This document has been approved
for public release and sale; its
distribution is unlimited

AD 718603

TECHNICAL REPORT
70-21-ES

MAINLAND SOUTHEAST ASIA:
A FOLIO OF THEMATIC MAPS FOR MILITARY USERS

By

R. J. Frodigh
A. D. Hastings, Jr.
T. E. Niedringhaus
J. M. Pianalp

GEOGRAPHY DIVISION

October 1969

DDC
FEB 26 1971
A

Project Reference
1TO62112A129

Series
ES-51

Earth Sciences Laboratory
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts 01760

CONTENTS

LIST OF FIGURES

LIST OF TABLES

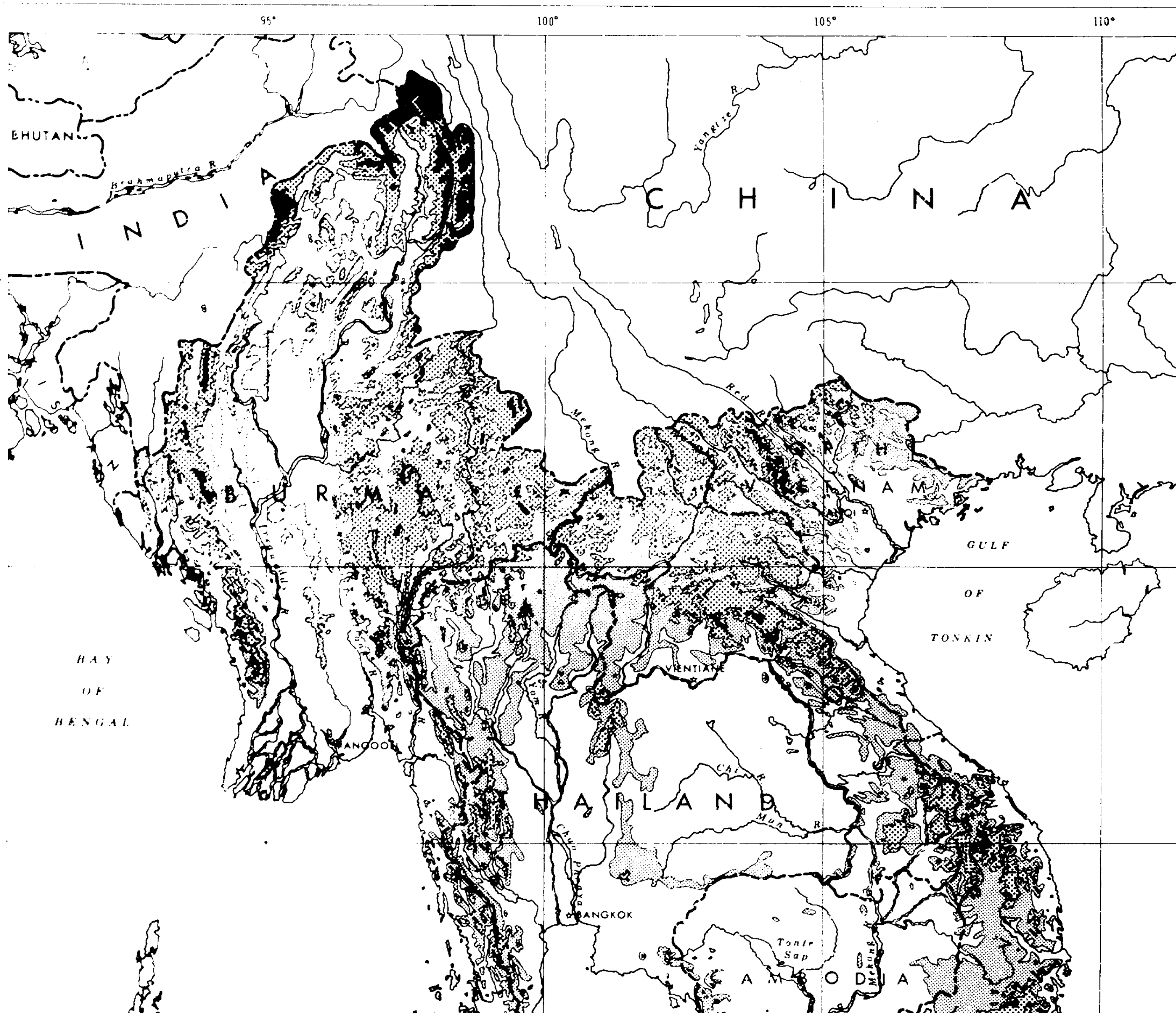
ABSTRACT

Militarily important environmental factors within Mainland Southeast Asia are topics of seventeen thematic maps in this report. The relationships between military operations and selected natural and cultural phenomena have been analyzed and mapped. Supplementing the cartographic coverage are narrative discussions, graphs, and tables.

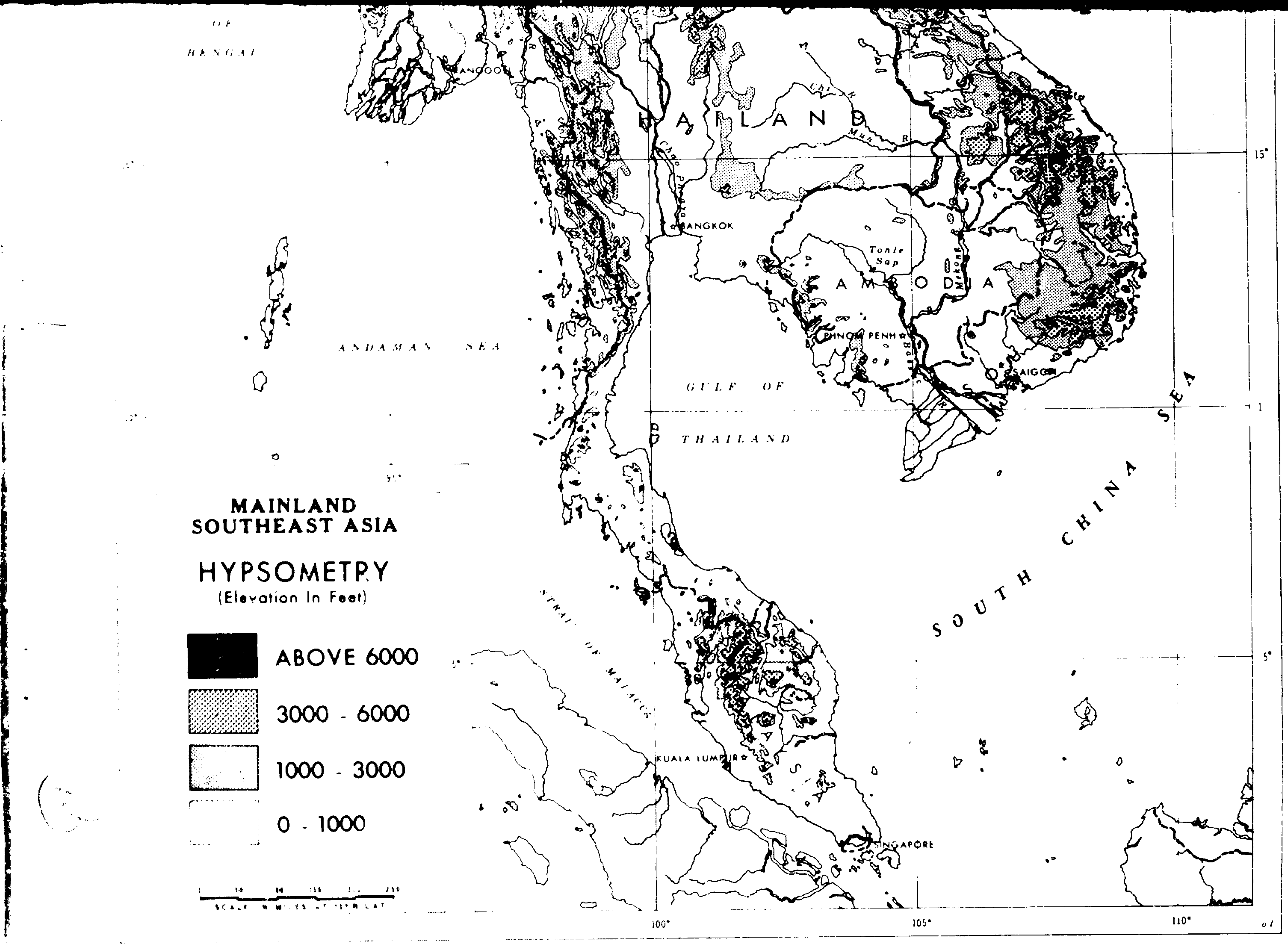
Nine of the maps relate directly and quantitatively to predictable physiological stress conditions, to food storage life expectancies, and to estimated visibility distances within different vegetational types. These maps are based on laboratory and/or field test determinations. Other maps in the series are concerned with the distributional relationships of such environmental factors as ethnolinguistic groups, ethnic minority types, malaria endemicity, and cloudiness regimes.

This study has been developed with the expectation that it will serve as a useful aid in military planning for Southeast Asia, and that it may also serve as a prototype for similar studies of other regions.

MAP 1


95°
100°
105°
110°
25°
20°
15°
BHUTAN
Brahmaputra R.
INDIA
CHINA
Yangtze R.
Red R.
Mekong R.
BURMA
Irrawaddy R.
RANGOON
NORTH VIETNAM
GULF
OF
TONKIN
BAY
OF
BENGAL
VIENTIANE
Yom R.
THAILAND
Chi R.
Mun R.
Chao Phraya
BANGKOK
Tonle Sap
Mekong R.
CAMBODIA

A



MAINLAND
SOUTHEAST ASIA
HYPSOMETRY
(Elevation In Feet)
ABOVE 6000
3000 - 6000
1000 - 3000
0 - 1000
THAILAND
CAMBODIA
BANGKOK
Tonle Sap
Mekong
Mun R
Chao Phraya
PHNOM PENH
SAIGON
RANGOON
KUALA LUMPUR
SINGAPORE
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
15°
5°
100°
105°
110°

POPULATION

Mainland Southeast Asia comprises an area of 802,060 square miles. In July 1968 it had an estimated population of about 116,740,000. Some basic demographic statistics for the individual countries within the region are given in Table I.

TABLE I: POPULATION OF MAINLAND SOUTHEAST ASIA

Country	Area (Sq. Mi.)	Date of latest available census data	Population (est. July 1968)	Reliability[1] % + or -	Total Population Density (persons per sq. mi.)	Rural Population Density[2] (persons per sq. mi.)
Burma	261,789	1953 (partial)	26,300,000	5	100.5	88.6
Thailand	200,148	1960	33,560,000	3	167.7	145.4
Malaya[3]	50,700	1957	8,920,000	3	175.9	149.2
Singapore	225	1957	2,010,000	2	893.3	-----
Laos	91,429	1936	2,770,000	10	30.3	27.7
Cambodia	69,898	1962	6,530,000	5	93.4	85.6
North Vietnam	61,923	1960 (partial)	19,250,000	6	310.9	281.6
South Vietnam	65,948	1960	17,400,000	5	263.9	225.0
Total	802,060		116,740,000	2	145.6	127.6

[1] "Reliability" is an estimate (90% probability) that the actual or true population lies within the range indicated (e.g., the total population is not more than 119,074,800 and not less than 114,405,200).

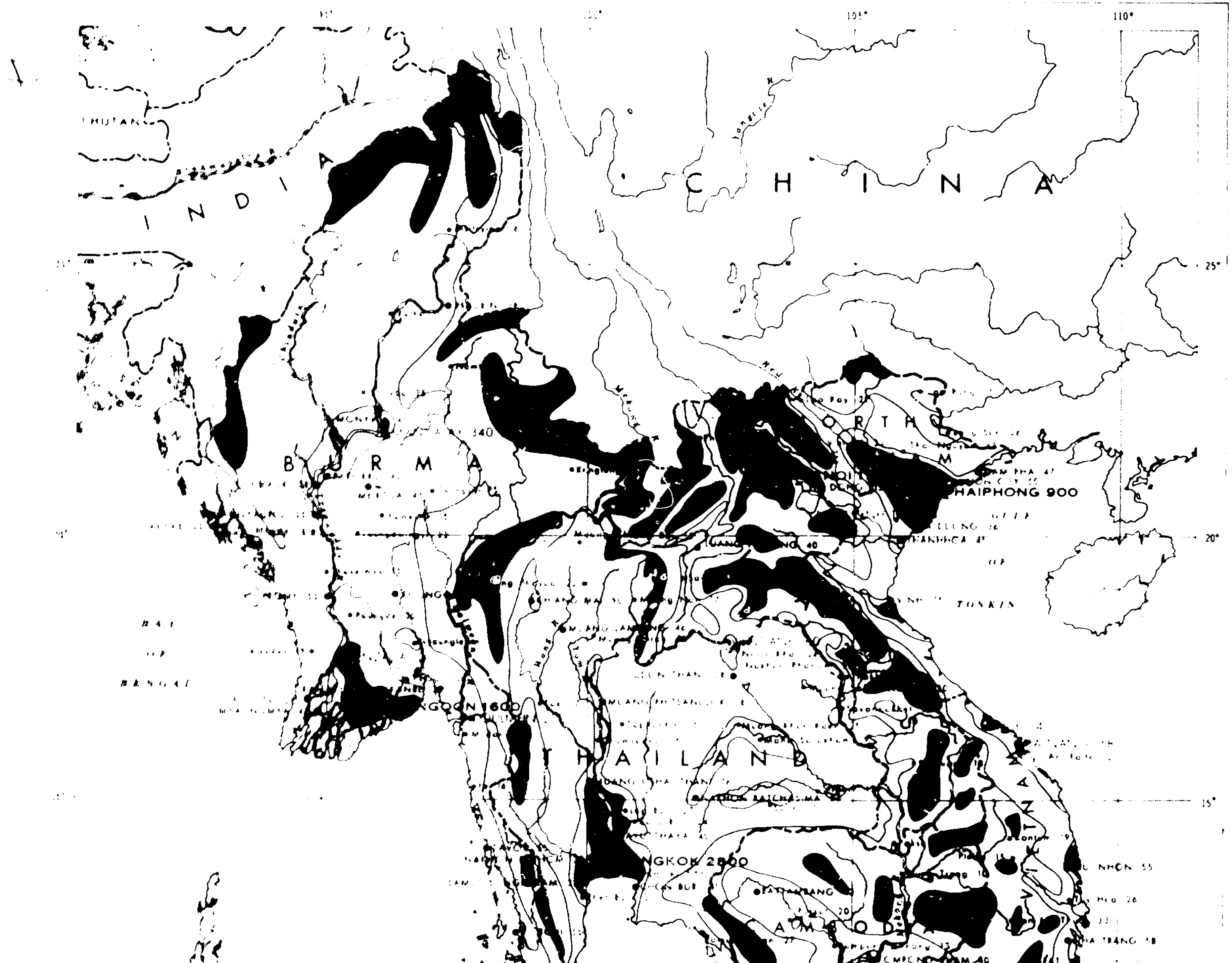
[2] The rural population density is calculated by excluding all cities of over 20,000 population.

[3] "Malaya" comprises the mainland portion of the federation of Malaysia. Although merely a regional term today, it is the only part of Malaysia included in this study.

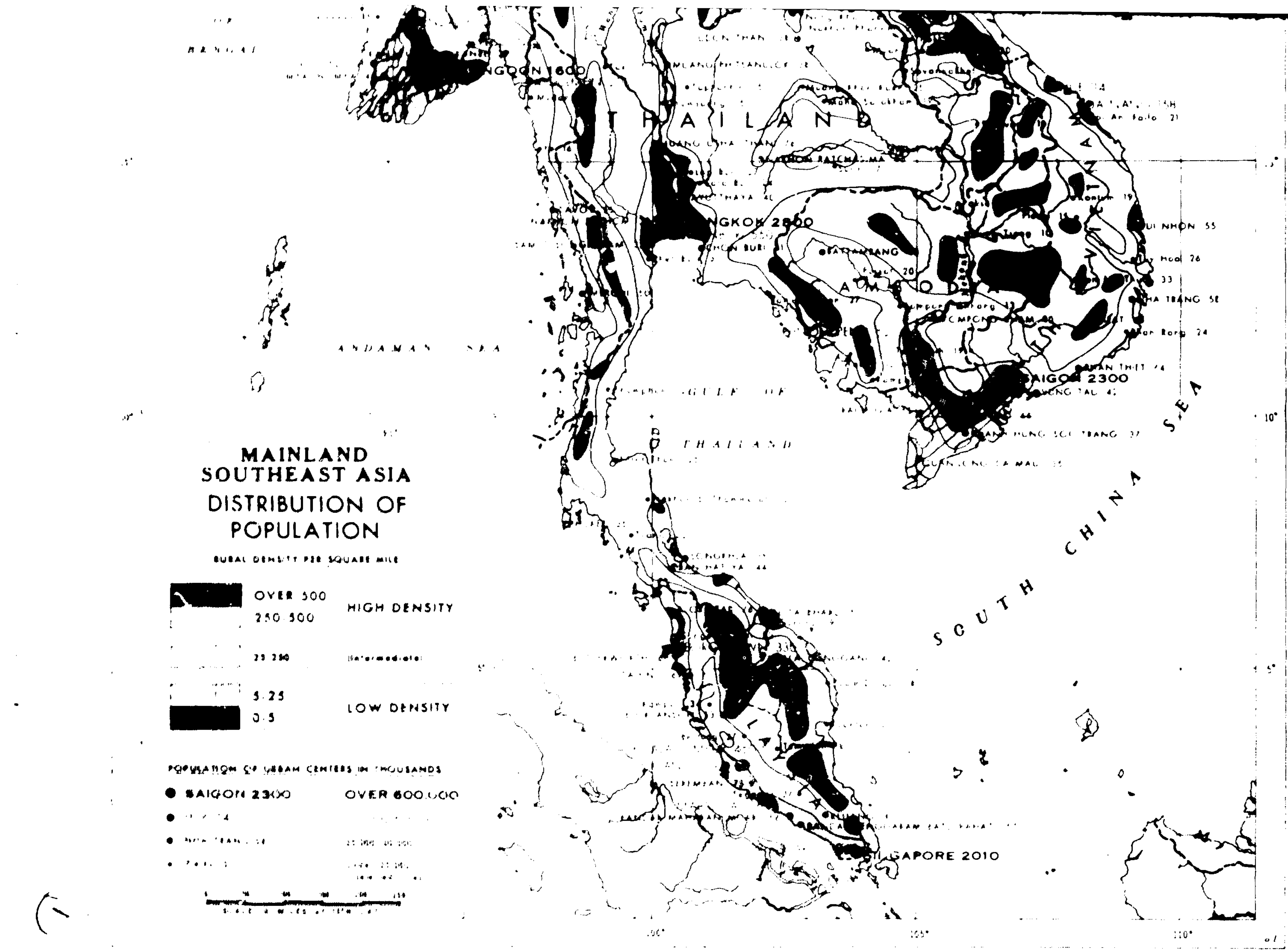
Partly because of the disruptions of war, the estimation of current populations of urban centers in Southeast Asia (in the absence of recent census data) is particularly risky. While the city populations shown on the accompanying map are simple projections based on the latest census figures (or, in a few cases, are U.N. estimates), their reliability, especially in the case of Laotian, North Vietnamese, and South Vietnamese cities, may well range up to the plus or minus 30% - 50% level.

About one in every 11 persons in Southeast Asia (9% of the population) lives in one of the six major urban concentrations of Rangoon, Bangkok, Singapore, Saigon, Hanoi and Haiphong. Another 6% live in an additional 140 cities with populations of more than 20,000 but less than 600,000, most of which are shown on Map 2.

MAP 2



110°
105°
25°
20°
15°
CHINA
INDIA
BHUTAN
BURMA
THAILAND
VIETNAM
NORTH
HAIPHONG 900
TONKIN
BENGAL
BANGKOK 2800
NHON 55
340



MAINLAND SOUTHEAST ASIA
DISTRIBUTION OF POPULATION
RURAL DENSITY PER SQUARE MILE
OVER 500
250-500
HIGH DENSITY
25-250
Intermediate
5-25
0-5
LOW DENSITY
POPULATION OF URBAN CENTERS IN THOUSANDS
SAIGON 2300
OVER 600,000
THAILAND
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
BANGKOK 2800
SAIGON 2300
SINGAPORE 2010
QUI NHON 55
NHA TRANG 58
PHAN THIET 74
VUNG TAU 42
BATTAMBANG
RANGOON 1600
10°
5°
100°
105°
110°

ETHNOLINGUISTIC GROUPS

In the conduct of military operations in Southeast Asia, consideration must be given to the various national and tribal groups which inhabit the region. The success of a mission may be affected by a knowledge of basic vocabulary, social customs, religion, political persuasion, agricultural practices and technology of the people that might be encountered.

