of direct and indirect ways, both intentionally and unintentionally.⁴⁵

In North Viet Nam, some fraction of the U.S. bombing and shelling cratered cultivated lands and destroyed irrigation systems. Moreover, the supporting infrastructure was to a large extent destroyed. Much livestock was killed, including some 24,000 water buffaloes; about 1,600 water

44. N.A.T., *Cuc Phuong National Park*, 12 VIETNAM COURIER 26-28 (No. 3, 1976).

45. Westing (1980), *supra* note 1, at 85; Duy, *Agriculture in South Viet Nam Before and After Liberation*, 13 VIETNAM COURIER 20 (No. 1, 1977); and Duy, *Agriculture in Southern Viet Nam Before and After Liberation*, 13 VIETNAM COURIER 11, 22 (No. 2, 1977).

conservancy works were damaged; dikes were breached in more than 1,000 places; and 48 agricultural schools and research stations were damaged.⁴⁶

In South Viet Nam, the United States carried out a routine military policy of systematic large-scale crop destruction.⁴⁷ Chemical crop destruction from the air made up the greatest proportion of the major U.S. resource denial program. Significant fractions of this U.S. program of so-called economic warfare were also carried out by bombing and shelling, as well as by a variety of ground operations. Chemical crop destruction alone is estimated to have affected 400,000 ha of agricultural lands in South Viet Nam, resulting in the immediate destruction of more than 300,000 tons of food.⁴⁸ Aside from the program of economic warfare, an enormous amount of casual agricultural destruction took place. In addition, South Viet Nam experienced a wartime dearth of available manpower, owing to the high proportion of persons in military service, military fatalities and other casualties, and the displacement of farmers to urban areas; widespread deterioration of farm land due to abandonment after the relentless rural bombing; and widespread destruction of livestock including, perhaps, 900,000 water buffaloes.⁴⁹

Some measure of the military disruption of agriculture in South Viet Nam can be gleaned from rice surplus and deficit figures.⁵⁰ Before the Second Indochina War, South Viet Nam's average annual export of processed (milled) rice was 200,000 metric tons, which represents the yield from almost 150,000 ha. During the war years, the average import of milled rice to South Viet Nam was 600,000 metric t/yr.⁵¹ In South Vietnamese terms, this figure represents the yield from just over 400,000 ha. Military disruption can thus be estimated to have taken out of production during the war years the equivalent of about 600,000 ha, or roughly one-fifth of Viet Nam's total farm land.

The immediate postwar efforts of the people of all Viet Nam made for a 10 percent increase in overall agricultural output and an 18 percent increase in food crop production by 1976 (Table 6). However, agricultural advances since 1976 have been extraordinarily slow and in some respects nonexistent (Table 7). The extent of cereal land sown has increased a little each year, but the nationwide yield per unit area has remained

46. VIEN, *supra* note 11, at 7-8, and VIET NAM: DESTRUCTION, WAR DAMAGE, *supra* note 6, at 28.

47. Westing, *Crop Destruction as a Means of War*, 37 BULL. OF THE ATOMIC SCIENTISTS 38 (No. 2, 1981).

48. Westing (1980), *supra* note 1, at 86.

49. VIEN, *supra* note 11, at 6-7, and VIET NAM: DESTRUCTION, WAR DAMAGE, *supra* note 6, at 23-27.

50. Duy (Vol. 1, 1977), *supra* note 45, at 20.

51. *Id.*

TABLE 6
Gross Production Indices for Viet Nam^a

Year	Population ^b	Food Crop Production ^c	Industrial Crop Production ^c	Livestock Production ^c	Overall Agricultural Production ^c	Industrial Production (Non-agricultural) ^d
1975	100	100	100	100	100	100
1976	103	118	103	101	110	113
1977	106	108	94	108	105	124
1978	108	108	108	94	105	131
1979	110	120	104	102	112	125

^aThe agricultural and industrial indices are all based on constant prices.

^bBased on population values from Table 2.

^cFrom VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM 53 (1979).

^d*Id.*, at 29.

essentially constant since before the war. Barely self-sufficient in cereals (by low standards) before the war, Viet Nam has had to rely on food imports since the war in order to stave off famine. Widespread signs of malnutrition have been reported.⁵²

Viet Nam has more than a million new mouths to feed each year (Table 2). The area sown in cereals in Viet Nam, 0.13 ha/cap (Table 7), is rather low by tropical standards which average 0.30 ha/cap,⁵³ but its expansion since the end of the war has more than matched the pace of population expansion. However, with an unimproved overall yield per unit area, the production per capita remains inadequate.

