

## ECOLOGICAL IMPACTS OF WARTIME HERBICIDES ON THE MANGROVE AREAS OF SOUTH VIETNAM

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### Abstract

Coastal dwellers in the South of Vietnam since ancient times have lived in a close relationship with the mangrove ecosystem. During the second Indochina war, mangrove forests provided significant bases for Vietnamese patriots. Consequently, the American army forces used bombs, cannons, and especially herbicides and defoliant (hereafter referred to as herbicides) in high concentrations to destroy these forests. The amount of herbicides sprayed on mangroves was estimated to be 22,214 gallons. The mangrove area sprayed with herbicides was 159,851 ha, accounting for 55.1 percent of their total area (290,000 ha); biological resources drastically reduced, erosion along river banks and coasts accelerated; and large areas of fallow land became acid sulphate soil. After the war, many localities grew a wide range of agricultural and industrial crops on bare land where mangroves had been destroyed in order to improve the life of the poor and the unemployed, but had no success. A large amount of money has been spent on these activities and on reforestation.

### Introduction

Mangroves form a rich and diversified ecosystem, which is, however, very fragile and prone to human activities. Growing in a tropical region with favorable climate and rich alluvia from Dong Nai and Mekong River systems, the mangrove ecosystem in the South of Vietnam has provided significant necessities and livelihoods for local dwellers. Mangrove forests also play a major role in trapping sediments and dispensing the energy of wave storms, tidal bores and monsoons, thus protecting people's life.

Mangrove forests, with their dense root systems, made it difficult for big patrol ships or boats to pass by, and so they were very useful as shelters for anti-American troops. During the Vietnam war, mangroves in the South were used to receive and store weapons transported from the North, and were therefore heavily targeted for destruction by the American army in the defoliation campaign named "Operation Ranch Hand" from 1962 to 1970. The disruption of vegetative cover following herbicidal attacks badly affected the highly diverse mangrove vegetation and fauna and the environment.

This paper will take a look at three coastal areas sprayed by warring herbicides, namely Rung Sat (Southeast of Viet Nam), coastal Mekong River Delta, and Ca Mau Cape. (Fig. 1: Study area)

### Materials and methods

Data from HERBS tapes provided by Smith and Watkins<sup>12</sup> were used to determine the amount of herbicide spray missions. The percentages of mangrove lands sprayed and not sprayed are based on the aerial photos of the World Wide Survey in 1958 and 1972<sup>9</sup>. The percentage calculation on UTM picture maps in 1965, Lansat MSS photos in 1973<sup>1</sup>, and statistic data of the FIPI<sup>3</sup> were used for area calculation. Field surveys and sampling were undertaken from 1977 to 1982. Soil samples collected were analyzed at the Central Institute for Agro-chemistry and Pedology.

Key informant interviews with village elders facilitated better understanding of the historical situation of Operation Ranch Hand and the changes of mangrove ecosystem resources after the US defoliation campaign.

### Results and discussion

#### *Quantity of herbicides used to destroy mangrove areas*

According to Ross<sup>11</sup>, mangroves were sprayed with herbicides along Highway 15 from Bien Hoa to Phuoc Tuy in January and again in March 1962. Some areas along the coast of the Mekong Delta were sprayed in 1964 and 1965. Two areas heavily sprayed with herbicides from 1966 to 1970 were Rung Sat and the tip of Ca Mau Peninsula. The tapes of the herbicide data file (HERBS) for the years 1965 to 1970 show that a total of 299 missions were flown into the Rung Sat area with 927,116 gallons. From 1966 to 1970, the tip of Ca Mau Peninsula received 669,548 gallons of herbicides (Table 1) through 55 missions. The number of defoliation

missions over mangroves rapidly increased from 1966 to 1969. In 1966, the mangroves in all the provinces along the coast of the Mekong Delta were sprayed.<sup>6</sup>

Table 1. Amount of herbicides sprayed by the American air force on main mangrove areas (unit: gallon)

Province	Principal herbicide				Total
	Orange	White	Blue	Others	
Bac Lieu	98,818	21,098	5,675	55	125,646
Ben Tre	186,869	53,333		2,966	243,168
Ca Mau	448,396	197,621	22,138	1,385	669,548
Can Gio (Ho Chi Minh City, Dong Nai)	542,052	273,208	78,357	33,389+110	927,116
Soc Trang	43,374	10,002	1,280	2,558	57,914
Tra Vinh	164,038	16,163	6,000	2,825	189,026

Source: Cl. Smith and Don Watkins<sup>12</sup>, NAS<sup>9</sup> and P.Ross<sup>11</sup>

#### Areas of mangroves sprayed with herbicides

Rollet<sup>10</sup>, using aerial photography taken in 1952-1953, estimated there were 725,000 acres (290,000 ha) of mangrove forests in the South of Viet Nam.



Photo 1: Mangrove forest at Ca Mau Cape before the war (left) by Moquillon, C. 1950

Photo 2: A trace of mangrove forest in Ca Mau Cape totally destroyed by defoliation operation (right) by Minh Hai Historical Museum, 1967

#### Rung Sat

Based on aerial photos of the World Wide Survey of 1958 and 1972, the Committee on Impacts of Herbicides in Vietnam calculated that approximately 51.2% of the Rung Sat tidal swamps were covered by mangroves. From 1962 to 1970, 65.42% of the Rung Sat mangroves<sup>9</sup> (equivalent to 35,275.5 ha) was sprayed with herbicides<sup>7</sup>

#### Ca Mau Cape

Ca Mau Cape is the largest natural intact healthy mangrove forests of Viet Nam. It acted as a very important resistance base and the store of weapons transported from the North<sup>5</sup>. The total area of mangroves in Ca Mau before the war was 149,982 ha<sup>8</sup>. According to NAS<sup>9</sup> and P.Ross<sup>11</sup>, 52% of the mangrove area in Ca Mau was sprayed with herbicides. Nguyen Manh Cuong's calculation<sup>1</sup> based on UTM picture maps 1965 and Lansat MSS 1973 photos resulted in a lower percentage of forests destroyed by herbicides, being 49.3% (Table 2).