Living in eight different countries, the people of Southeast Asia speak at least 100 different languages (defined as mutually unintelligible tongues), and there are hundreds more of recognized dialects. However, the three principal languages--Vietnamese, Thai (including Laotian) and Burmese--include over 70% of the total, and there are many remnant languages having fewer than 5,000 speakers.

Since tribal and linguistic divisions in Southeast Asia are closely related, Map 3 combines them to show the approximate ethnolinguistic divisions. But it should be recognized that in many parts of the region tribal and linguistic boundaries are presently uncertain. This is especially true in the more remote mountain regions and wherever populations have been affected by political unrest and military operations.

In much of Southeast Asia, differing ethnic groups live too closely intermixed to be easily represented on a map. For example, Chinese are mixed in proportions varying from 10% to 80% of the population in virtually every township of western coastal Malaya, while an Indian minority about half this size is almost equally widely distributed in the same area together with the Malays who are the nationally dominant ethnic group. In the mountains of northern North Vietnam, Laos, Thailand, and Burma, ethnic mixture tends to be based on altitudinal stratification: the Miao and Yao live at the highest altitudes (over 5000 ft.); certain other peoples, often shifting cultivators, are at intermediate levels; and still others cultivate the plains and river valleys. However, the lines of ethnolinguistic division on this map should not be taken as sharp boundaries, since transition zones and ethnic interpenetrations are much more typical.

The language families and ethnolinguistic groups in Southeast Asia which are represented on this map are detailed in Table II. Specific languages, generally coinciding with specific tribes or peoples, are underlined. Population figures are estimated as of July 1968, the reliability of estimate being shown by degree of possible deviation, as percent plus or minus. (For comparison, note that the U. S. Census Bureau generally regards U. S. population figures as accurate to ±1% or 1-1/2%.) The possible error in population estimates made here is due to either or both: (1) old or incomplete census data; and (2) ambiguity in ethnic definition or identification.

The number of Southeast Asians with a knowledge of English is extremely difficult to estimate, and at any rate would depend upon some arbitrary standard of familiarity or fluency. Relatively, the proportions are probably highest in Singapore and Malaya, while they are lowest in Laos, Cambodia and North Vietnam. Dominant national groups seldom know any non-European language but their own, whereas certain minority tribes and groups (of which the Chinese traders are a prime example) are often very talented in this respect (Kunstadter, 1967).

TABLE II: LANGUAGE FAMILIES AND ETHNOLINGUISTIC GROUPS IN MAINLAND SOUTHEAST ASIA

	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
I. AUSTROASIATIC				
A. Mon-Khmer				
1. Lowland groups				
Khmer (Cambodians)	Cambodia	5,200,000	10	5,900,000
	South Vietnam	450,000	30	
	Thailand	250,000	50	
Mon	Burma	380,000	30	480,000
	Thailand	100,000	30	
2. Northern Upland groups				
Khmu	Laos	160,000	30	170,000
	Thailand	10,000	50	
Lamet	Laos	10,000	30	10,000
Lawa	Thailand	10,000	20	10,000
Palaung	Burma	180,000	30	180,000
P'u Noi	Laos	20,000	50	20,000
T'in	Thailand	30,000	30	40,000
	Laos	10,000	30	
Wa	Burma	400,000	30	400,000
3. Central Upland groups				
Alak	Laos	5,000	50	5,000
Bahnar (including Rengao, Kayong & Monom)	South Vietnam	150,000	50	150,000
Brao or Love	Laos	15,000	50	19,000
	Cambodia	4,000	50	
Bru (including Pakoh)	South Vietnam	30,000	40	55,000
	North Vietnam	15,000	30	
	Laos	10,000	50	
Chaobon	Thailand	3,000	50	3,000
Cua	South Vietnam	20,000	30	20,000
Halang	Laos	30,000	50	60,000
	South Vietnam	20,000	50	
	Cambodia	10,000	50	
Hre	South Vietnam	60,000	50	60,000
Jeh	Laos	15,000	50	25,000
	South Vietnam	10,000	30	

	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
Kasseng	Laos	10,000	50	10,000
Katu (including Phuong)	South Vietnam	30,000	20	30,000
Loven or Boloven	Laos	40,000	30	40,000
Oy	Laos	15,000	50	15,000
Rengao	South Vietnam	8,000	50	8,000
Sedang	South Vietnam	70,000	30	70,000
So	Laos Thailand	30,000 10,000	50 50	40,000
Souei	Laos	15,000	50	15,000
Tau-oi	Laos South Vietnam	15,000 5,000	50 50	20,000
Other scattered groups	Laos, South Vietnam, Cambodia			30,000
4. Southern Upland groups				
Chong	Thailand Cambodia	3,000 3,000	50 50	6,000
"Koho" (including Lat, Laya, Ma, Nop, Pru, Rien, Sop, Tring, etc.)	South Vietnam	120,000	20	120,000
Kui	Thailand Cambodia	150,000 70,000	30 50	220,000
"Mnong" (including Budong, Kil, Preh, etc.)	South Vietnam Cambodia	50,000 30,000	50 50	80,000
Pear	Cambodia	10,000	50	10,000
Saoch	Cambodia	1,000	50	1,000
Sre	South Vietnam	35,000	30	35,000
Stieng	South Vietnam Cambodia	40,000 40,000	30 30	80,000
Other scattered groups	South Vietnam, Cambodia, Thailand			10,000
B. Viet-Muong				
Vietnamese	North Vietnam South Vietnam Cambodia Thailand Laos	16,980,000 14,770,000 420,000 25,000 25,000	5 5 10 50 50	32,220,000
Muong	North Vietnam South Vietnam	450,000 40,000	20 50	490,000

	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
C. Senoi-Semang				
Senoi (including Semai, Temiar, etc.)	Malaya	50,000	30	50,000
Semang	Malaya	10,000	50	11,000
	Thailand	1,000	50	
II. MALAYO-POLYNESIAN				
A. Cham				
1. Lowland groups				
Cham	Cambodia	80,000	30	130,000
	South Vietnam	50,000	30	
2. Upland groups				
Hroy	South Vietnam	10,000	50	10,000
Jarai	South Vietnam	170,000	30	180,000
	Cambodia	10,000	50	
Raglai (including Churu and Noang)	South Vietnam	50,000	?	50,000
Rhade (including Bih and Krung)	South Vietnam	120,000	30	120,000
B. Malay				
Malay	Malaya	4,570,000	5	5,830,000
	Thailand	1,000,000	5	
	Singapore	260,000	5	
Jakun	Malaya	30,000	50	30,000
Moken ("Sea Gypsies")	Burma	5,000	50	15,000
	Thailand	5,000	50	
	Malaya	5,000	50	
III. SINO-TIBETAN				
A. Karen				
Sgaw sub-group	Burma	1,000,000	10	2,480,000
	Thailand	60,000	10	
Pwo sub-group	Burma	910,000	10	
	Thailand	20,000	10	
Pa-O sub-group	Burma	430,000	10	
Kayah sub-group	Burma	60,000	10	
B. Miao-Yao				
Miao or Meo	North Vietnam	260,000	30	420,000
	Laos	100,000	30	
	Thailand	60,000	20	

	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
Yao or Man	North Vietnam	215,000	30	250,000
	Laos	15,000	50	
	Thailand	15,000	20	
	South Vietnam	5,000	50	
C. Sinitic				
Chinese (including some eight distinct dialects)	Thailand	3,500,000	15	10,350,000
	Malaya	3,200,000	5	
	Singapore	1,530,000	5	
	South Vietnam	950,000	5	
	Cambodia	450,000	10	
	Burma	440,000	10	
	North Vietnam	220,000	10	
	Laos	60,000	20	
D. Tibeto-Burman				
1. Burmese	Burma	19,400,000	10	19,457,000
	Thailand	5,000	50	
	Cambodia	2,000	50	
2. Western Upland groups				
Chin	Burma	360,000	30	360,000
Naga	Burma	120,000	50	120,000
3. Eastern Upland groups				
Akha	Burma	55,000	50	95,000
	Thailand	30,000	30	
	Laos	10,000	50	
"Ho" (including Lolo and Woni)	North Vietnam	40,000	50	80,000
	Laos	30,000	50	
	Thailand	10,000	50	
Kachin or Jinghpaw (including Kadu)	Burma	700,000	20	700,000
Lahu	Burma	70,000	20	95,000
	Thailand	15,000	20	
	Laos	10,000	50	
Lisu	Burma	40,000	40	60,000
	Thailand	20,000	10	
Lutzu	Burma	15,000	50	15,000

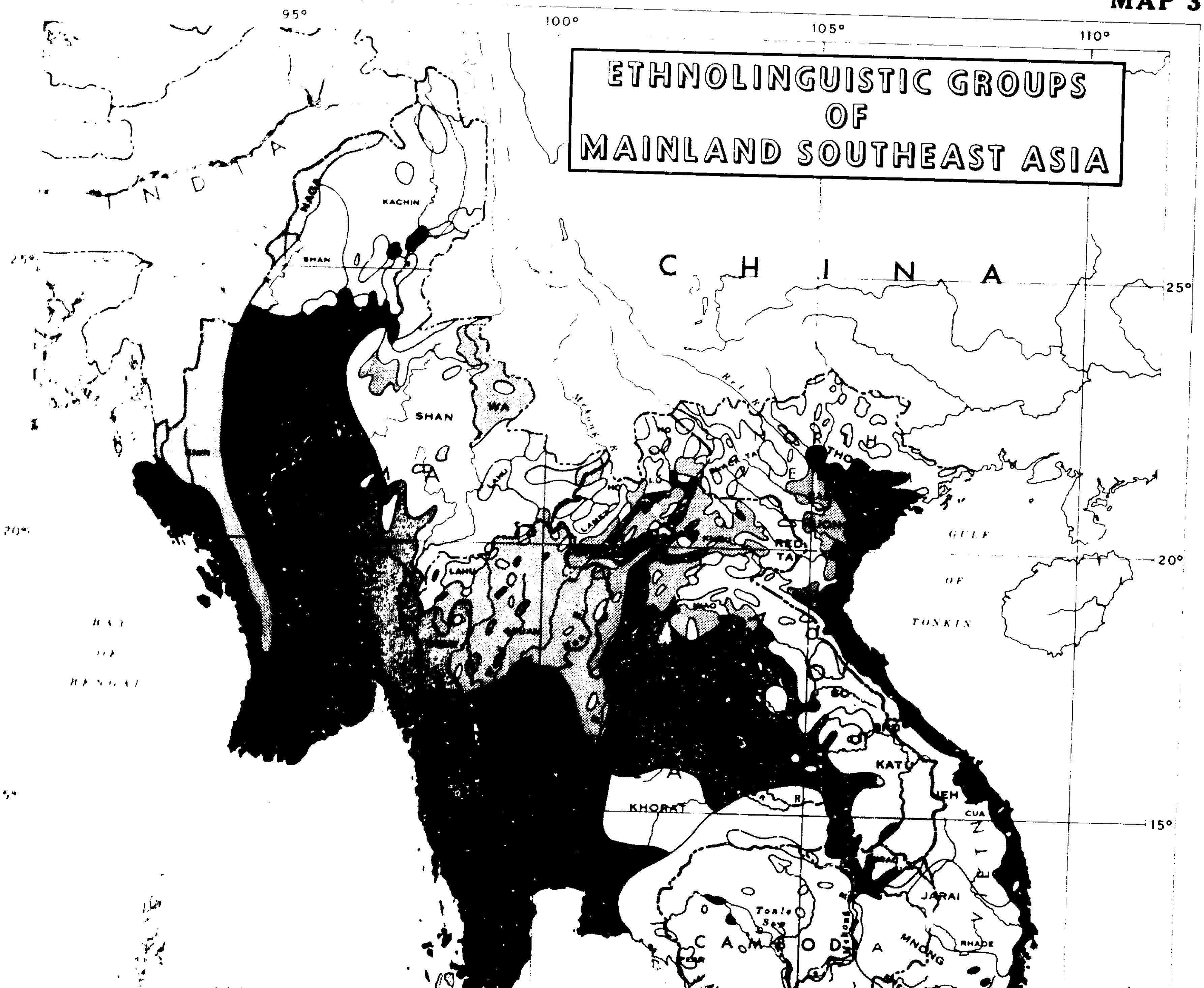
	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
IV. TAI				
A. Thai				
Central Thai or Siamese dialect	Thailand	10,760,000	5	
Northern Thai (Yuan or Kham Muang) dialect	Thailand	3,800,000	5	
	Laos	10,000	50	
Southern Thai (Pak Tai or Dambro) dialect	Thailand	2,900,000	5	19,435,000
	Malaya	20,000	50	
Khorat Thai dialect	Thailand	1,930,000	5	
	Cambodia	15,000	50	
Northeastern Thai (see Laotian below)				
B. Mekong River groups				
Laotian (=Northeastern Thai dialect)	Thailand	7,655,000	5	
	Laos	1,730,000	15	9,400,000
	Cambodia	15,000	50	
Khün	Burma	100,000	50	100,000
Lü	Burma	60,000	50	
	Thailand	60,000	50	160,000
	Laos	40,000	50	
C. Shan	Burma	1,500,000	30	1,560,000
	Thailand	60,000	10	
D. North-Central Upland groups				
"Black" Tai	North Vietnam	320,000	20	
	South Vietnam	20,000	50	360,000
	Laos	20,000	50	
"White" Tai	North Vietnam	30,000	50	35,000
	South Vietnam	5,000	50	
"Red" Tai	Laos	40,000	50	
	North Vietnam	20,000	50	65,000
	South Vietnam	5,000	50	
Neua or Tai Neua	Laos	70,000	50	70,000
Phuan	Laos	10,000	50	10,000
Phuthai	Thailand	90,000	20	140,000
	Laos	50,000	50	
Sek	Laos	20,000	50	25,000
	Thailand	5,000	50	
Other scattered groups				20,000

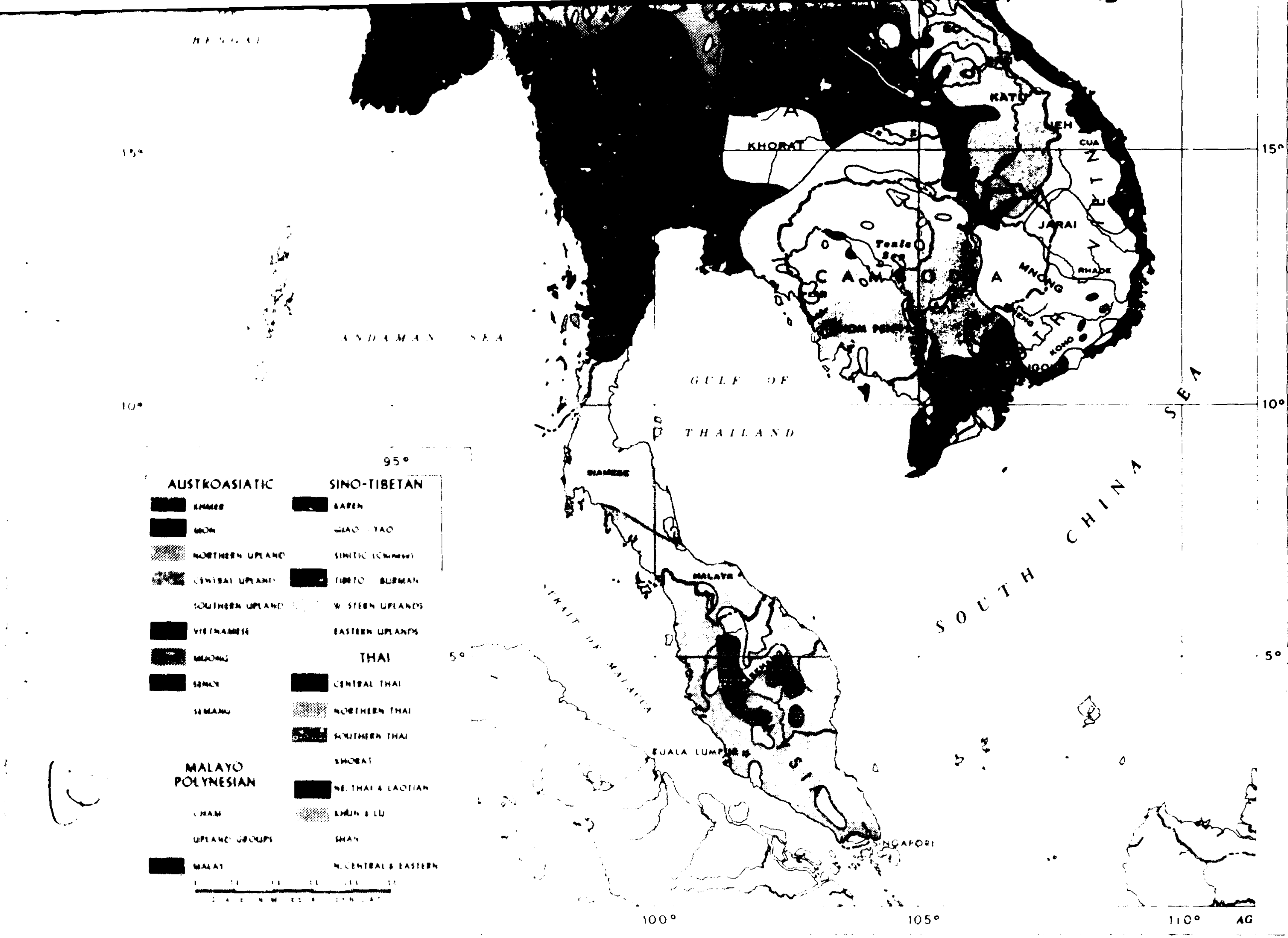
	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
E. Eastern groups				
Nhang	North Vietnam	20,000	20	20,000
Nung	North Vietnam	340,000	20	350,000
	South Vietnam	10,000	50	
Tho	North Vietnam	580,000	20	585,000
	South Vietnam	5,000	50	

Two important minority groups--primarily urban, and speaking a number of languages--in Southeast Asia should be added to this list for completeness:

	Country or Region	Estimated Population	Reliability Estimate (% + or -)	Population Total
1. Indians and Pakistanis	Malaya	940,000	10	1,384,000
	Singapore	180,000	10	
	Burma	180,000	50	
	Thailand	70,000	40	
	Cambodia	5,000	50	
	South Vietnam	4,000	50	
	Laos	4,000	50	
	North Vietnam	1,000	50	
2. Europeans and Eurasians	Malaya	70,000	20	340,000
	South Vietnam	70,000	20	
	Singapore	50,000	20	
	Burma	40,000	30	
	North Vietnam	30,000	50	
	Cambodia	30,000	50	
	Laos	25,000	50	
	Thailand	25,000	50	

MAP 3


ETHNOLINGUISTIC GROUPS
OF
MAINLAND SOUTHEAST ASIA
95°
100°
105°
110°
25°
20°
15°
C H I N A
I N D I A
KACHIN
NAGA
SHAN
SHAN
WA
THO
RED TAI
MEO
GULF
OF
TONKIN
BAY
OF
BENGAL
KATU
KHORAT
CUA
JARAI
RHADE
MNONG
Tonle Sap
C A M B O D I A



KHORAT
KATU
CUA
JARAI
RHADE
MNONG
KOHO
CAMBODIA
Tonle Sap
GULF OF THAILAND
SOUTH CHINA SEA
ANDAMAN SEA
STRAIT OF MALACCA
MALAYA
KUALA LUMPUR
SINGAPORE
15°
10°
5°
95°
100°
105°
110°
AUSTROASIATIC
KHMER
MON
NORTHERN UPLAND
CENTRAL UPLAND
SOUTHERN UPLAND
VIETNAMESE
MUONG
SENOI
SEMANG
SINO-TIBETAN
KAREN
MIAO - YAO
SINITIC (Chinese)
TIBETO - BURMAN
WESTERN UPLANDS
EASTERN UPLANDS
THAI
CENTRAL THAI
NORTHERN THAI
SOUTHERN THAI
KHORAT
NE THAI & LAOTIAN
KHUN & LU
SHAN
N. CENTRAL & EASTERN
MALAYO POLYNESIAN
CHAM
UPLAND GROUPS
MALAY
AG

DOMINANT ETHNO-POLITICAL MAJORITIES AND ETHNIC MINORITY TYPES

Just as a knowledge of the ethnic and linguistic diversity of the region contributes to a better understanding of the human problems that may be encountered by military forces, so does a knowledge of the dominant and minority groups within each country.