The essentially constant national unit area yield figures can be attributed to a host of factors. Without question, wartime disruption of the rural areas has been a major contributor to this calamity; postwar area yields have increased over prewar yields in lightly damaged North Viet Nam, but remained stationary in more heavily damaged South Viet Nam (Table 7). In addition, the agricultural expansion associated with the new frontier or new economic zone program has occurred on relatively unsuitable land. The war-destroyed forest lands included in the agricultural expansion are better suited to growing trees than farm crops, especially in the absence of increasingly expensive fertilizers.

The inauspicious agricultural situation can be further attributed to the large-scale loss of draught animals (water buffaloes) and a lack of fuel

52. Kaufman, *Vietnam 1978: Crisis in Food, Nutrition, and Health*, 74 J. AM. DIETETIC ASSOC. 310 (1979).

53. Westing (1980), *supra* note 1, Table 1.1.

TABLE 7
Cereal (Grain) Production in North and South Viet Nam^a

Year	Area Sown ^b (million ha)	Yield (unprocessed) ^c (million tons)	Yield per Unit Area (unprocessed) tons/ha	Area Sown per Capita ^d (ha/cap)	Production per Capita (processed) ^e (kg/cap)	Imports (processed) ^f (million tons)
<i>North Viet Nam</i>						
1960	2.0	3.1	1.5	0.13	128	
1976	2.8	6.2	2.2	0.11	166	
1979	3.1	6.0	1.9	0.12	152	
<i>South Viet Nam</i>						
1960	2.5	5.4	2.2	0.18	257	
1976	3.4	7.3	2.2	0.14	200	
1979	3.8	7.7	2.0	0.14	195	
<i>All Viet Nam,</i>						
1960	4.5	8.5	1.9	0.15	189	8
1975	5.6	11.6	2.1	0.12	162	1.0
1976	6.2	13.5	2.2	0.13	183	0.7
1977	6.6	12.9	2.0	0.13	170	1.3
1978	6.8	12.9	1.9	0.13	167	1.4
1979	6.9	13.7	2.0	0.13	174	1.6
1980		14.0			174	

^aRice accounted for over 90 percent of cereal area and production in 1960, decreasing to about 80 percent in 1979.

^b1960 data from G. HUNG, ECONOMIC DEVELOPMENT OF SOCIALIST VIETNAM 1955-80 at 4-5 (1977); 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM at 54, 56 (1979).

^c1960 data from HUNG, *supra* item b; 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, *supra* item b, at 55-56; 1980 datum from Chanda, *Vietnam's Economic Post-mortem: Realism Creeps into Planning as the Second Five-Year Plan Fails*, III FAR EASTERN ECON. REV. 3, at 40. (1981). The data are presented in terms of unprocessed rice equivalent. 1.43 kg. of maize equals 1 kg. of rice.

^dBased on population figures from Table 2, using appropriate growth rates for North and South Viet Nam.

^eBased on population figures from Table 2 and a conversion factor of 0.667 from unprocessed to processed (milled) rice. A minimal annual amount for nutrition is considered to be about 187 kg/cap. Somewhat more (about 10 percent?) is needed to account for seed requirements and loss in storage.

^fFrom VIET NAM GENERAL STATISTICAL OFFICE, *supra* item b, at 87; and VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM at table 39 (1978).

^gSouth Viet Nam exported 0.4 million tons of processed rice in 1960 (and an annual average of 0.2 million tons during the four years 1957-61). Duy, 13 VIETNAM COURIER 1, *supra* note 45, at 20.

or spare parts for the few existing farm tractors. The prewar number of water buffaloes per unit area of sown land has not been reattained during the postwar years, and postwar fertilizer and pesticide inputs per unit area remain low and relatively unchanging (Table 8). The water conservancy and associated irrigation systems that were disrupted during the war have not all been restored as yet. High-yield rice varieties developed in recent years cannot fulfill their genetic potential without a carefully regulated and fully adequate water regime as well as high levels of fertilizer and pesticide applications.

Some fraction of today's agricultural work force has inadequate agricultural experience or training, due to wartime military service or wartime displacement to urban centers, and some of the potential agricultural work force is in military service at this time.

Although North Viet Nam has been able to increase its prewar per capita cereal productivity (Table 7), it has nevertheless maintained its traditional inability to be agriculturally self-sufficient. South Viet Nam, whose agriculture was far more seriously disrupted by the Second Indochina War, is now essentially self-sufficient at an austere level, but has not as yet regained its comfortable prewar surplus. To some extent this appears to be the result of a reluctance on the part of South Vietnamese farmers to form agricultural collectives or to produce a surplus for the North without being able to receive compensation in the form of consumer goods.

United Viet Nam hopes to come to grips with its agricultural shortfalls by a multiplicity of approaches, as enunciated in its recent five-year plan which gave agricultural development top priority.⁵⁴ Continued dependence by Viet Nam on staple food imports is an unacceptable situation in the face of such modest present potential for exports and in the light of growing worldwide food shortages. Moreover, with a relatively modest endowment in the form of minerals, Viet Nam must develop more industrial crops, both as a source of raw materials to supply its indigenous industry and as a major contributor to exports.