The explanation of the difference in the percentages of herbicide sprayed area estimated by P.Ross and by N.M.Cuong is that there was 4.3% of bare land before the defoliation campaign.

Table 2. Areas of mangroves in Ca Mau before and after the spraying of herbicides

Year	Total area of mangrove land (ha)	%	Bare land before herbicide spraying (ha)	%	Area sprayed with herbicides (ha)	%	Area of remaining forests (ha)	%
1943	149,982	100						
1965	149,982	95.7*	6,449	4.3*	0		143,533*	
1973	149,982	100	6,449	4.3*	73,942	49.3*	69,591	46.4*

Note: \* Percentage of area supplied by N.M.Cuong<sup>1</sup>; mangrove areas calculated by P.N. Hong<sup>7</sup>

#### Coastal areas of the Mekong Delta

According to the statistics of the FIPI<sup>3</sup> and the data of provincial forestry agencies (checked against sprayed/spread traces on the Vietnam Smith and Watkins<sup>12</sup>), the areas sprayed with herbicides in coastal areas of the Mekong Delta are as shown in table 3.

Table 3. Areas of mangroves sprayed with herbicides in main provinces of the Mekong Delta

Current name	Previous name	Area (ha)	Current name	Previous name	Area (ha)
Ben Tre	Kien Hoa	24,396	Tien Giang	Go Cong	804
Tra Vinh	Vinh Binh	17,664	Bac Lieu		1,120
Soc Trang	Ba Xuyen	1,921	Kien Giang	Kien Giang	5,549

The above data and analysis show that the area of mangroves sprayed with herbicides in the main provinces of Southern Viet Nam was 159,851 ha.<sup>7</sup>

#### Impacts of wartime herbicides on naturally regenerated vegetation

Resistance bases were located in old dense mangrove forests with many big timber trees, namely *Rhizophora apiculata*, *Bruguiera parviflora*, *Sonneratia obovata*, *Avicennia alba* ... After spray missions, all of these species died because they were very sensitive to toxic chemicals (photo 2).

In 1977, when we conducted a survey in Ca Mau Province, most of the sprayed places flooded by daily tides still witnessed disordered dead mangrove trees. Waves and tidal water uprooted seedlings. On higher land, fast growing species such as *Acrostichum aureum* (fern), *Phoenix paludosa* (wild palm) and *Excoecaria agallocha* (toxic tree) often formed extensive dense stands, preventing the colonization of other original woody plants. Along river banks, some herbaceous species such as *Acanthus ilicifolius* and *Cryptocorine ciliata* replaced the protecting belt of *A. alba*, *S. caseolaris* and nipa palm<sup>5</sup>. Natural regeneration in mangrove areas affected by herbicides failed to re-establish the pre-disturbance sp. composition and forest structure<sup>13</sup>.

#### Impacts on fauna resources

The disruption of vegetative cover following warring herbicide attacks badly affected the highly diverse mangrove fauna, both aquatic and avifauna, which depend on the vegetative cover for food and shelter.<sup>15</sup> Through interviews, it was found that in the past, there had been foresters and fishermen eaten by tiger and crocodiles, but after herbicide missions, these animals became extinct. Only mice and mosquitoes remained, especially anopheles, because their enemies such as snakes, pythons, frogs, and fishes had declined markedly.

#### Impacts on soil degradation

After the loss of forests, the local soil went through tremendous changes. The strong impacts of sunlight, high temperature and the lack of rainwater in the dry season sped up the formation of pyrite (FeS<sub>2</sub>), changing the soil into acid sulphate soil and making it impossible for plants to grow.<sup>5,14,7</sup>

In order to address the food shortage during the post-war period, many localities set up agricultural enterprises for cultivating rice, maize, coconut, sugarcane, cashew nuts, soya beans and pineapples; yet, they suffered from failure due to the acid sulphate soil, wasting a great deal of money and labor. Afterwards, the government had to invest a large amount in reforestation.

#### Coastal and riverside erosions and salt intrusion

The East coast of Southern Vietnam is influenced by a semi-diurnal tide regime with high amplitude (3-4m). In the past, the mangrove vegetation of *A. alba*, *Sonneratia alba*, *R. apiculata* with a dense system of roots above the ground, and nipa palm, reduced the impacts of strong waves, thus restricting erosion of river banks and the coastal line. The dense mangrove canopy plays a great role in reducing wind intensity. Every year, pioneer species gradually invaded rivers and created good coverage for the soil surface. After the loss of these forests, the soil was no longer protected, especially in the dry season with high tides and the strong northeast monsoon. Consequently, erosion has become more and more serious<sup>6</sup>

Analysis of aerial photos shows that the water surface area has increased. The percentage of water surface in Can Gio river system was 22.70 percent of the total area in 1958<sup>9</sup>, but increased to 30.56 per cent in 1978.<sup>2</sup> According to FIPI<sup>3</sup>, the erosion speed was twice as much as that of the forested area.

### Conclusions

The US force's Operation Ranch Hand applied in mangrove areas had a severe impact on natural resources and the environment. Biological resources were reduced. Erosion was accelerated. Fallow land became acid sulphate soil and the mangrove land was devastated. A large amount of money has been spent on these activities and on reforestation.

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