The success of military missions in Southeast Asia may depend to a considerable extent upon an understanding of the customs and traditions of ethnic majority and minority groups within individual countries. Also of importance is a knowledge of the attitudes of such peoples toward neighboring groups, neighboring countries, and to the national policies of the country within which they live. Map 4 has been designed to portray Southeast Asia's political majority groups and certain characteristic types of ethnic minorities. In this map, each country must be considered separately, since a people who constitute a dominant political majority in one country may be a minority group in a neighboring country.

In general, each Southeast Asian country is governed by an ethnic group which is densely settled on plains or in river deltas where lowland rice is cultivated (the Burmese in Burma, the "Thai proper" or Central Thai in Thailand, the Khmer in Cambodia, etc.). In every country, however, there are important urban minority groups and in most countries there are also sizable tribal or semi-tribal populations, generally living in the hills and mountains. The upland tribal peoples (essentially the "Montagnards" of French usage) tend to be regarded and treated as less "civilized" or as inferior by the dominant lowland peoples, and the tribal peoples in turn prize some degree of political aloofness or independence from the dominant majority. Both the "primitive" tribes and the peasant minorities are likely to differ from the dominant ethnic majority in one or more of the following characteristics (approximate order of importance): language, culture, dress, historical association, economy, religion, and race or physical appearance.

Map 4 distinguishes between:

a. The dominant ethnic majority <u>in each country</u>. In every country except Singapore the dominant ethnic group has its primary locus in fertile rice-producing deltas, coastal plains, or river valleys.

b. Upland tribal minorities. These are relatively small, remote, politically decentralized and "primitive" tribal groups, located mostly in mountains and jungles.

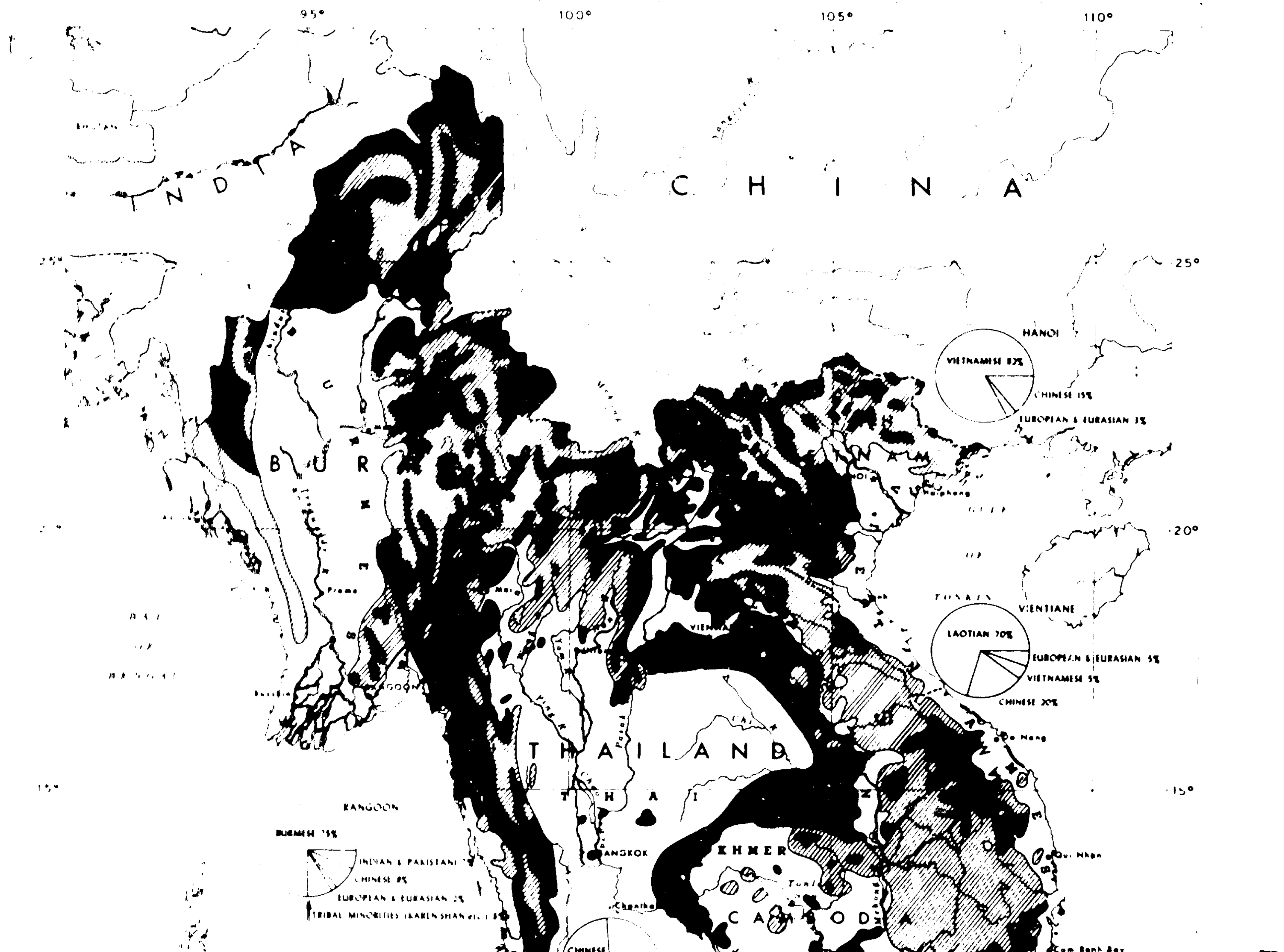
c. Peasant ethnic minorities or tribes. These are relatively larger, more acculturated and politically unified minority groups.

d. Urban and "irredentist" ethnic minorities. These peoples represent an overflow or migration of the dominant ethnic group of a neighboring or a nearby country, whether an essentially urban group of middlemen such as the Chinese in the Republic of Vietnam, a specialized immigrant labor force such as the South Indian rubber plantation workers in Malaya, or simply a contiguous peasant extension from a neighboring country, such as the Khmers in Thailand and South Vietnam.

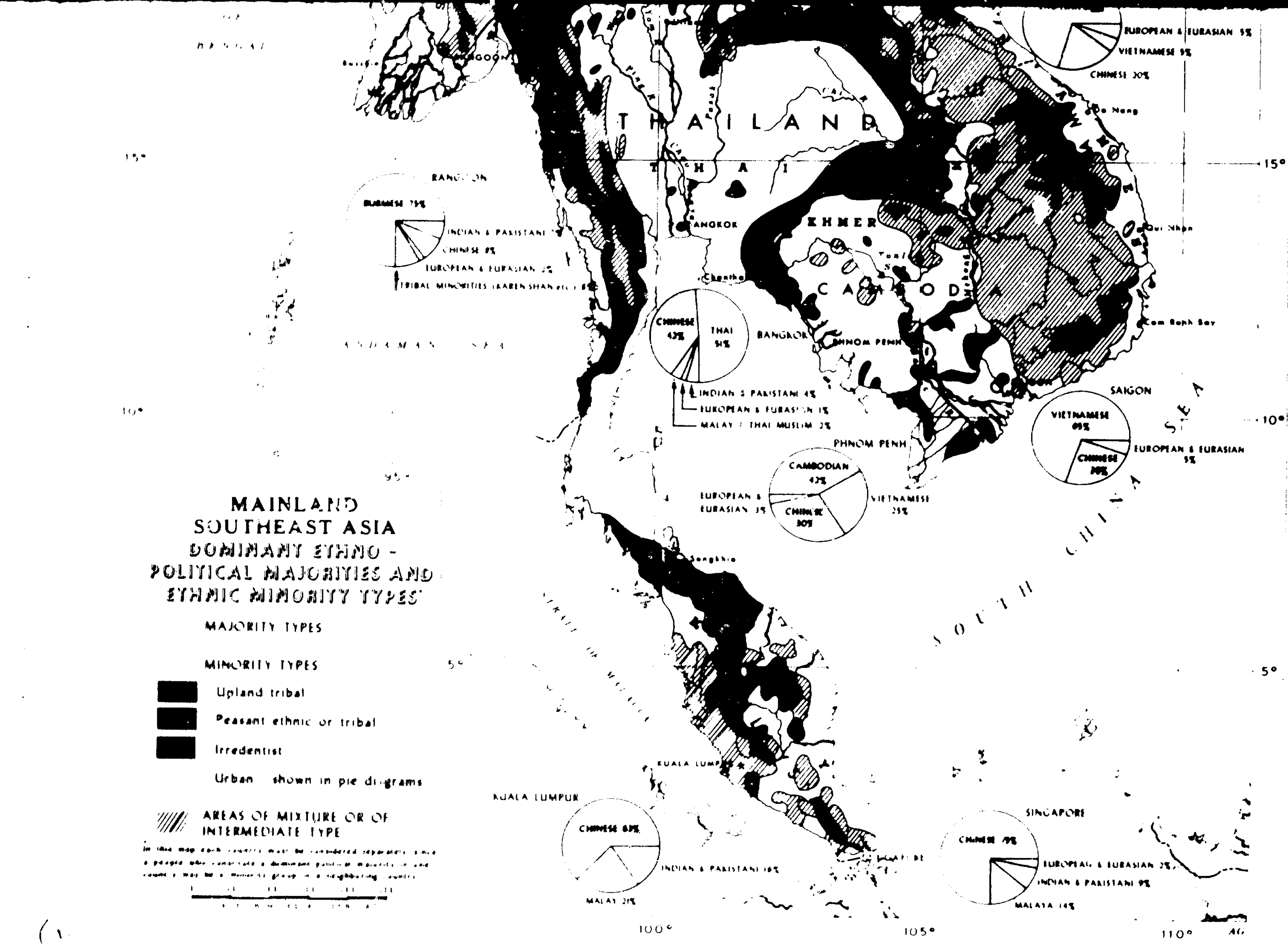
Although these "ideal types" of ethnic minorities may be distinguished in the abstract, in social reality there are many gradations and mixtures among them, as this map partly recognizes by intermediate shadings.

It should be noted also that only ethnic minorities are included here. Religious, political and other types of minorities are excluded, although they may be quite important in some areas (e.g., the Roman Catholic, Cao Dai and Hoa Hao religious minorities in the Republic of Vietnam).

MAP 4



95°
100°
105°
110°
25°
20°
15°
INDIA
CHINA
BURMA
THAILAND
CAMBODIA
KHMER
HANOI
VIETNAMESE 82%
CHINESE 15%
EUROPEAN & EURASIAN 3%
VIENTIANE
LAOTIAN 70%
EUROPEAN & EURASIAN 5%
VIETNAMESE 5%
CHINESE 20%
RANGOON
BURMESE 75%
INDIAN & PAKISTANI
CHINESE 8%
EUROPEAN & EURASIAN 2%
Haiphong
Da Nang
Qui Nhon
Cam Ranh Bay
BANGKOK
Prome
CHINESE



MAINLAND SOUTHEAST ASIA
DOMINANT ETHNO - POLITICAL MAJORITIES AND ETHNIC MINORITY TYPES
MAJORITY TYPES
MINORITY TYPES
Upland tribal
Peasant ethnic or tribal
Irredentist
Urban shown in pie diagrams
AREAS OF MIXTURE OR OF INTERMEDIATE TYPE
THAILAND
CAMBODIA
KHMER
SOUTH CHINA SEA
ANDAMAN SEA
RANGOON
BURMESE 75%
INDIAN & PAKISTANI
CHINESE 8%
EUROPEAN & EURASIAN 2%
TRIBAL MINORITIES (KAREN SHAN etc.)
BANGKOK
CHINESE 43%
THAI 51%
INDIAN & PAKISTANI 4%
EUROPEAN & EURASIAN 1%
MALAY / THAI MUSLIM 2%
PHNOM PENH
CAMBODIAN 42%
CHINESE 30%
VIETNAMESE 25%
EUROPEAN & EURASIAN 3%
SAIGON
VIETNAMESE 65%
CHINESE 30%
EUROPEAN & EURASIAN 5%
CHINESE 30%
VIETNAMESE 5%
EUROPEAN & EURASIAN 5%
KUALA LUMPUR
CHINESE 63%
INDIAN & PAKISTANI 16%
MALAY 21%
SINGAPORE
CHINESE 75%
EUROPEAN & EURASIAN 2%
INDIAN & PAKISTANI 9%
MALAYA 14%
Da Nang
Qui Nhon
Cam Ranh Bay
Chanthaburi
Songkhla
15°
10°
5°
95°
100°
105°
110°

MALARIA ENDEMICITY

Malaria incidence has traditionally been defined in terms of either parasite rate (the percentage of individuals in a given human population who are found to contain the malaria parasite in their blood) or spleen rate (the percentage of children aged 2 to 10 with enlarged spleens--an invariable concomitant of malarial infection). In practice the two indices have been found to correlate closely, and since spleen rates are by far the more easily identified in large, remote or scattered populations, the World Health Organization has adopted this index as its standard for defining malaria endemicity, recognizing four levels of severity:

a. Holoendemic (spleen rate over 75%)

b. Hyperendemic (spleen rate 50 - 75%)

c. Mesoendemic (spleen rate 10 - 50%)

d. Hypoendemic (spleen rate under 10%)

It is not easy, however, to portray malaria endemicity on a map except in very broad general terms. In the first pla , the spleen rate or the parasite rate can vary enormously (e.g., from 0% to 100% within a ten-mile radius in one survey in Malaya) due to the many special and localized factors which will be noted below. Secondly, on any short-term or up-to-date basis the malaria indices can change precipitously: downwards with the intensive application of control and eradication measures, or upwards when these are interrupted by war, ecological shifts, or when epidemics sweep an area. Finally, many modern malariologists believe that the traditional malaria indices are useless if not misleading, since they entirely fail to distinguish the complex interplay of causative factors which we are only beginning to understand and which require much more work by parasitologists, entomologists, ecologists, and geneticists.

Malaria is an extremely debilitating and, especially in infants, a potentially lethal disease caused by a protozoon of the genus Plasmodium. For the completion of its life cycle (and hence for the persistence of malaria in human populations) the parasite requires an intermediate host: any of numerous species of Anopheles mosquitoes. The sporozoite phase of the plasmodium is spent in the mosquito and the gametocyte phase in the human host. In view of the intimate interrelationships of three different animals--man, mosquito and micro-organism--which are necessary to maintain endemic malaria, the actual occurrence and rate of malarial endemicity in a given time and place in Southeast Asia are strongly affected by factors such as those described below.

a. Plasmodium type. Four major species, with various and newly-emergent strains, of human plasmodia are recognized: P. vivax, P. falciparum, P. malariae and P. ovale. Each tends to produce a distinctive pattern of malarial fever in the patient (the so-called "quartan," "tertian," "estivo-autumnal," etc.), but simultaneous infection by two or more plasmodial types can complicate these patterns. Ovale malaria is generally mild, vivax malaria can be the most debilitating, while falciparum malaria is particularly lethal. In addition, there is recent evidence that the plasmodia P. cynomolgi and P. knowlesi, which normally cause malaria only in such simians as monkeys and gibbons, can in certain situations also infect man.

Plasmodium falciparum is the dominant malarial parasite in Southeast Asia, although P. vivax and P. malariae are also present. Falciparum malaria tends to be associated with "stable" or holoendemic malari a condition in which the adult population (but not the children) shows a low spleen rate and a high tolerance of the disease as compared to non-immune visitors to the area.

b. Chemotherapy. Chemotherapeutic agents reduce malaria dramatically by eliminating plasmodia from the bloodstream and the liver. However, drug-resistant strains of plasmodia, especially P. falciparum, have recently appeared in Southeast Asia. Thus, parasite rates have again increased in some areas where control measures had previously caused them to fall sharply.

c. Mosquito type. Over 100 species and subspecies of anopheline mosquitoes occur in Southeast Asia, most of which are in fact incapable of carrying malaria. However, in any given locality of a malarious zone there are likely to be from one to six Anopheles species which can transmit at least one of the types of plasmodium. Each species has distinctive habits and tends to be associated with a characteristic pattern of malaria. The actual occurrence of a species of Anopheles and its effectiveness as a carrier of malaria are in turn dependent upon various factors, described below.

d. Breeding site. The various species of Anopheles in a given locale tend to have distinct and non-competitive breeding site preferences, that is, the kind of water in which the larval form can thrive or at least survive rather than perish. (Only about 15 days elapse from hatching to emergence of the adult mosquito.) For example, one species requires water in full sunlight while another prefers shade; one requires flowing water, another stagnant; one will die in saline water, while another prefers it. Temperature, mineral or organic content, and other qualities of the water are presumably involved as well. Given these important requirements, it is not difficult to see that human transformation of the environment (the cutting of forests, the draining of swamps, the creation of reservoirs of water by irrigation, by discarding tin cans, by making footprints, etc.) acts as a potent influence in favoring one species over another. In Malaya, for example, different locales in the country have been shown to have unique histories of malaria based on their particular chronologies of ecological, microclimatic and vector succession--sometimes even including a transitory phase that is entirely malaria-free.

e. Climate. This is a determining or modifying factor in relation to both the plasmodium and the mosquito vector. The optimum temperature and humidity for both of these may vary slightly according to species, but they generally are most closely approximated in the humid tropics. World distribution of malaria shows that with the lowering of average temperatures, whether due to altitude or latitude, malaria lessens and becomes more sharply seasonal in occurrence, eventually disappearing altogether in the cold temperate regions. In Southeast Asia malaria tends to decrease as the altitude rises over 3000 feet, but does not disappear until about 7000-8000 feet. A pronounced seasonality of incidence is generally characteristic of malaria in Southeast Asia, since the parasite and vector respond quickly to changes in temperature and rainfall, and to the sudden expansion of suitable breeding sites. The peak occurrence of malaria generally falls near the end of the monsoon season.

f. Mosquito behavior. Some Anopheles species limit their biting entirely to cattle or other animals, while other species are markedly anthropophilic. Some even show as yet little-understood fluctuations in feeding preference, perhaps related to seasonal or life-cycle factors. Another significant difference in mosquito biting behavior relates to the fact that some species are much more averse than others to alighting on a moving body, and thus tend to bite their victim only when he is sleeping. Anopheline species also vary greatly in the time of day or night at which they prefer to feed, and in some cases biting activities may be restricted to relatively narrow time limits. The amount of blood ingested by the mosquito at a single feeding also bears a relationship to malaria transmission. Thus, A. minimus minimus is estimated to consume an average of 0.55 mg. of blood at a meal, while the amount ingested by A. balabacensis is 1.53 mg. This implies that there is nearly three times the likelihood of ingestion by the mosquito of malaria gametocytes from the human bloodstream in the case of a bite from A. balabacensis as from A. minimus minimus.

g. Mosquito infection rate. Infection rate refers to the proportion of individual mosquitoes of a given species which are found to be infected by malaria sporozoites. It is determined by making hundreds of dissections. The infection rate of A. balabacensis, in sites where it has been carefully studied in Thailand, has been found to be 8.7% while that of A. minimus minimus is 2.5%. Some anopheline vectors in Southeast Asia have infection rates so low that they can usually be ignored for practical purposes. Yet the possibility of their serving as a temporary or epidemic vector is always present.

h. Mosquito longevity. Longevity of the adult mosquito is another critical factor affecting the role of a given species at a particular time and place as a malaria vector. A. balabacensis lives over a month, but some species have only a one-week life span. Malariologists have attempted to quantify a "transmission index" based upon the mathematical combination of such factors as the mosquito infection rate, the daily man-biting frequency of the particular species and the length of life of the average individual mosquito of the species. A relatively high index is required to maintain "stable" or hyperendemic malaria. However, serious malaria epidemics with high mortality are most likely to occur seasonally in areas with a low transmission index; indeed, where malaria is holoendemic, epidemics as such do not occur.

i. Man-mosquito proximity. Proximity of human habitation to a mosquito's breeding site is often a determining factor in malaria rates. Most anopheline mosquitoes do not fly more than two or three hundred yards from their breeding site and in Malaya a difference of only a few hundred yards in the location of houses relative to the jungle has been found to produce large variations in the malaria rate within a given community or population. However, A. balabacensis is virtually absent in Malaya, and this dangerous vector does fly over a mile from its breeding site in order to feed.

j. Protective devices. Knowledge of the mosquito's role in malaria transmission among Southeast Asian natives is relatively recent and indigenous protective devices against the annoyance of biting mosquitoes were poorly developed. It was only with the introduction of mosquito nets that a really effective device (when used properly) became available to reduce the hazard of mosquito bites. Malaria surveys in

Southeast Asian towns and cities invariably show an inverse correlation of malaria rates with socio-economic status and with education or literacy, due at least in part to the widespread use of mosquito netting by the social elite in the population.

k. Control and eradication. Although larvicides have been used against mosquitoes for decades, it was only with the large-scale employment of DDT in residual spraying against adult mosquitoes after 1945 that complete eradication of malaria could be achieved in the U.S.A. and many other hypoendemic regions. In addition, the prospect of control and ultimately of eradication throughout the world could at least be entertained. However, both larvicides and insecticides have proved to be highly selective in their effectiveness, depending on the habits of the particular species. In Southeast Asia, the reduction or elimination of a principal vector in a particular region often results in the emergence of a less susceptible, previously secondary, vector. The spraying of house walls initially reduced malaria rather dramatically, since it was particularly effective against A. minimus minimus, long recognized as the principal malaria vector in the region. However, hopes for the complete eradication of malaria in Southeast Asia, at least in the forest or jungle uplands, have for the moment been dashed as a result of knowledge recently gained about A. balabacensis, a jungle mosquito which does not rest on house walls and whose breeding sites are almost impossible to eliminate or to spray.

l. Genetic adaptation and resistance. The worst augury for the success of malaria eradication programs is the appearance of drug-resistant strains of P. falciparum, and in the case of mosquitoes the behavioral aversion and genetic resistance both to DDT and to the steady stream of improved chlorinated hydrocarbons, organosphors and other compounds used as insecticides. The especially villainous role of A. balabacensis in Southeast Asia today is again shown in its close association with those strains of the dangerous falciparum plasmodium which have become most drug-resistant. In view of the failure of clinical malaria to respond to chloroquine, primaquine, etc., it has been necessary to return to large doses of quinine to combat the resistant strains of this parasite.

m. Cultural and other factors. Much has yet to be discovered about even the most basic of mechanisms in malaria transmission and their interactions. In Malaya, for example, settlements at sea level in one local area of the coastal plain show low spleen rates, but others which are completely identical except for standing on a slightly raised ground elevation (about 25 ft.) have a spleen rate of over 60%. The large difference in malaria rate here represents some as yet unexplained preference of the vector, A. maculatus.