Rubber

Before the Second Indochina War, rubber was of great economic importance in South Viet Nam,⁵⁵ accounting for about 60 percent of the total value of exports and employing some 100,000 workers. The rubber plantations were located in areas subject to intense military activity during

54. Brow, *Vietnam's 5-year Plan Stresses Agriculture*, 16 FOREIGN AGRICULTURE 2 (No. 16, 1978); Vy, *Green Belt Around Ho Chi Minh City*, 15 VIETNAM COURIER 10-11 (No. 8, 1979).

55. Westing (1980), *supra* note 1, at 83; and Cuong, *Natural Rubber in Vietnam*, 14 VIETNAM COURIER 23 (No. 11, 1978).

TABLE 8
Selected Contributors to Agricultural Productivity in Viet Nam

Year	Water Buffaloes ^a (million)	Water Buffaloes per Unit Area ^b (no./10 ha)	Chemical Fertilizer Production ^c (million tons)	Chemical Fertilizer Imports ^d (million tons)	Chemical Fertilizer per Unit Area ^e (kg/ha)	Pesticide Production ^c (million tons)	Pesticides per Unit Area ^b (kg/ha)
1960	2.25	5.0					
1975	2.19	3.9	0.45	0.41	150	7.2	1.3
1976	2.24	3.6	0.46	0.57	170	16.4	2.6
1977	2.29	3.5	0.52	0.64	180	19.0	2.9
1978	2.32	3.4	0.61	0.64	180	19.7	2.9
1979	2.29	3.3	0.26	0.41	100	18.4	2.7

^a1960 datum combined from 1.45 million for North Viet Nam, G. HUNG, ECONOMIC DEVELOPMENT OF SOCIALIST VIETNAM 1955-80 at 131 (1977); plus 0.80 million for South Viet Nam, Smith, *Area Handbook for North Vietnam*, U.S. DEPARTMENT OF THE ARMY PAMPHLET No. 550-55, at 329 (1967); 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM, at 74 (1979). Viet Nam also has in use an estimated 24,000 farm tractors. FAO, FAO PRODUCTION Y.B. at 276 (1979).

^bBased on the areas of cereal land sown, from Table 7.

^cFrom VIET NAM GENERAL STATISTICAL OFFICE, *supra* item a, at 32, and VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIET NAM, table 13 (1978).

^d*Id.* at 817 (1979), and table 39 (1978).

^eBased on the areas of cereal land sown, from Table 7. A substantial, although unknown amount, of organic fertilizer originating from livestock and human excrement, etc., is also used.

the war and, as a result, suffered considerable damage from indiscriminate wide-area bombing, shelling, and chemical attack. Processing facilities were also destroyed in many instances. About 40 percent of South Viet Nam's plantation trees were destroyed during the war, and overall production was reduced by about 70 percent (Table 9).

The war-reduced land area devoted to rubber plantations has hardly been expanded since the war ended, although there are plans to match the prewar scope as economic conditions permit. Existing plantations have been in part rehabilitated through removal of unexploded munitions (so far resulting in some 400 casualties), replanting, and so forth. The yield per unit area is beginning to approach prewar levels. Rubber export in the form of latex has regained roughly half the prewar level (Table 9).

In short, Viet Nam's important rubber industry suffered substantial damage from the Second Indochina War and is recovering at a very slow pace. Indeed, the reattainment of prewar production and export levels seems to be many years off.

THE LESSON OF VIET NAM

It is a truism that warfare is detrimental to the environment. However, the Second Indochina War ushered in a new level of anti-environmental ferocity. Faced with a dispersed and elusive enemy in South Viet Nam, the United States sought to deny this foe both sanctuary and freedom of

TABLE 9
Rubber Data for Viet Nam^a

Year	Area ^b (million ha)	Yield ^c (thousand tons)	Yield per Unit Area (kg/ha)	Exports ^d (thousand tons)
1960	135	78	580	70
1975	81	24	300	7
1976	82	24	300	28
1977	81	42	520	36
1978	81	46	570	25
1979	83	43	520	33

^aVirtually all rubber production is in South Viet Nam.

^b1960 datum from SIPRI Y.B. (1980), *supra* note 1, at 84; 1975, 1976, 1978, and 1979 data from VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIETNAM at 68 (1979); 1977 datum interpolated.

^c1960 datum from G. HUNG, ECONOMIC DEVELOPMENT OF SOCIALIST VIETNAM 1955-80 at table 4-5 (1977); 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, *supra* item b, at table 43. Yield is expressed in terms of dried latex.