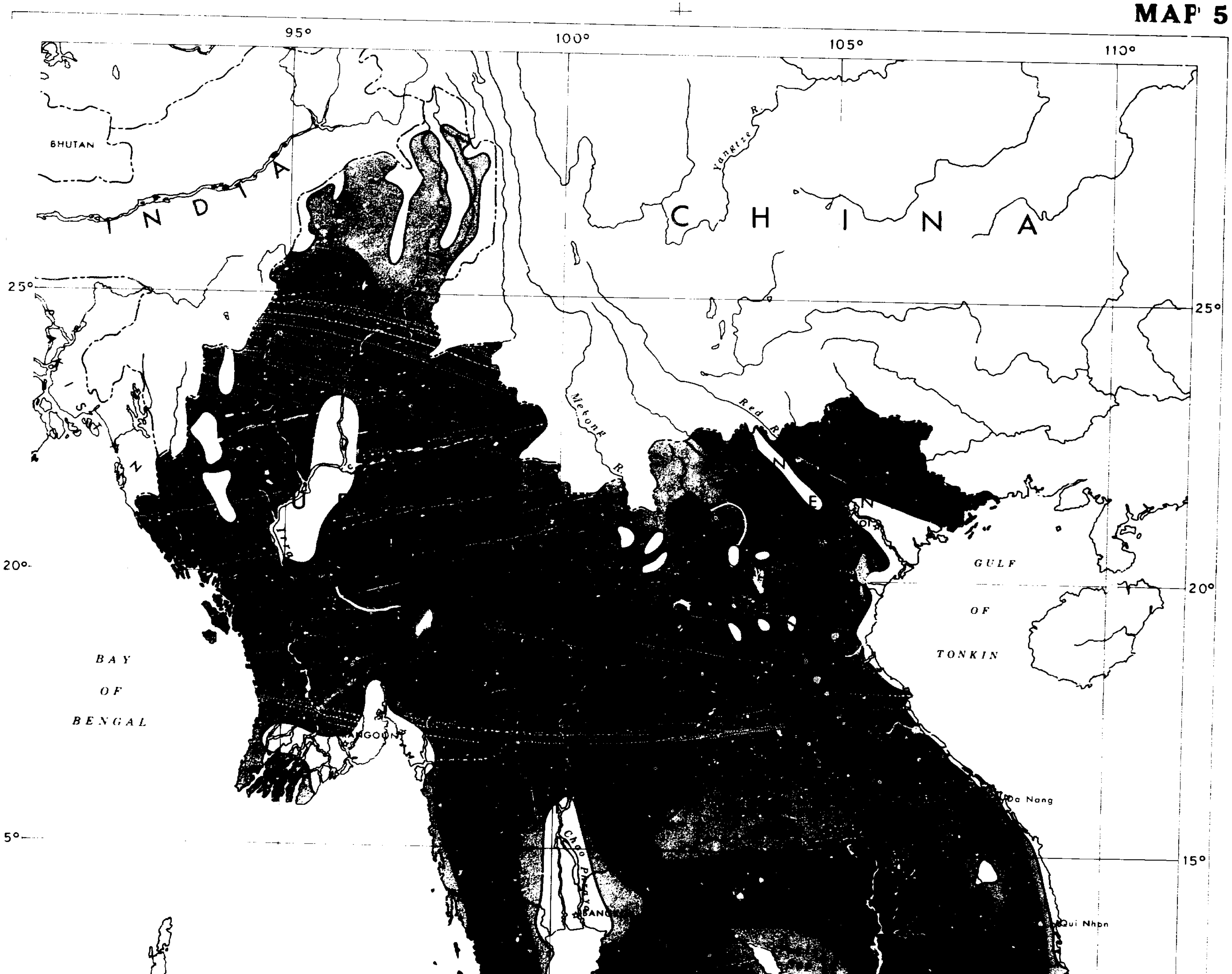
Another example of how little-understood factors may combine to produce unexpected results in malaria occurrence is that of A. annularis in Burma. This species was confidently exonerated for many years as a malaria vector, since it is normally zoophilous and has a brief life span. Recently, however, it has been shown that the transmission of malaria by A. annularis does occur in the September - November period, due to a remarkable combination of previously unsuspected events. These involve a seasonal rise in the parasite numbers in the blood, a temporary increase in the mosquito's longevity and its numbers (causing an overflow from cowsheds into houses), and finally a "gonotrophic discordance" causing the mosquito to remain indoors for a prolonged period and to begin feeding on man rather than on animals.

The effect of war and civil strife on malaria in Southeast Asia is obvious. Malaria eradication teams have for so long been a prime target of Viet Cong terrorism in the Republic of Vietnam that the whole country is today (early 1969) described as having regressed to the natural or pre-control stage. Residual spraying has often encountered cultural obstacles also, e.g. the custom of frequently whitewashing or renewing interior house walls, thus negating the effect of residual spraying. In some areas where DDT was originally welcomed by the people the spraying now tends to arouse hostility, partly from disillusion with earlier results.

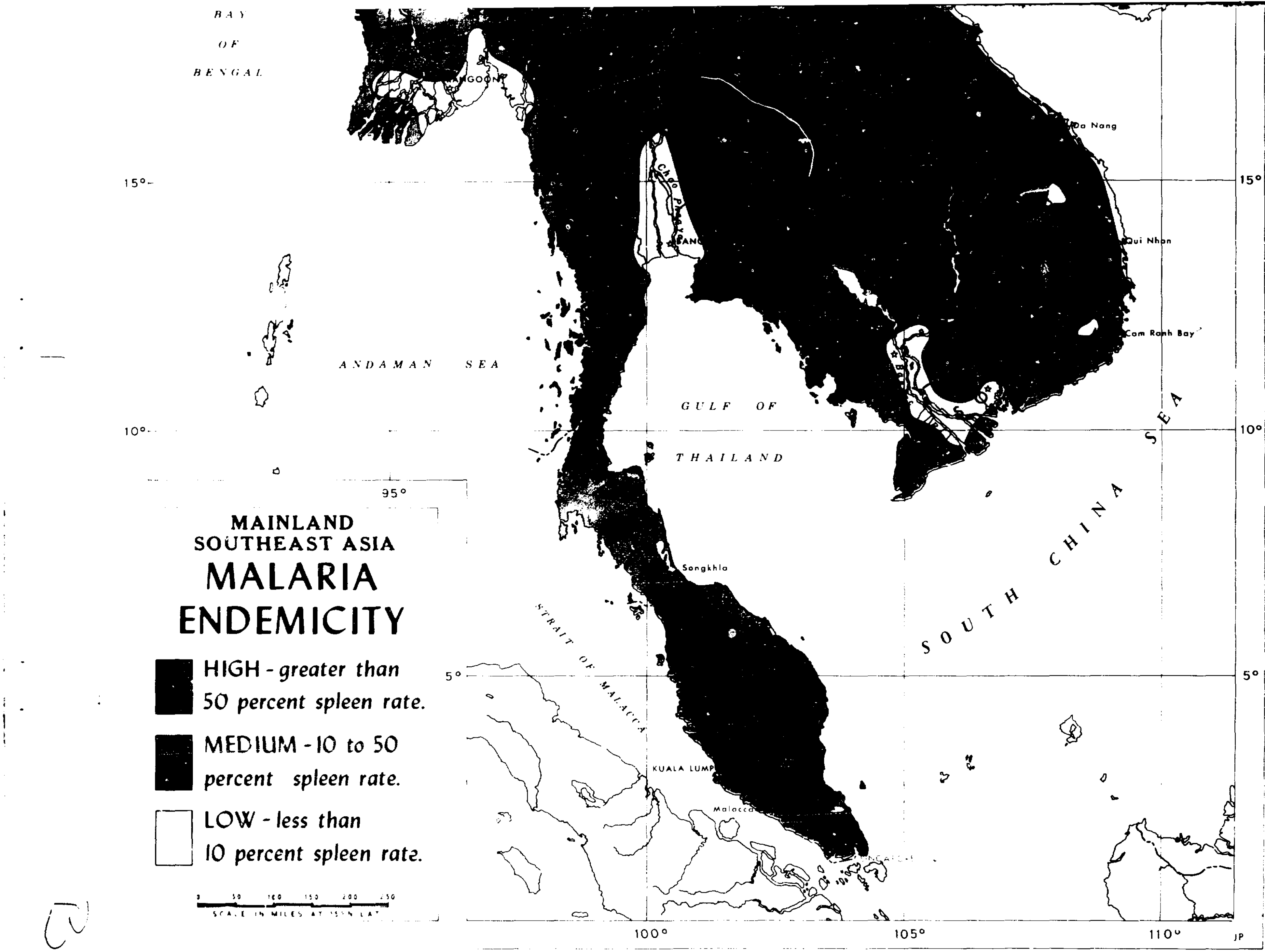
Map 5 does not attempt to show the constantly changing and highly localized patterns of malaria incidence in Southeast Asia in detail. It is rather a generalized portrayal of long-term or "natural" endemicity patterns in the region, indicating the approximate rate of malaria which would be found in the event of any prolonged interruption of man's continuous battle by means of drugs and insecticides against this formidable scourge. Thus, it can be noted that the fertile, densely populated delta areas of Southeast Asia are now and have always been relatively free of malaria. The most virulently affected areas, on the other hand, were (and still are) the forested foothills and low mountains, especially those between 100 and 1000 meters.

Of the 23 species and 16 varieties of malaria-transmitting Anopheles mosquitoes in Southeast Asia listed in a recent authoritative source, merely two--A. minimus minimus and A. balabacensis--account for most of the hyperendemic areas on this map outside of Malaya. A. minimus minimus breeds in sunlit, clear slow-running mountain streams and is highly androphilous. Given conditions of peace and an accelerated eradication program, however, A. minimus minimus appears to be much easier to control than A. balabacensis, which breeds in innumerable small depressions, such as footprints, in inland forested foothills, and which displays many other intractable characteristics as described above.

MAP 5



95°
100°
105°
110°
25°
20°
15°
BHUTAN
INDIA
CHINA
Yangtze R.
Mekong R.
Red R.
GULF OF TONKIN
BAY OF BENGAL
Da Nang
Qui Nhon


MAINLAND
SOUTHEAST ASIA
MALARIA
ENDEMICITY
HIGH - greater than 50 percent spleen rate.
MEDIUM - 10 to 50 percent spleen rate.
LOW - less than 10 percent spleen rate.
SCALE IN MILES AT 15°N LAT.
BAY OF BENGAL
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
Da Nang
Qui Nhon
Cam Ranh Bay
Songkhla
Malacca
Chao Phraya
15°
10°
5°
95°
100°
105°
110°
JP

DRINKING WATER REQUIREMENTS

Estimated drinking water requirements depicted on Map 6 have been derived from a relationship between mean daily air temperature and water needs, established by A. H. Brown (in Adolph, 1947). This relationship is also shown in graph form (Fig. 1). The curve is for drinking water requirements for soldiers doing moderate work at mean daily temperatures which might reasonably be encountered in Southeast Asian military operations. Moderate work is described as those levels of exertion demanding energy expenditures between 150 and 300 calories per hour. The mid-range example selected for Map 6 is an average daylight jungle patrol in which the men are carrying appropriate organizational weapons and ammunition, but are not burdened with packs or body armor. This level of activity has been shown to require an average output of 225 calories per hour. Other activities which would fall in this same general range include: manual of arms (168 cal/hr); bayonet drill (198 cal/hr); route road march with 60 pound packs at 2 miles per hour (234 cal/hr); and close-order drill (252 cal/hr).

Since mean daily temperature data for climatic stations in Southeast Asia were unavailable for the preparation of this map, the mean monthly temperature for the hottest month at each station has been substituted. Considered as being representative of a typical day during the hottest month, the mean monthly temperature has been applied to the graph in determining the predicted drinking water requirements for a typical day in that month.

For purposes of comparison, the reader may be interested in knowing what the 24-hour water requirements would be for an individual engaged in 8 hours of moderate work on a typical day during the hottest month (July) in a temperate, mid-latitude region. Analysis of climatic records for six stations along an east-west transect in the United States, from Natick, Massachusetts (NLABS) to Portland, Oregon, indicates that the average drinking water requirements at these locations would be 2.8 quarts.

DAILY DRINKING WATER REQUIREMENTS

QUARTS PER MAN PER 24-HOUR DAY DURING WHICH RIFLEMEN SPEND EIGHT DAYLIGHT HOURS ON JUNGLE PATROL AT AN ENERGY EXPENDITURE LEVEL OF 225 CALORIES PER HOUR.

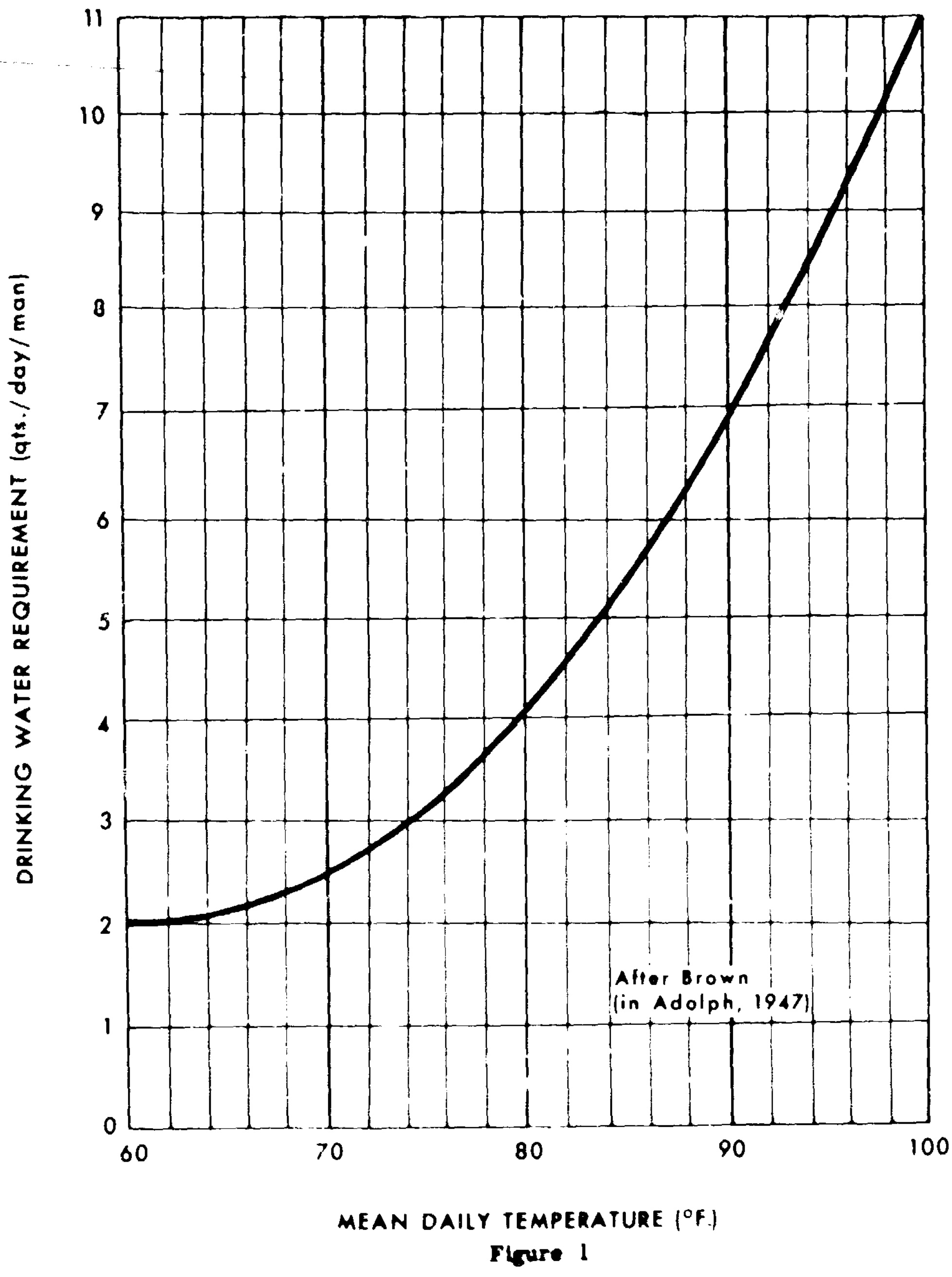
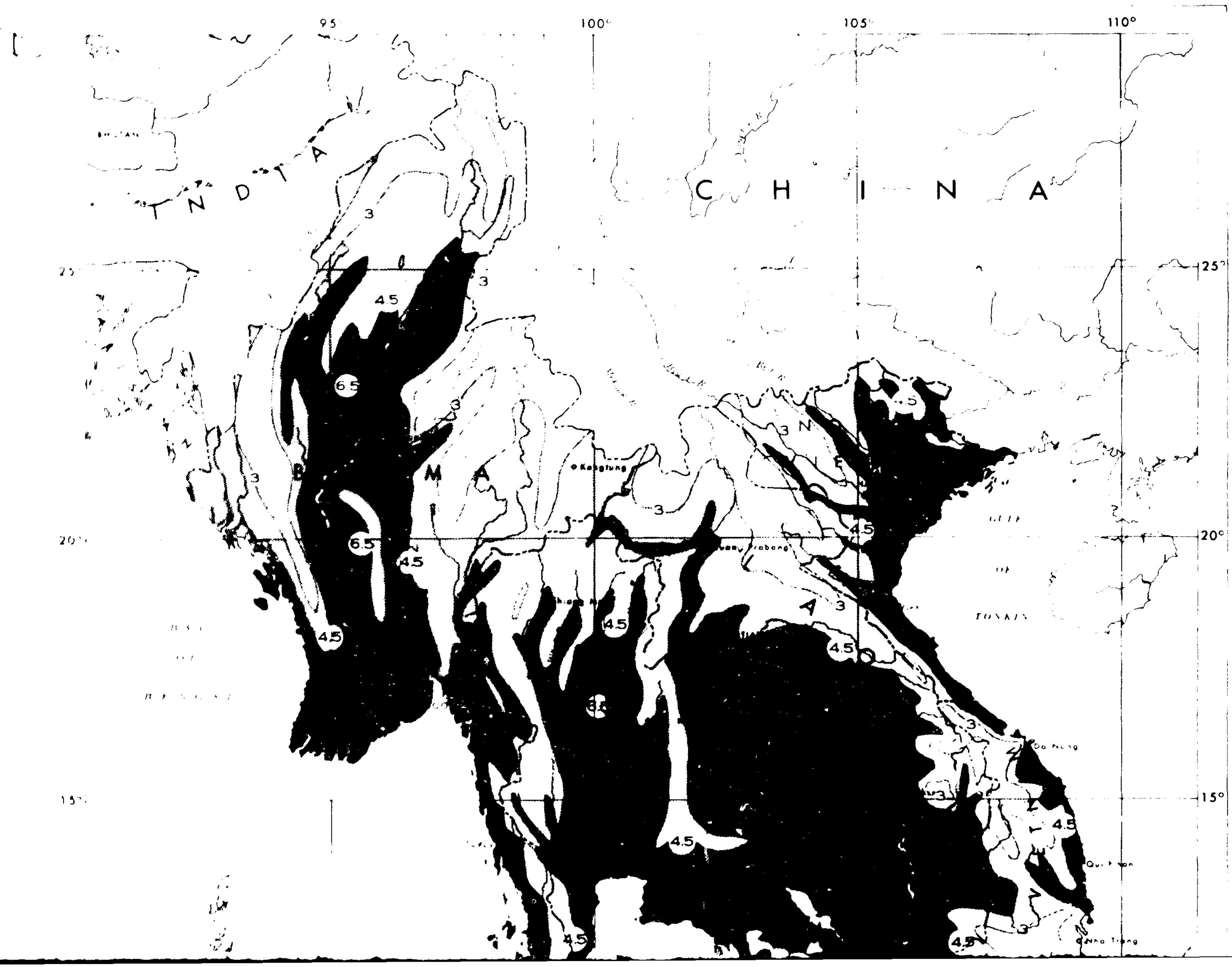
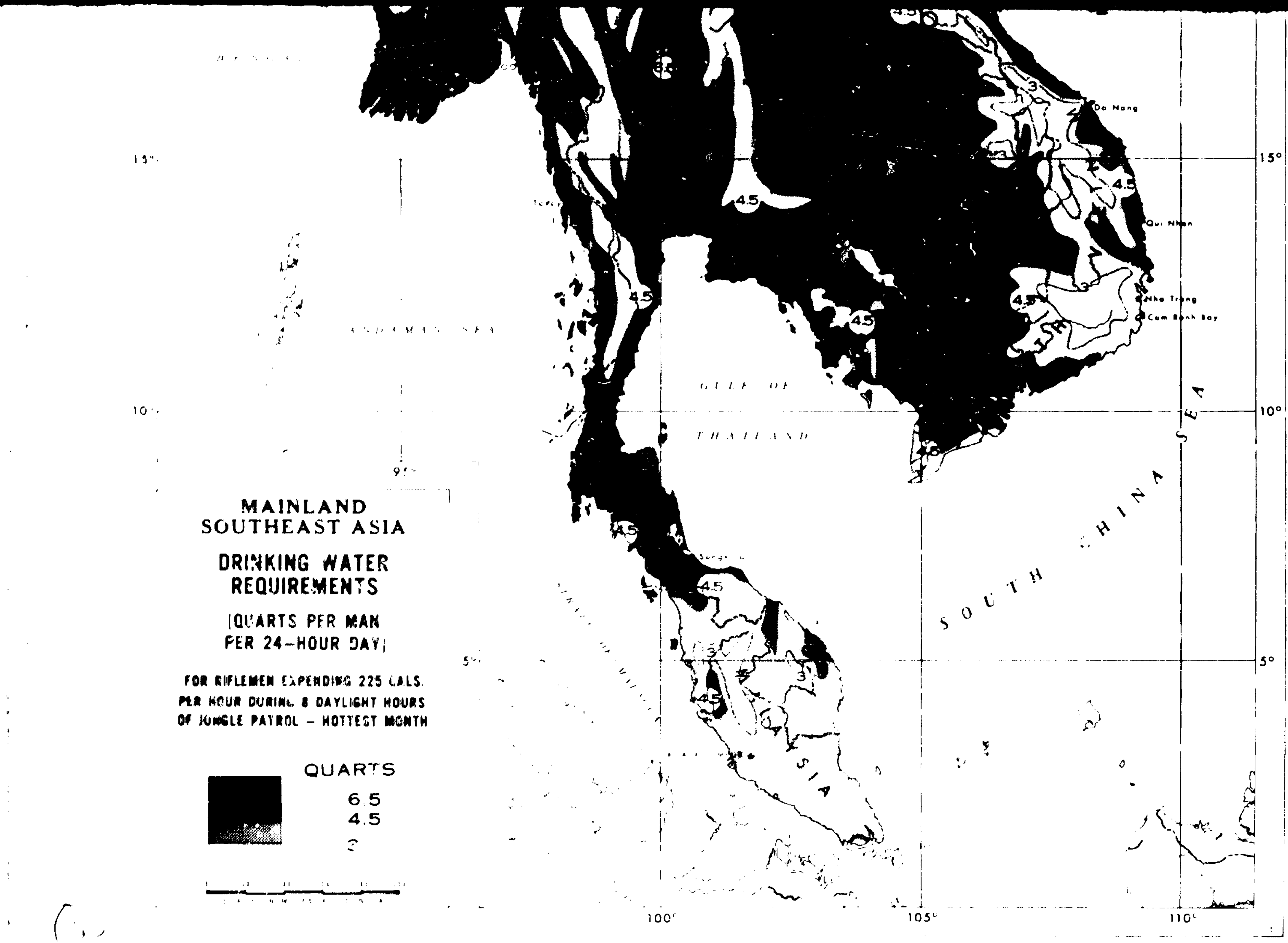