^d1960 datum from Duy, 13 VIETNAM COURIER NO. 1, *supra* note 45, at 21; 1975-79 data from VIET NAM GENERAL STATISTICAL OFFICE, *supra* item b, at 86; and VIET NAM GENERAL STATISTICAL OFFICE, STATISTICAL DATA OF THE SOCIALIST REPUBLIC OF VIETNAM at table 38 (1978).

movement and a local civilian economy from which to derive sustenance. The U.S. strategy, meant to achieve these goals, required the profligate expenditure of munitions, both conventional and unconventional, directed in large measure against the fields and forests of South Viet Nam. The emphasis here has been on the impact of these actions on the ecology and economic development of Viet Nam, and only cursory treatment has been given to the more strictly social sequelae of the war.

The Second Indochina War has shown that the impact of environmental warfare spills over the spatial and temporal bounds of the attacks and that the brunt of such attacks is borne by the civilian population. Indeed, the civilian sector continues to bear this burden long after hostilities have ended. Despite the massive level of disruption of Viet Nam's natural resources, the military objectives were not achieved in the end. Their realization would have required an intensification of the assault to truly ecocidal and thus genocidal proportions.

Presumably as a direct outcome of the Second Indochina War, at least some faction of the international community has come to recognize the unacceptability of military assaults on the environment as a strategy of war. For example, 38 or more nations have, as of the end of 1982, ratified or acceded to the 1977 Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques. This Convention, which took effect in 1978, prohibits the parties from engaging in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage, or injury.⁵⁶ Similarly, 18 nations, as of the end of 1981, have ratified the 1977 Protocol (1) Additional to the Geneva Convention of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts. This Protocol, which took effect in 1978, inter alia limits attacks on agricultural lands, prohibits starvation as a method of warfare, and restricts means of war that would damage the natural environment.⁵⁷

As much as a decade has now elapsed since the time of the major anti-environmental assaults against Viet Nam. Their effects are agonizingly slow to disappear. Indeed, Viet Nam's industrial production is recovering more rapidly than its far more directly land-based agricultural productivity (Table 6), a phenomenon that was also observed among European countries embroiled in World War II.⁵⁸

Natural ecological recovery of a disrupted habitat is an inevitable phenomenon, albeit a slow one. In many instances, human action can aid

56. Goldblat, *Arms Control: A Survey and Appraisal of Multilateral Agreements*, 1978 SIPRI Y.B. 123 (1978); and Westing (1980), *supra* note 1, at 201.

57. Goldblat, *id.* at 125.

58. Westing (1980), *supra* note 1, at 61.

such natural recovery. The expertise and financial resources required, however, are in short supply in a war-ravaged and otherwise impoverished nation such as Viet Nam. Viet Nam is thus now dependent upon foreign assistance, a need that has been recognized by the United Nations⁵⁹ and at least tacitly acknowledged by Viet Nam itself in that its national five-year plan of 1976–80 was heavily dependent upon such aid.⁶⁰

In the postwar period Viet Nam has received aid from at least 11 organizations of the United Nations system, from 17 or more nations, and from various private agencies located around the world. Total annual aid in recent years has been approximately \$1.5 billion, placing Viet Nam among the several highest aid recipients in the world. One might add that the poor condition in which Viet Nam finds itself today despite the relatively high level of foreign assistance emphasizes the enormity of its war damage. One can also argue that the situation might improve if fewer resources were allocated to the military sector. Indeed, Viet Nam's complement of armed forces of 600,000⁶¹ or more⁶² is extraordinarily large by various standards.⁶³

Viet Nam's introduction into the age of technology has been a brutal one. It can only be hoped that the future will be kinder to it than the recent past, and that man and nature will cooperate to restore this region to its former productive beauty as rapidly as possible.

59. UMBRIGHT, *supra* note 11, at 100; U.N.G.A. Res. 32/3 (1977); *Assembly Calls for Aid for Viet Nam Reconstruction*, 14 UN MONTHLY CHRONICLE 11 at 57 (1977); and *Viet Nam's Aid for This Year Estimated at \$800 Million*, 15 UN MONTHLY CHRONICLE 4, at 61 (1978).

60. Thayer, *Vietnam: Beleaguered Outpost of Socialism*, 79 CURRENT HISTORY 165–67 (1980); Niehaus, *Vietnam 1978: the Elusive Peace*, 19 ASIAN SURVEY 1, at 87 (1979).

61. U.S. ARMS CONTROL AND DISARMAMENT AGENCY, *supra* note 4, at Table 2.

62. INTERNATIONAL INST. FOR STRATEGIC STUDIES, *MILITARY BALANCE, 1980–81* at 76 (1980).

63. Westing (1980), *supra* note 1, at Table 1.13.