Figure 1

MAP 6



95°
100°
105°
110°
25°
20°
15°
INDIA
CHINA
BURMA
3
4.5
6.5
Da Nang
Qui Nhon
Nha Trang


MAINLAND
SOUTHEAST ASIA
DRINKING WATER
REQUIREMENTS
(QUARTS PER MAN
PER 24-HOUR DAY)
FOR RIFLEMEN EXPENDING 225 CALS.
PER HOUR DURING 8 DAYLIGHT HOURS
OF JUNGLE PATROL - HOTTEST MONTH
QUARTS
6.5
4.5
3
GULF OF
THAILAND
SOUTH CHINA SEA
Da Nang
Qui Nhon
Nha Trang
Cam Ranh Bay
15°
10°
5°
100°
105°
110°

Southeast Asia, for the most part, falls within the broad climatic classification of the "humid tropics." This is a region where the uninitiated might conceive of no situation where a shortage of drinking water would become critical. Yet there are lengthy dry periods in much of Southeast Asia when rainfall is scant and surface water is lacking. For example, 27 of 30 South Vietnamese climatic stations have recorded at least one month (during their periods of record) with less than one-tenth of an inch of precipitation. Of these 27 stations, 23 have reported three or more months during the year with a trace or less.

Totally deprived of liquid intake, man cannot be expected to survive, even under intensive medical care, past the point where his water deficit reaches 20 percent of his initial body weight. This would be equivalent to 14.4 quarts of water in the case of a 150-pound individual. At about 19 to 20 percent dehydration loss, the kidneys cease to function (anuria) and further sweating is largely derived from the circulatory system.

Figure 2 relates mean air temperature to survival time without water to a point where the weight deficit of an individual equals 20 percent. It is based on research by Adolph (1947) in which measurements of water losses by men in life rafts were made for the purpose of establishing a technique for predicting survival time for castaways at sea. Results of this study were subsequently applied to desert survival predictions by U. S. Army research physiologists. The validity of this application and of the continued use of these early data is substantiated by the unmodified acceptance and reproduction of original Adolph curves in an exhaustive compendium published by the American Physiological Society (Lee, 1964), and many other recent works (e.g., A. V. Wolf, 1958; Leithead and Lind, 1964).

A resting man (expending about 80 calories per hour) without water in the tropical forest can be expected to reach his limit of endurance in 9 days when the temperature averages 70°F. At 60°F he may survive for as many as 10 days, whereas at 100°F he probably would not survive the second day. There is some reason to believe that heavy individuals might survive longer than thin types; however, there are complex physiological interactions countering one another, and this, coupled with the fact that clinical evidence is extremely scarce beyond 11 percent dehydration, leaves the question currently unresolved.

Map 7 shows the distribution of mean survival times without water during the hottest month(s) in Southeast Asia. The user should note that these data are based on mean monthly temperatures, and that 90°F is the highest computed for the region (equivalent to 4.5 days survival). If a man is immobilized without water during a shorter period averaging 100°F, as previously noted, his survival expectancy would be reduced to less than half that at 90°F.

The most dangerous areas in Southeast Asia are located in the middle Irrawaddy Valley of Burma and the Central Menam Valley of Thailand where mean survival time in April would likely be less than 5 days. Certain highland stations in North Vietnam and the Republic of Vietnam have survival times in excess of 10 days.

Table III, which shows symptomological relationships to percent of dehydrated weight loss illustrates progressive stages in physiological deterioration.

TABLE III: SYMPTOMOLOGICAL RELATIONSHIPS TO PERCENT OF DEHYDRATED WEIGHT LOSS

Percent Body Weight Loss	Symptoms
4	Marked discomfort, anorexia
6	Stumbling, vertigo, flushed skin, sleeplessness
8	Disturbed balance, labored breathing, impaired speech
10	Spasticity
12	Delirium, wakefulness
14	Shriveled skin, inability to swallow (self-help ends)
16	Sunken eyes, dim vision
17	Numb skin, deafness
18	Stiffened eyelids
19	Cracked skin, kidney failure, blood sweat

SEDENTARY SURVIVAL TIME IN SHADE WITHOUT WATER

BASED ON CONTINUOUS DEHYDRATION TO THE POINT WHERE WATER LOSS REACHES 20% OF INITIAL BODY WEIGHT (WATER WEIGHS 2.0825 LBS. PER QUART, HENCE A 14.4 QUART LOSS IN A 150 LB. INDIVIDUAL.)

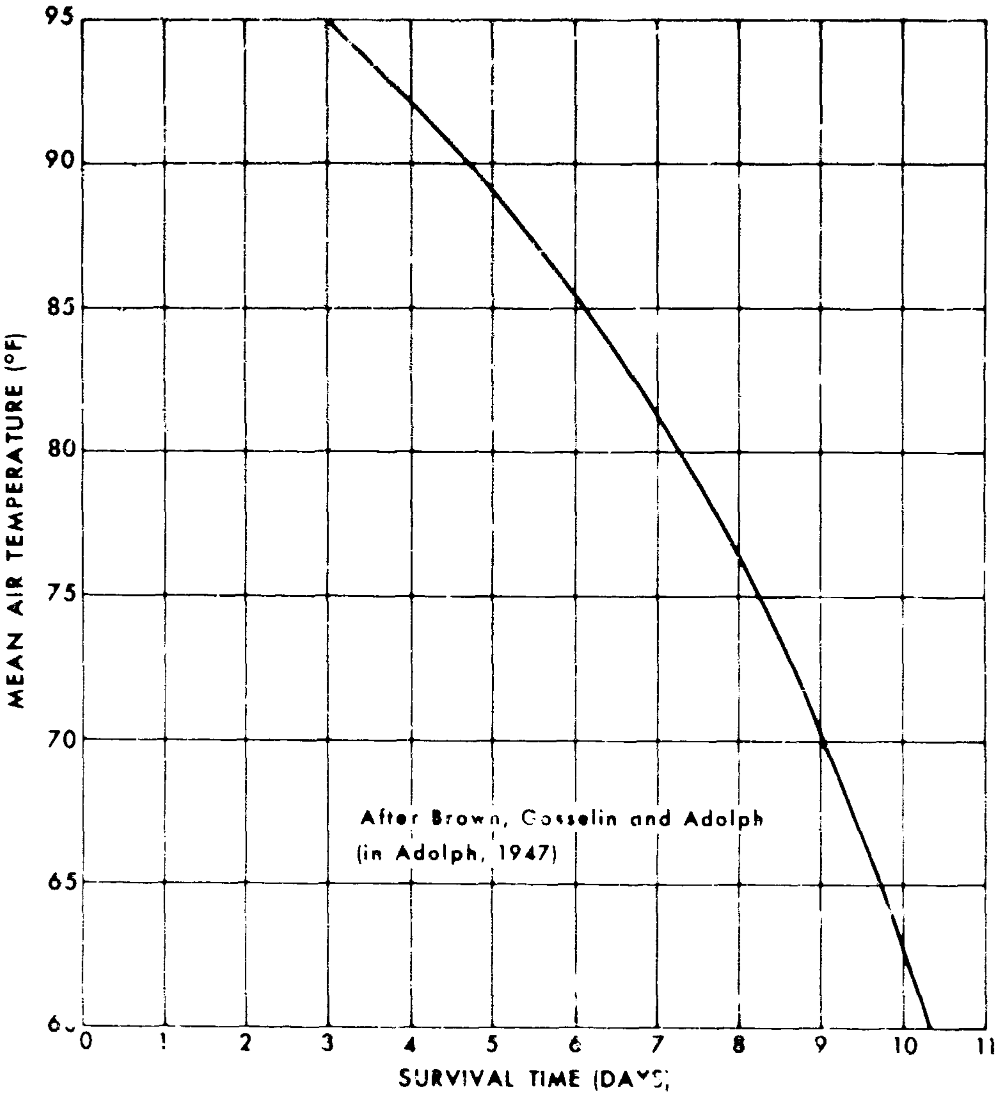
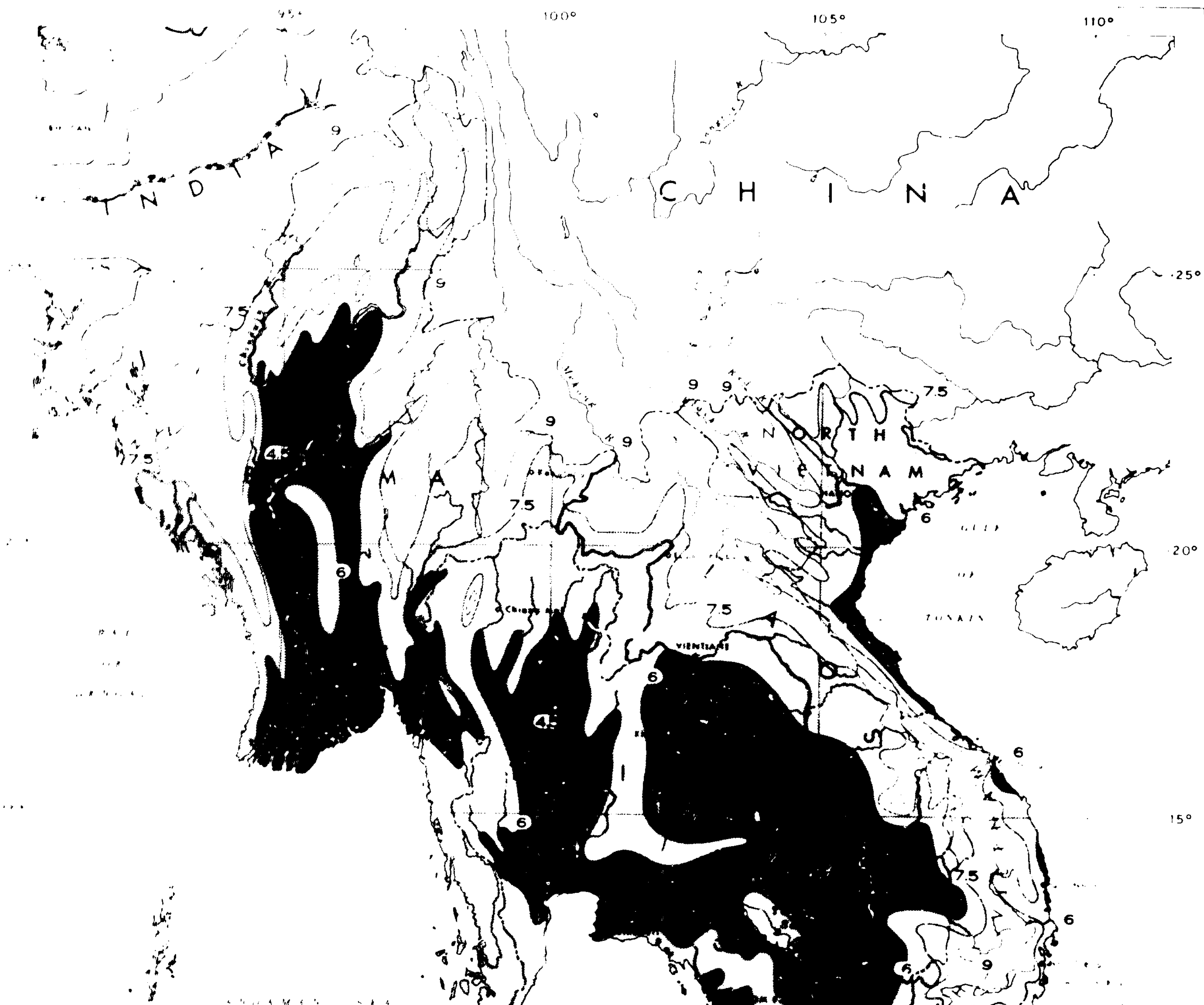
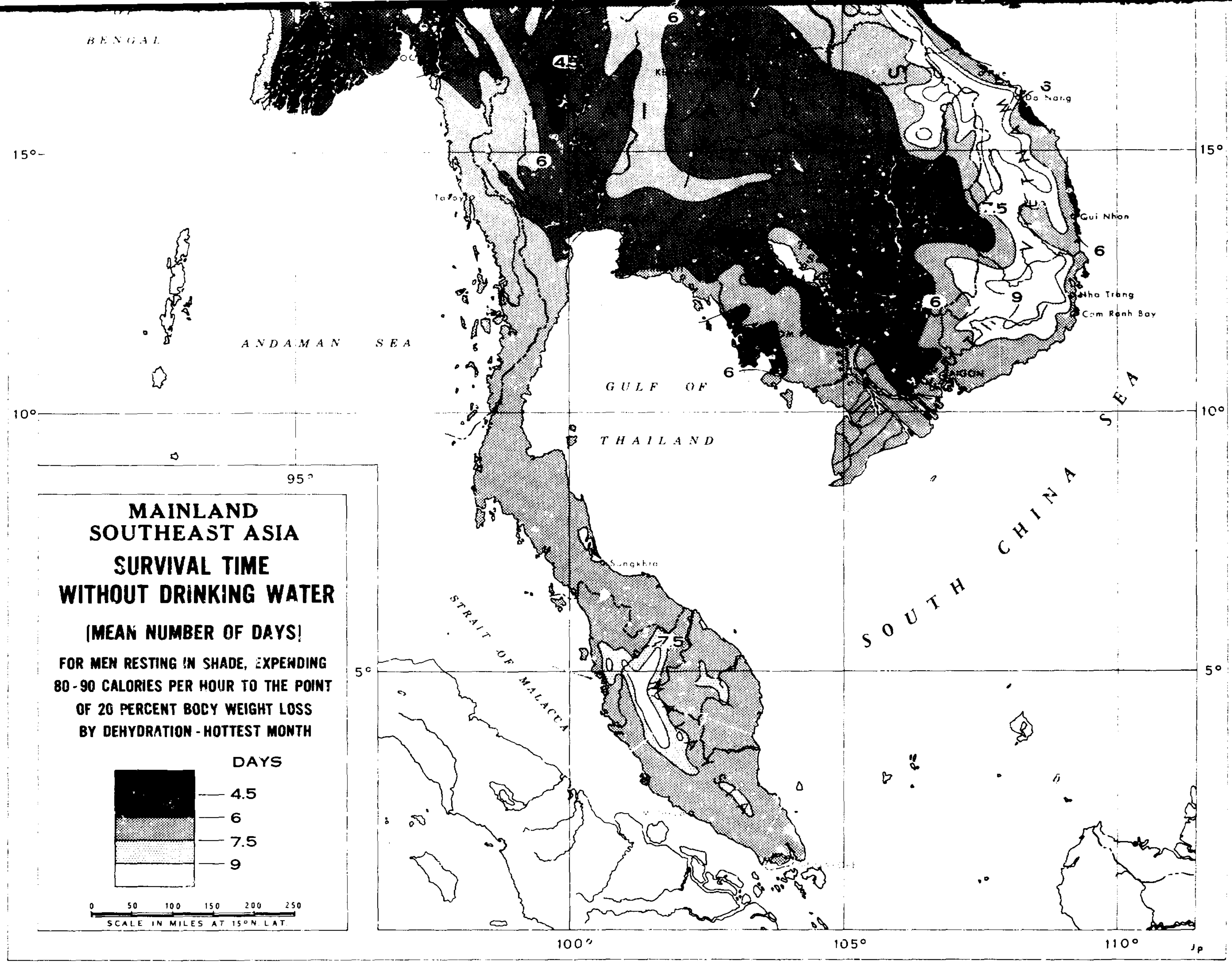


Figure 2

MAP 7



INDIA
CHINA
NORTH VIETNAM
VIENTIANE
95°
100°
105°
110°
25°
20°
15°
9
7.5
6
4.5



MAINLAND SOUTHEAST ASIA
SURVIVAL TIME WITHOUT DRINKING WATER
(MEAN NUMBER OF DAYS)
FOR MEN RESTING IN SHADE, EXPENDING 80-90 CALORIES PER HOUR TO THE POINT OF 20 PERCENT BODY WEIGHT LOSS BY DEHYDRATION - HOTTEST MONTH
DAYS
4.5
6
7.5
9
0 50 100 150 200 250
SCALE IN MILES AT 15°N LAT.
BENGAL
ANDAMAN SEA
GULF OF THAILAND
STRAIT OF MALACCA
SOUTH CHINA SEA
Da Nang
Qui Nhon
Nha Trang
Cam Ranh Bay
Songkhla
15°
10°
5°
95°
100°
105°
110°

TIME TO IMPAIRMENT OF PSYCHOMOTOR EFFICIENCY FOR MEN DOING MODERATE WORK ON HALF RATION OF DRINKING WATER

When humans are required to perform skillfully and energetically day after day while losing more body water than they replace, they rapidly reach the point where their psychomotor efficiency shows measurable deterioration. Given a substantial deprivation of water intake in a hot, humid environment, this deterioration may begin as early as one or two days after exposure.

Map 8 illustrates the distribution of time tolerance to the point of onset of measurable symptoms in a situation where a unit is required to conduct repeated, 8-hour daily jungle patrols during the year's hottest month with a water ration that provides only 50% of their calculated needs. As with other patrol-level analyses in this series, the energy expenditure rate is assumed to average 225 calories per hour during the 8-hour work period and 80 to 130 calories per hour for the balance of each 24-hour day. Under these conditions, Figure 3 shows tolerance time as a function of mean daily temperature. Higher temperatures not only limit tolerance to shorter periods, but do so at an increasing rate. The values (hours to impairment) used to draw Map 8 were converted from mean temperatures through this graphic relationship.

The most severely restrictive locations for which data were available are Myingyan and Minbu, situated at less than 200 feet elevation in the middle Irrawaddy Valley of Burma. In that general area, patrol tolerance may be limited to a maximum of 24 hours on a 50 percent water ration. The longest tolerance time in the map area was found to be 70 hours at Malaya's Cameron Highlands where temperatures are moderated both by elevation (4,757 feet) and exposure to marine influences. Possibly there are sites between 5,000 and 8,500 feet elevation in the South Vietnamese Highlands, and almost certainly in the Sino-Burmese border ranges, which would permit longer tolerance times.

It is known that individuals with greater experience and skill in jungle patrol operations will experience slower rates of performance deterioration than those who are lacking in this regard. For this reason and because of variability of temperature from day to day, speculation about possible lengths of tolerance to a group level of impairment sufficient to cripple a mission cannot be offered at this time. Nevertheless, this map should be regarded as representing the mean maximum expectancy for the conditions given. This will become more clear upon examination of the companion heat stress casualty map (for patrols) in this series. Obviously, among those individuals who become heat stress victims within approximately 30 minutes on full water ration, there certainly will be serious psychomotor impairment. The difficulty of comparison here lies in the fact that the heat stress maps are based on the month of highest dewpoint, which normally is not the month of highest mean temperature.

PSYCHOMOTOR EFFICIENCY IMPAIRMENT

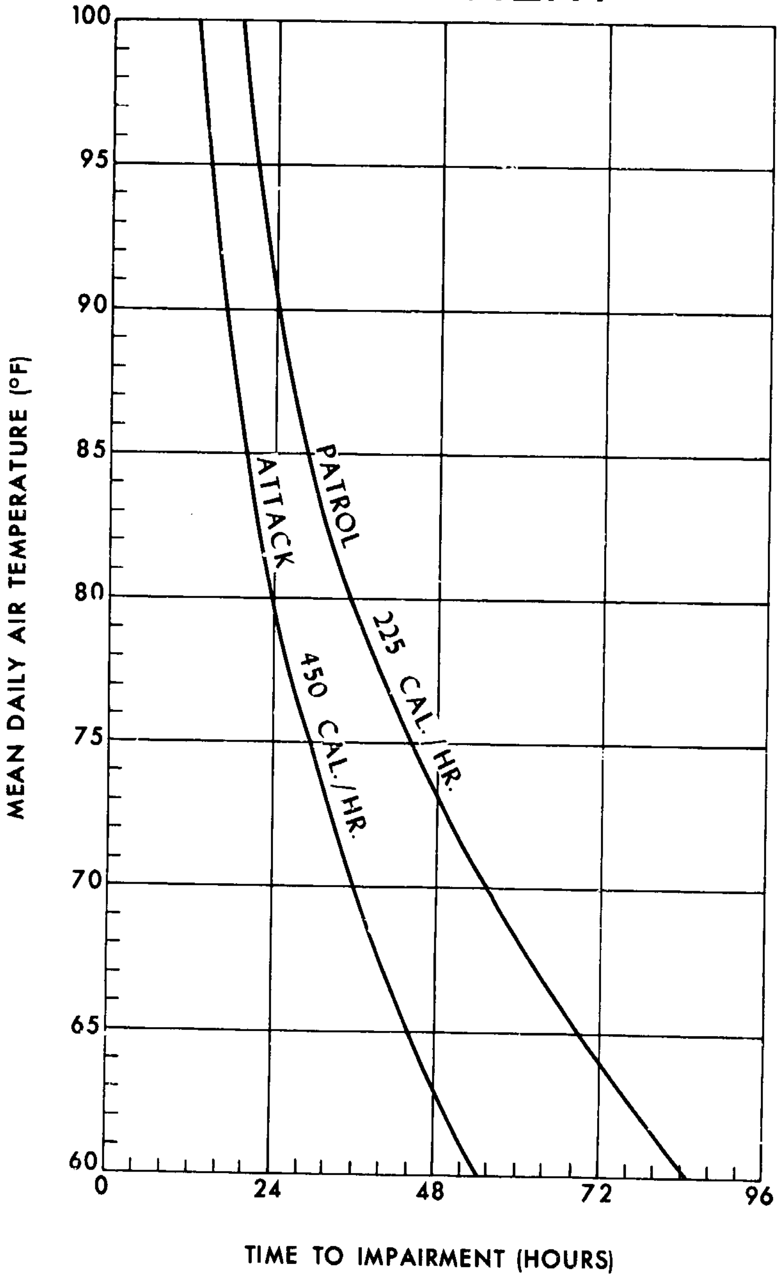
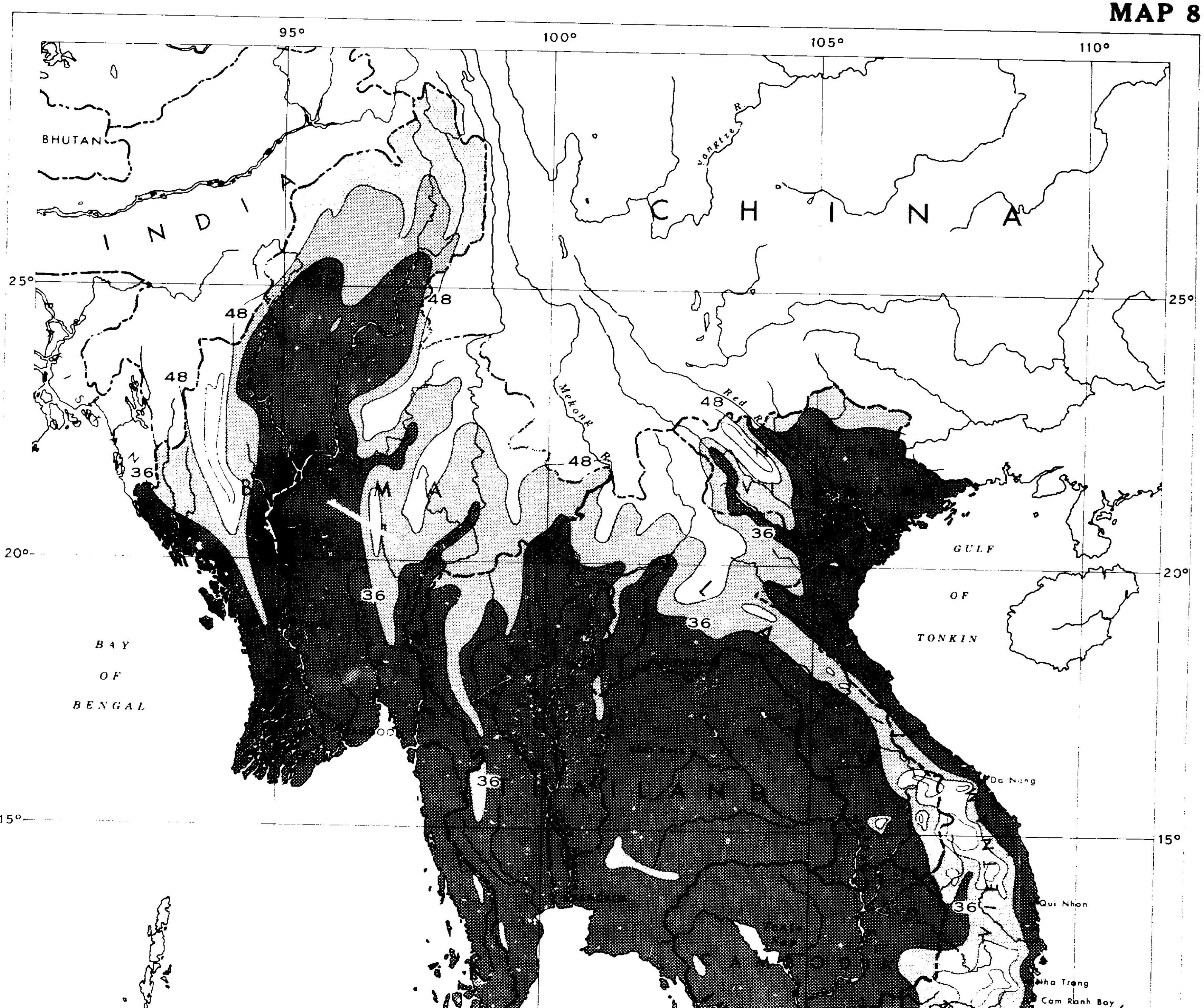
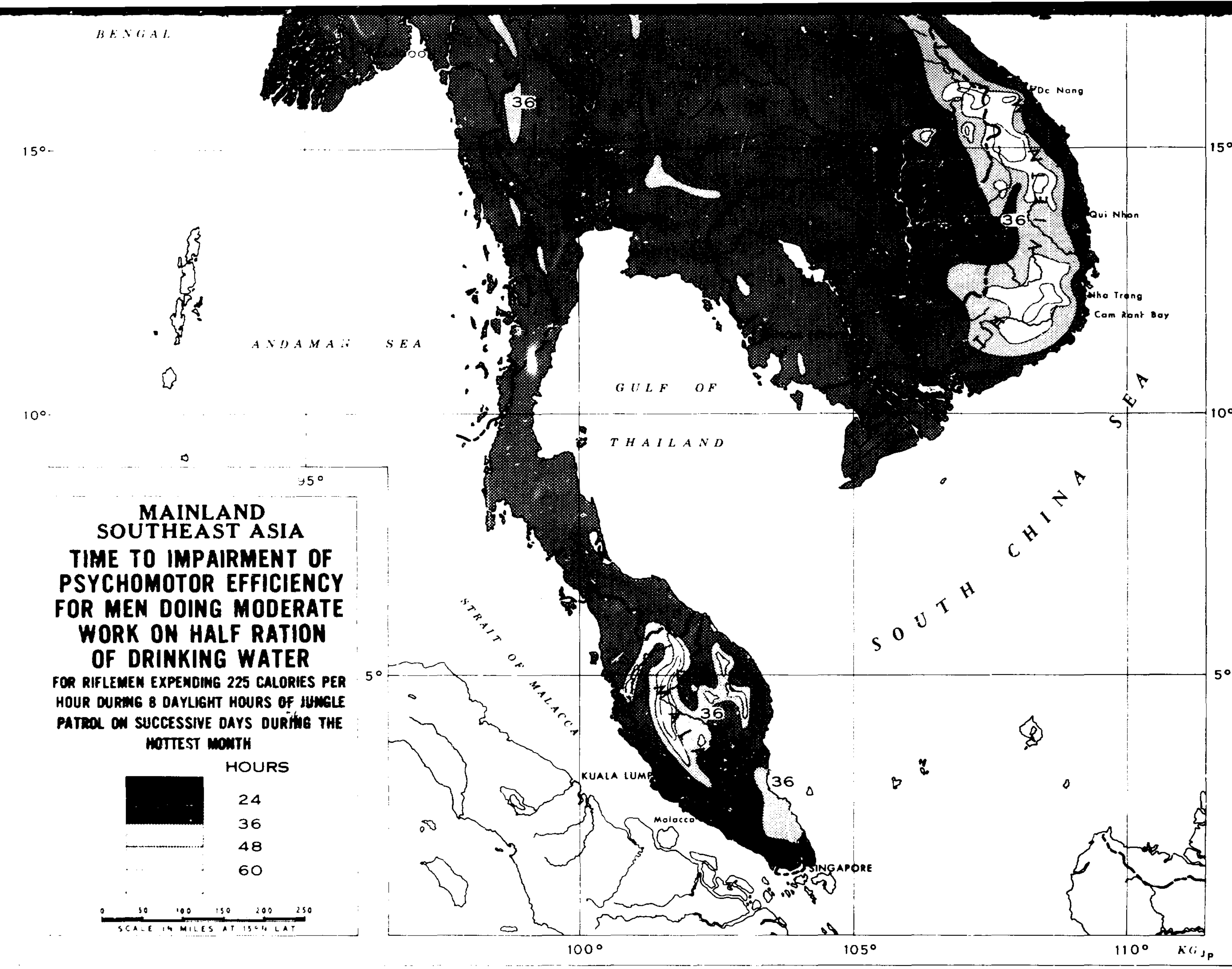


Figure 3

MAP 8



95°
100°
105°
110°
25°
20°
15°
BHUTAN
INDIA
CHINA
BURMA
LAOS
THAILAND
CAMBODIA
VIETNAM
Yangtze R.
Mekong R.
Red R.
GULF OF TONKIN
BAY OF BENGAL
48
36
Da Nang
Qui Nhon
Nha Trang
Cam Ranh Bay



BENGAL
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
Da Nang
Qui Nhon
Nha Trang
Cam Ranh Bay
KUALA LUMP
Malacca
SINGAPORE
36
15°
10°
5°
95°
100°
105°
110°
MAINLAND SOUTHEAST ASIA
TIME TO IMPAIRMENT OF PSYCHOMOTOR EFFICIENCY FOR MEN DOING MODERATE WORK ON HALF RATION OF DRINKING WATER
FOR RIFLEMEN EXPENDING 225 CALORIES PER HOUR DURING 8 DAYLIGHT HOURS OF JUNGLE PATROL ON SUCCESSIVE DAYS DURING THE HOTTEST MONTH
HOURS
24
36
48
60
0 50 100 150 200 250
SCALE IN MILES AT 15°N LAT

HEAT STRESS TOLERANCE

Maps 9 and 10 are concerned with two levels of combat activity for which the distribution of daytime tolerance is shown for the month(s) of highest mean daily maximum dewpoint. Map 9 illustrates a jungle patrol level of activity in which the men are on the move in an essentially shaded situation. They are clothed in the standard combat fatigue uniform without helmet or body armor and their average energy expenditure rate is 225 calories per hour. Map 10 shows the more stressful situation of an assault mission operating in direct sunlight, with men wearing both helmet and body armor in addition to their regular uniform, and expending energy at an average rate of 450 calories per hour. Tolerance times in both instances are determined by the point where 50 percent of a randomly selected group of riflemen would likely accumulate a body-heat storage load of 160 calories and thereby become heat stress casualties.

Such predictions are possible from field observations related to air temperature and coincident vapor pressure. It is specified that these activities are conducted during the hottest part of an average sunny day during the most stressful (highest dewpoint) month(s). The time of the daily maximum temperature is generally the time of daily minimum relative humidity, yet it should closely approximate the time of maximum vapor pressure. Thus, these calculations based upon mean daily maximum temperature and mean 1300-hour relative humidity are considered to yield reasonable approximations of mean maximum vapor pressure, hence the most stressful average daytime condition. Figures 4 and 5 illustrate the results of determinations on which the maps were based. Similar determinations are possible for other levels of energy expenditure, other amounts of clothing coverage, and for different casualty ratios.

The heat stress casualty threshold used here might not produce 50 percent exhaustion cases, but at least 50 percent of the men would experience dangerous deep-body overheating with 160 calories of heat storage load. Under these conditions one would expect to find rectal temperatures higher than 103°F. Assuming that no tactical plan can tolerate having 50 percent of the personnel significantly impaired by heat stress alone, it is readily seen that missions such as described here must be capable of completion within the tolerance times mapped; otherwise, concessions must be made with respect to duration of activity or weather changes.

It should further be realized that there will be approximately as many days which exceed the average conditions as fall below them. For example, among the data which contributed to Map 10 one finds that an assault mission on a sunny May afternoon in the Mekong Delta would, on the average, produce 50 percent heat stress casualties within 28 minutes. In the same locality the full range of May afternoon conditions throughout the month will permit daily tolerances as long as 40 and as brief as 20 minutes. The principle shortcoming of the assault determinations is that we assume a no-shade situation in areas where evaporative cooling is greatest due to increased air movement. Thus, the mean maximum calculations in the case of the assault situation actually represents the very worst conditions expected.

HEAT STRESS TOLERANCE FOR RIFLEMEN ON JUNGLE PATROL

Without helmets or body armor expending 225 cals./hour
After R. F. Goldman (1968)

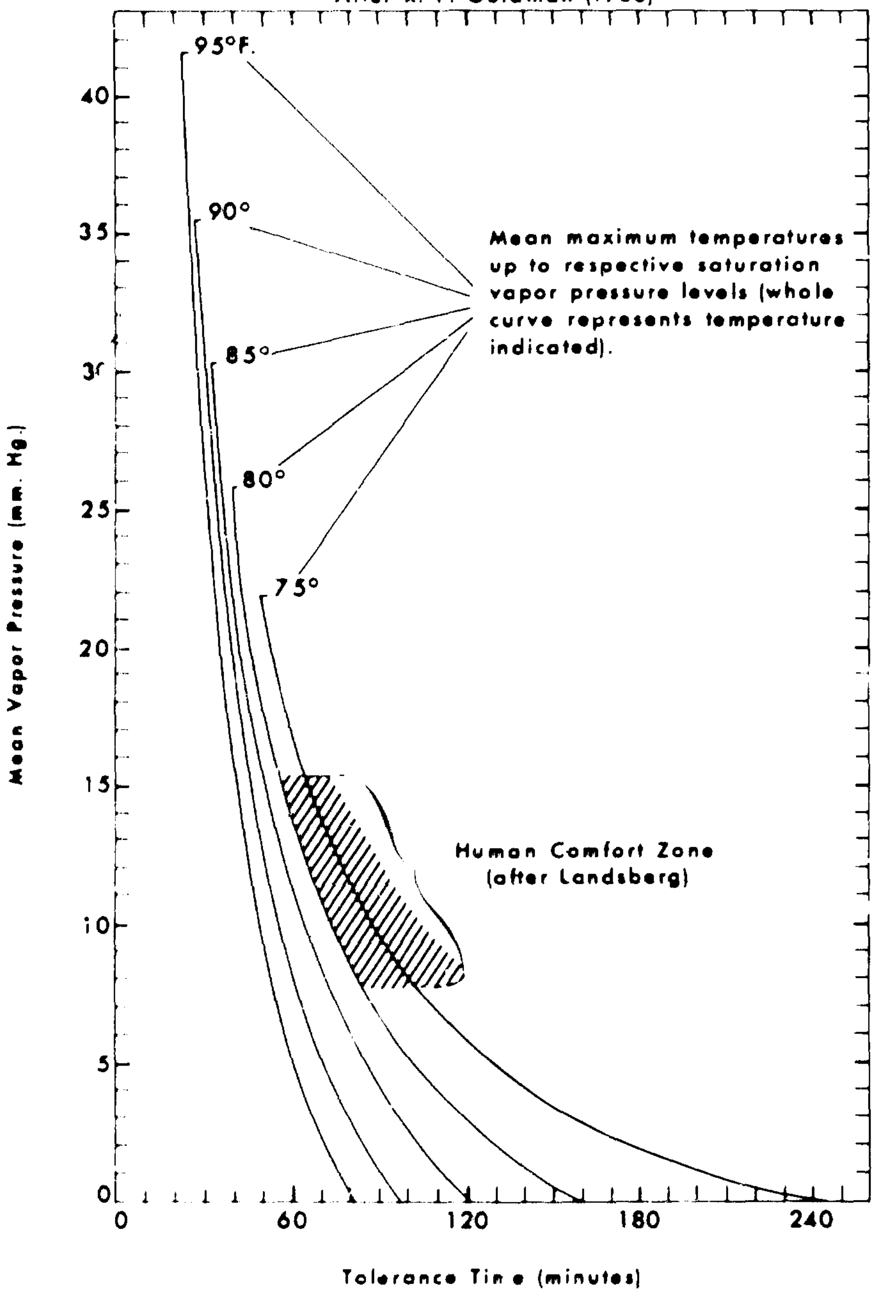


Figure 4

HEAT STRESS TOLERANCE FOR RIFLEMEN IN SUNLIGHT ATTACK

With helmets and body armor, expending 450 cals./hour
After R.F. Goldman (1968)

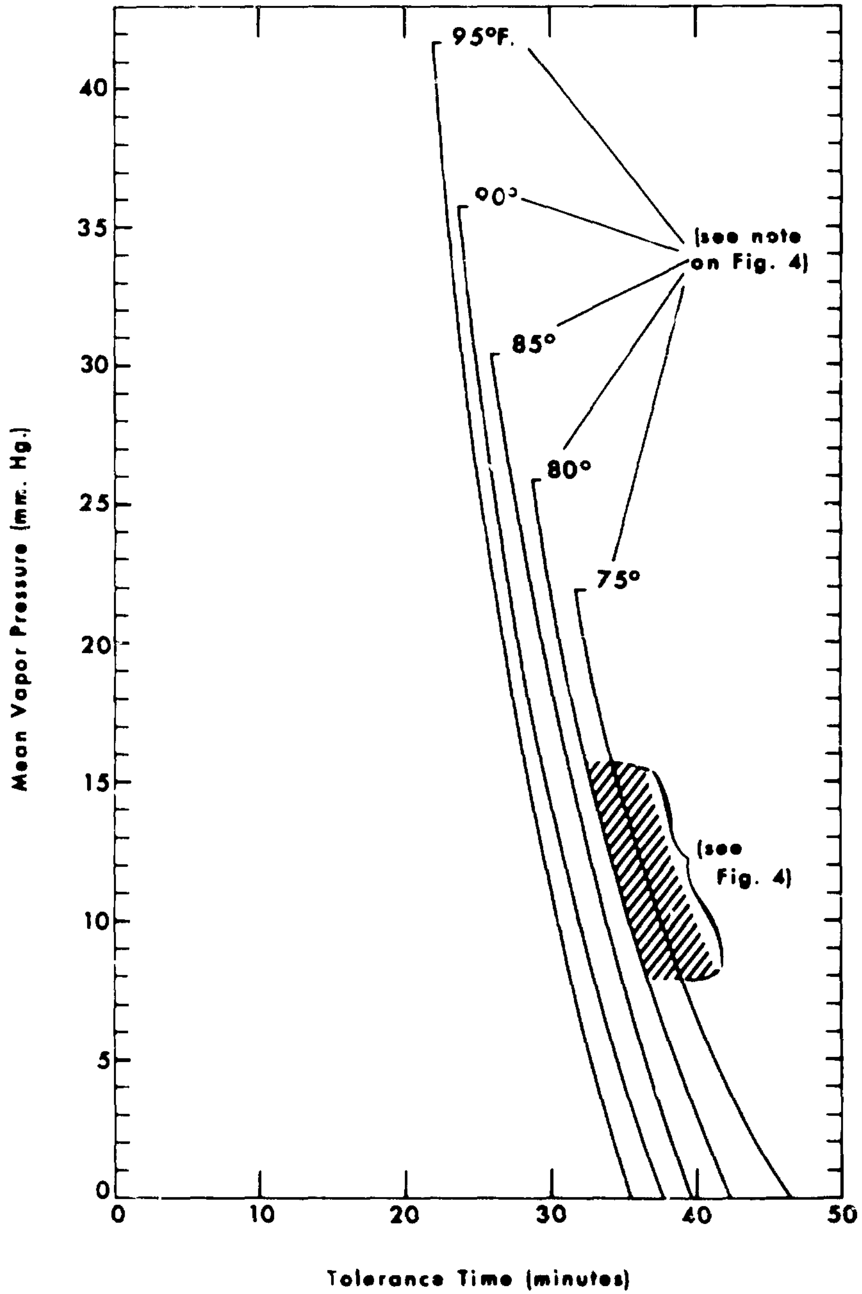


Figure 5

HEAT STRESS TOLERANCE

Maps 9 and 10 are concerned with two levels of combat activity for which the distribution of daytime tolerance is shown for the month(s) of highest mean daily maximum dewpoint. Map 9 illustrates a jungle patrol level of activity in which the men are on the move in an essentially shaded situation. They are clothed in the standard combat fatigue uniform without helmet or body armor and their average energy expenditure rate is 225 calories per hour. Map 10 shows the more stressful situation of an assault mission operating in direct sunlight, with men wearing both helmet and body armor in addition to their regular uniform, and expending energy at an average rate of 450 calories per hour. Tolerance times in both instances are determined by the point where 50 percent of a randomly selected group of riflemen would likely accumulate a body-heat storage load of 160 calories and thereby become heat stress casualties.

Such predictions are possible from field observations related to air temperature and coincident vapor pressure. It is specified that these activities are conducted during the hottest part of an average sunny day during the most stressful (highest dewpoint) month(s). The time of the daily maximum temperature is generally the time of daily minimum relative humidity, yet it should closely approximate the time of maximum vapor pressure. Thus, these calculations based upon mean daily maximum temperature and mean 1300-hour relative humidity are considered to yield reasonable approximations of mean maximum vapor pressure, hence the most stressful average daytime condition. Figures 4 and 5 illustrate the results of determinations on which the maps were based. Similar determinations are possible for other levels of energy expenditure, other amounts of clothing coverage, and for different casualty ratios.

The heat stress casualty threshold used here might not produce 50 percent exhaustion cases, but at least 50 percent of the men would experience dangerous deep-body overheating with 160 calories of heat storage load. Under these conditions one would expect to find rectal temperatures higher than 103°F. Assuming that no tactical plan can tolerate having 50 percent of the personnel significantly impaired by heat stress alone, it is readily seen that missions such as described here must be capable of completion within the tolerance times mapped; otherwise, concessions must be made with respect to duration of activity or weather changes.

It should further be realized that there will be approximately as many days which exceed the average conditions as fall below them. For example, among the data which contributed to Map 10 one finds that an assault mission on a sunny May afternoon in the Mekong Delta would, on the average, produce 50 percent heat stress casualties within 28 minutes. In the same locality the full range of May afternoon conditions throughout the month will permit daily tolerances as long as 40 and as brief as 20 minutes. The principle shortcoming of the assault determinations is that we assume a no-shade situation in areas where evaporative cooling is greatest due to increased air movement. Thus, the mean maximum calculations in the case of the assault situation actually represents the very worst conditions expected.

HEAT STRESS TOLERANCE FOR RIFLEMEN ON JUNGLE PATROL

Without helmets or body armor expending 225 cals./hour

After R. F. Goldman (1968)

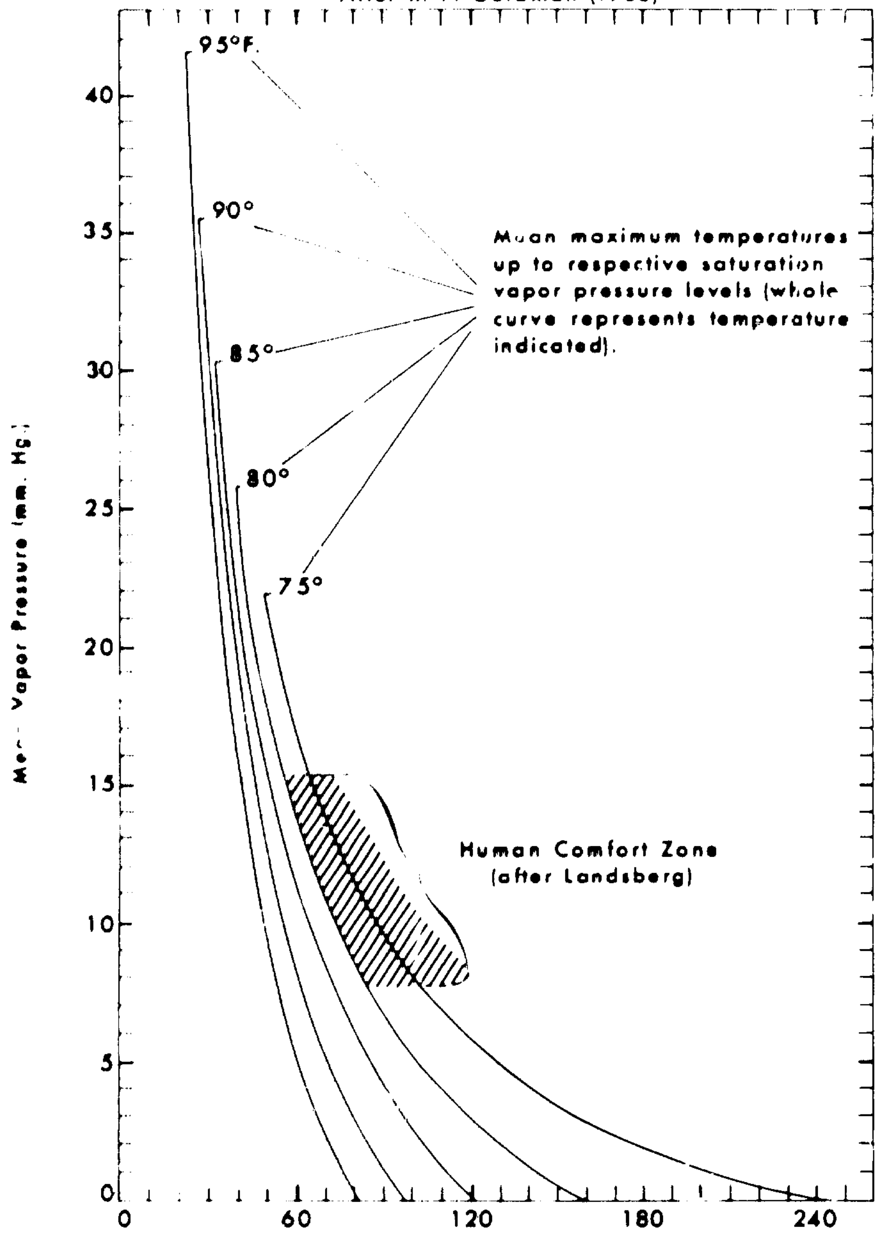


Figure 4

HEAT STRESS TOLERANCE FOR RIFLEMEN IN SUNLIGHT ATTACK

With helmets and body armor, expending 450 cals./hour

After R.F. Goldman (1968)

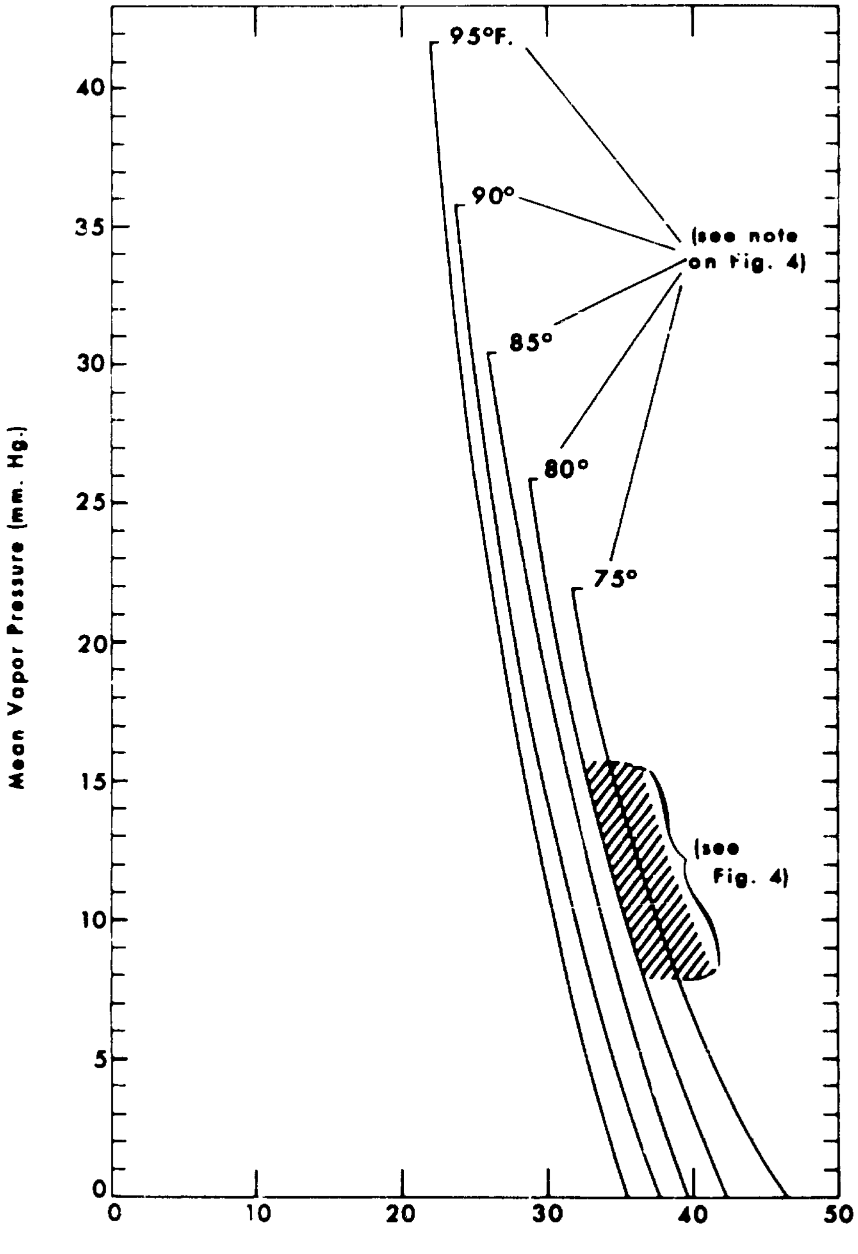
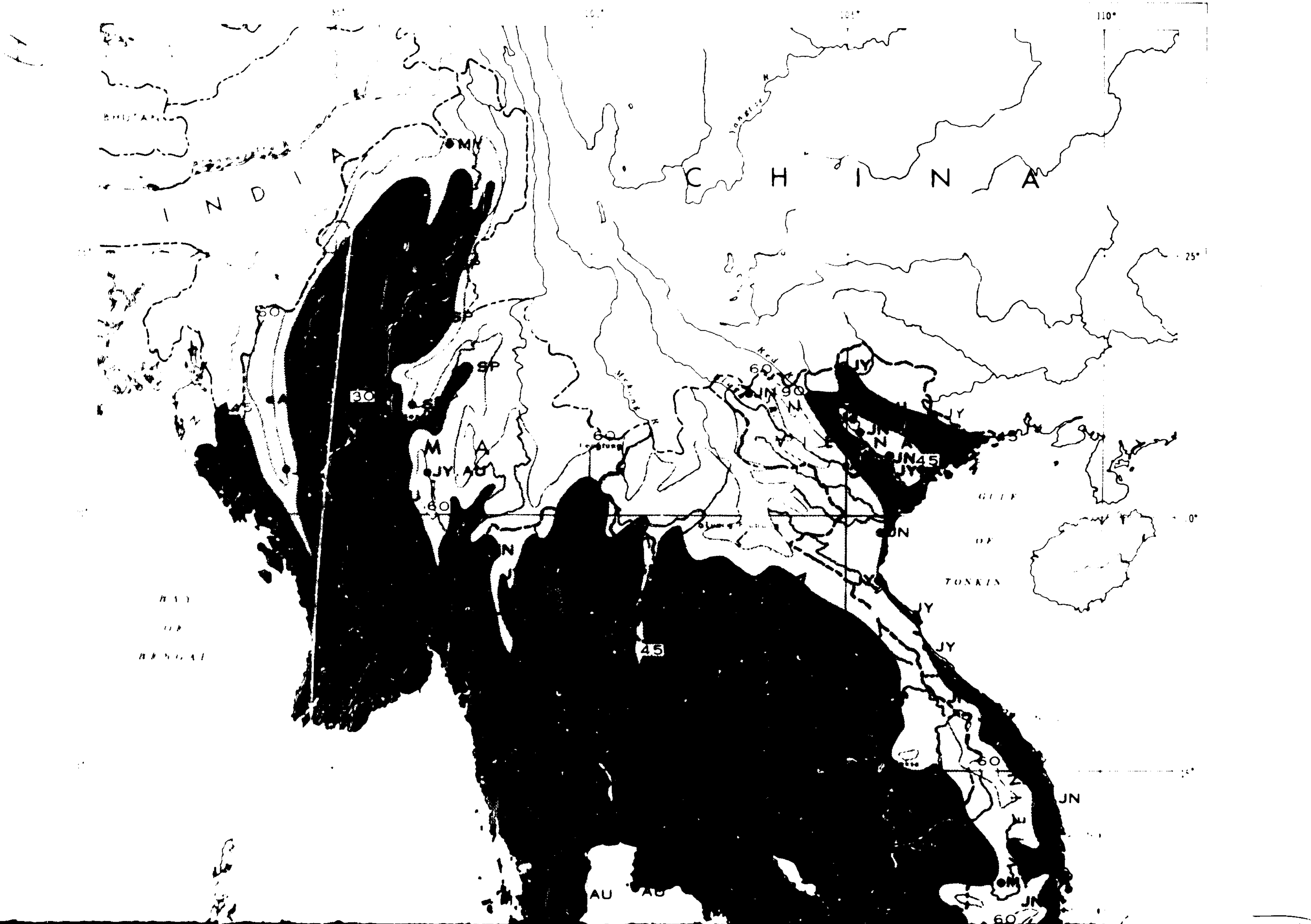
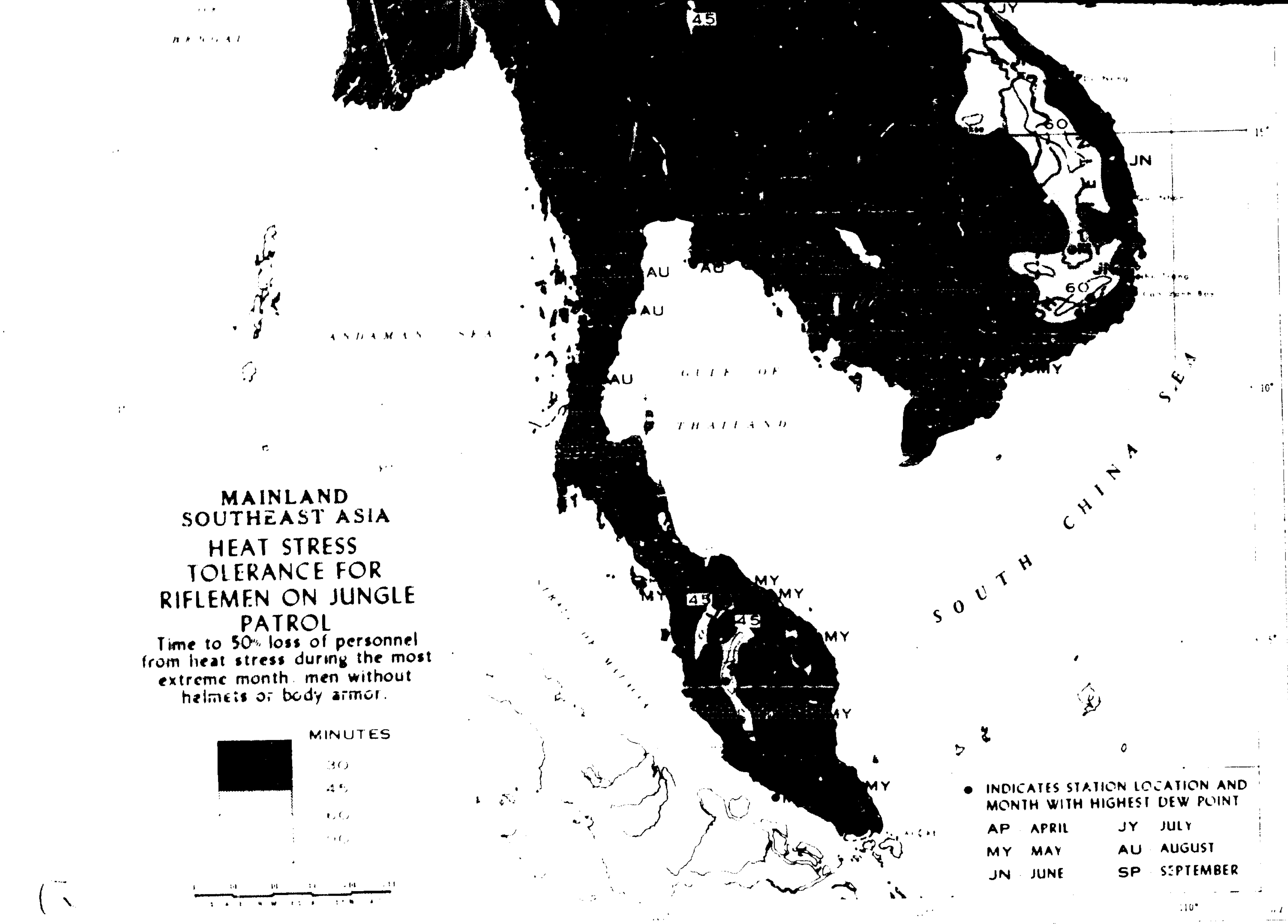


Figure 5

MAP 9



110°
25°
CHINA
INDIA
GULF OF TONKIN
BAY OF BENGAL
MY
SP
30
45
JN45
JN90
JY
JN
AU
60

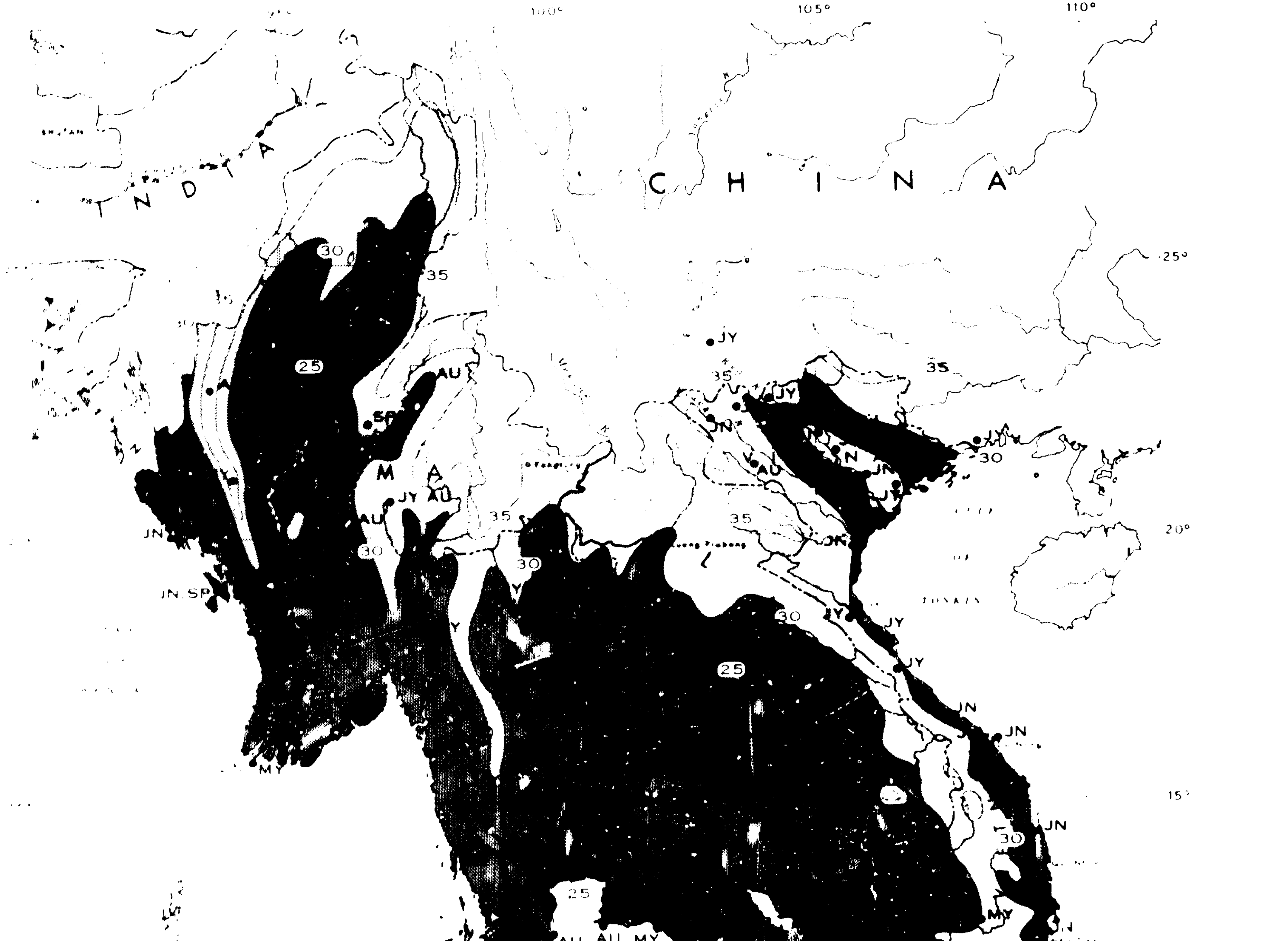


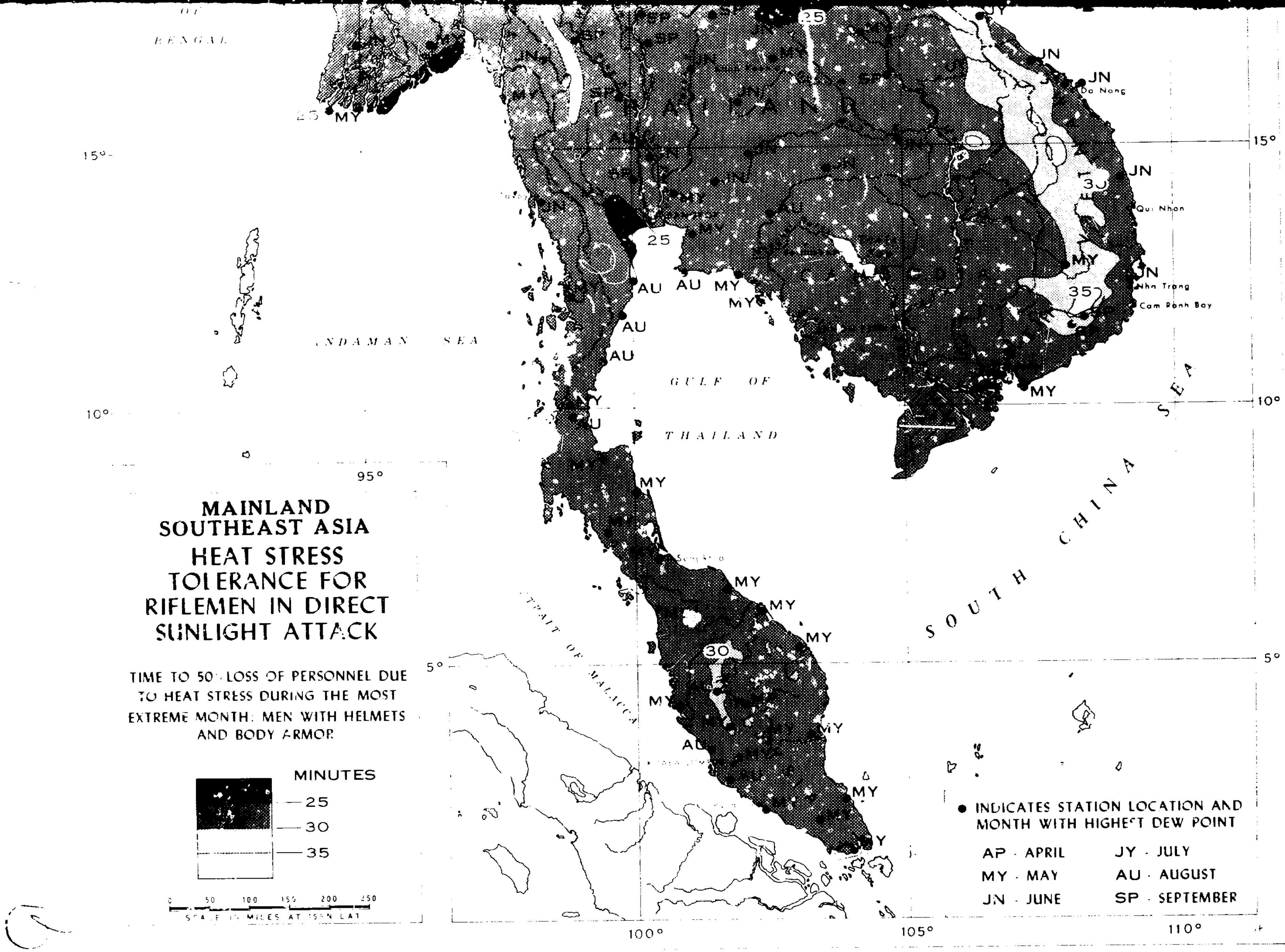
MAINLAND SOUTHEAST ASIA

HEAT STRESS TOLERANCE FOR RIFLEMEN ON JUNGLE PATROL

Time to 50% loss of personnel from heat stress during the most extreme month, men without helmets or body armor.

MAP 10





MAINLAND SOUTHEAST ASIA
HEAT STRESS TOLERANCE FOR RIFLEMEN IN DIRECT SUNLIGHT ATTACK

TIME TO 50% LOSS OF PERSONNEL DUE TO HEAT STRESS DURING THE MOST EXTREME MONTH: MEN WITH HELMETS AND BODY ARMOR

OCCURRENCE OF SEVERE MICROBIOLOGICAL DETERIORATION

The breakdown of equipment or material, whatever the cause, is detrimental to military operations. A wide variety of materials are susceptible to microbial attack under conditions which occur in varying degrees in Southeast Asia. Map 11 shows the degree of risk in terms of the number of months per year with conditions contributing to the probable occurrence of severe microbiological deterioration.

When different materials are subjected to microbial attack, they show considerable variation in their susceptibility to deterioration and the rate at which deterioration progresses. Fungal growth rates are also dependent upon the specific organism and the intensity and duration of climatic conditions favoring its proliferation. When assessing a region in terms of its overall relative hazard to military materiel, the most important factor to consider is the combination of moderate to high temperatures with high humidity. With respect to the relationship between the temperature-humidity factor and microbial activity, there are certain generalizations which can be made about most attacking organisms and most materials such as plastics, leather, fabrics, wood, rope, and fiber cartons. These materials, when unprotected, are especially subject to deterioration problems when used in items or systems such as ammunition boxes, sandbags, and electronic systems.

Microbiological life forms are most active within the range of dry-bulb temperatures between 59°F and 95°F with at least 70 percent relative humidity; however, mildew sufficient to injure foodstuffs can tolerate temperatures in the low 40's if the humidity is extremely high. Below 59°F and above 95°F regardless of humidity, and at any temperature when the relative humidity is less than 70 percent, fungal deterioration of materials other than food is generally considered to be negligible.

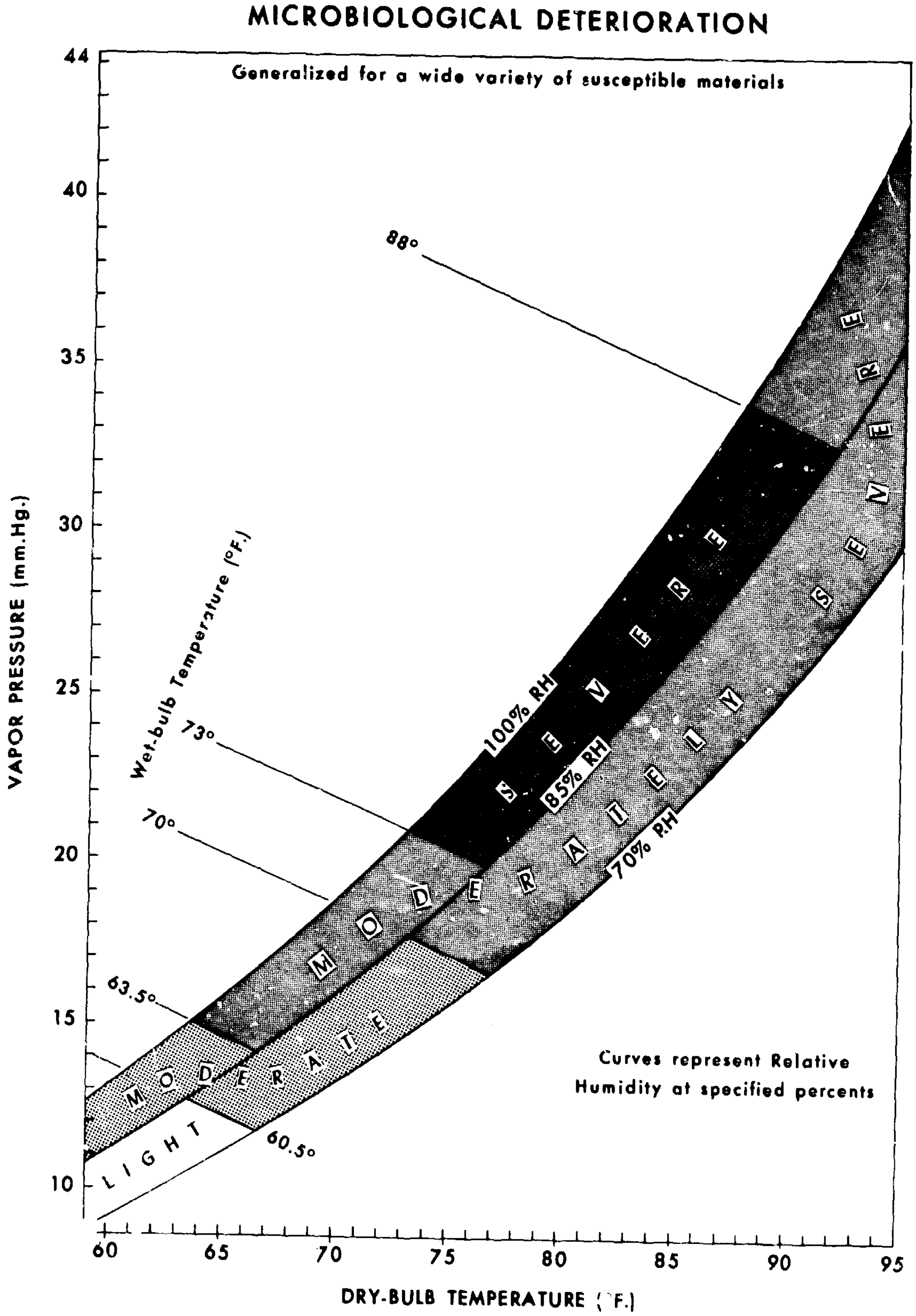
Up to about 88°F wet-bulb temperature within this most active range, damaging growth of fungi becomes substantially more vigorous as both temperature and humidity increase, with humidity being the more important parameter. When relative humidity exceeds 85 percent with wet-bulb temperatures between 73°F and 88°F, conditions for deterioration are classed as "severe". Figure 6 delimits classes of deterioration from light to severe. Stations with conditions representing all parts of these classes are found on the mainland of Southeast Asia.

Map 11 illustrates the annual number of months which are likely to experience conditions under which "severe" deterioration will take place. Since the map is based on mean values, the areas shown are approximations only.

At least three noteworthy features are revealed in this distribution. The higher plateau and mountain areas have no or few qualifying months except on their western flanks. Despite rather high relative humidities in the uplands, the mean temperature even in the hottest months is too low to suggest the likelihood of severe deterioration, even though climatic conditions are suitable for fungal growth. At the other extreme, the lowlands of Malaya emerge as the poorest area in which to store susceptible materiel. At least three stations there experience severe mean deterioration conditions during every month of the year.

The most anomalous area on the map is the Central Menam Valley of Thailand. Although the climate here imposes severe human heat stress resulting from very high air temperatures and dewpoints, its leeward location with respect to prevailing moisture advection leaves the valley relatively dry. Among all the stations in this densely populated lowland, few months exceed 80 percent relative humidity and none are within the severe range for microbial activity. The dryness caused by the rain shadow effect is further accentuated by a relatively large proportion of unforested land which permits greater surface air movement and more rapid evaporation than in most parts of Southeast Asian lowlands.

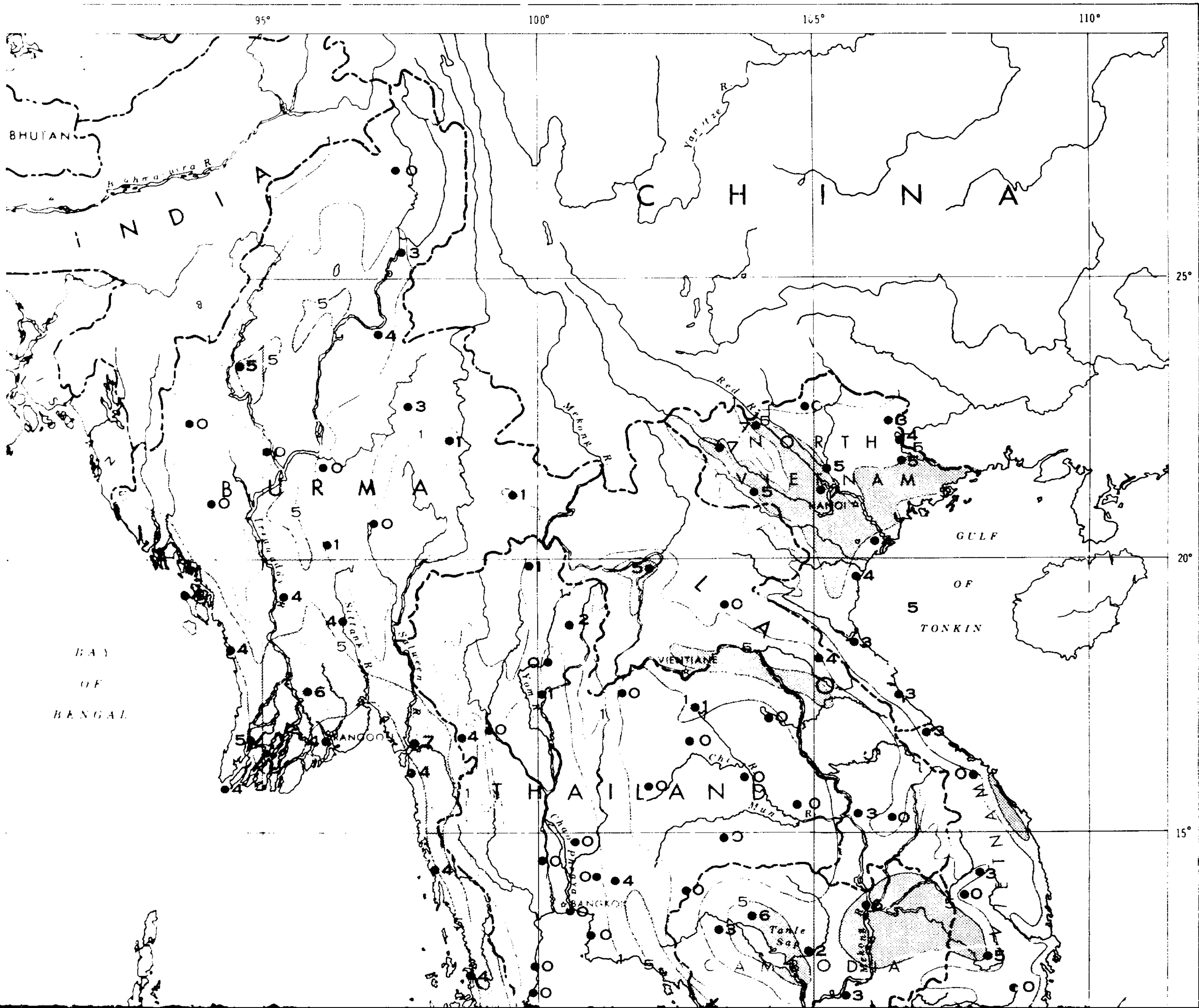
It should be noted that "severe" conditions can damage such items as leather goods in as few as ten days. Ten-day durations of severe conditions could easily occur in many places without being reflected in the monthly means which are used as threshold criteria in this analysis.

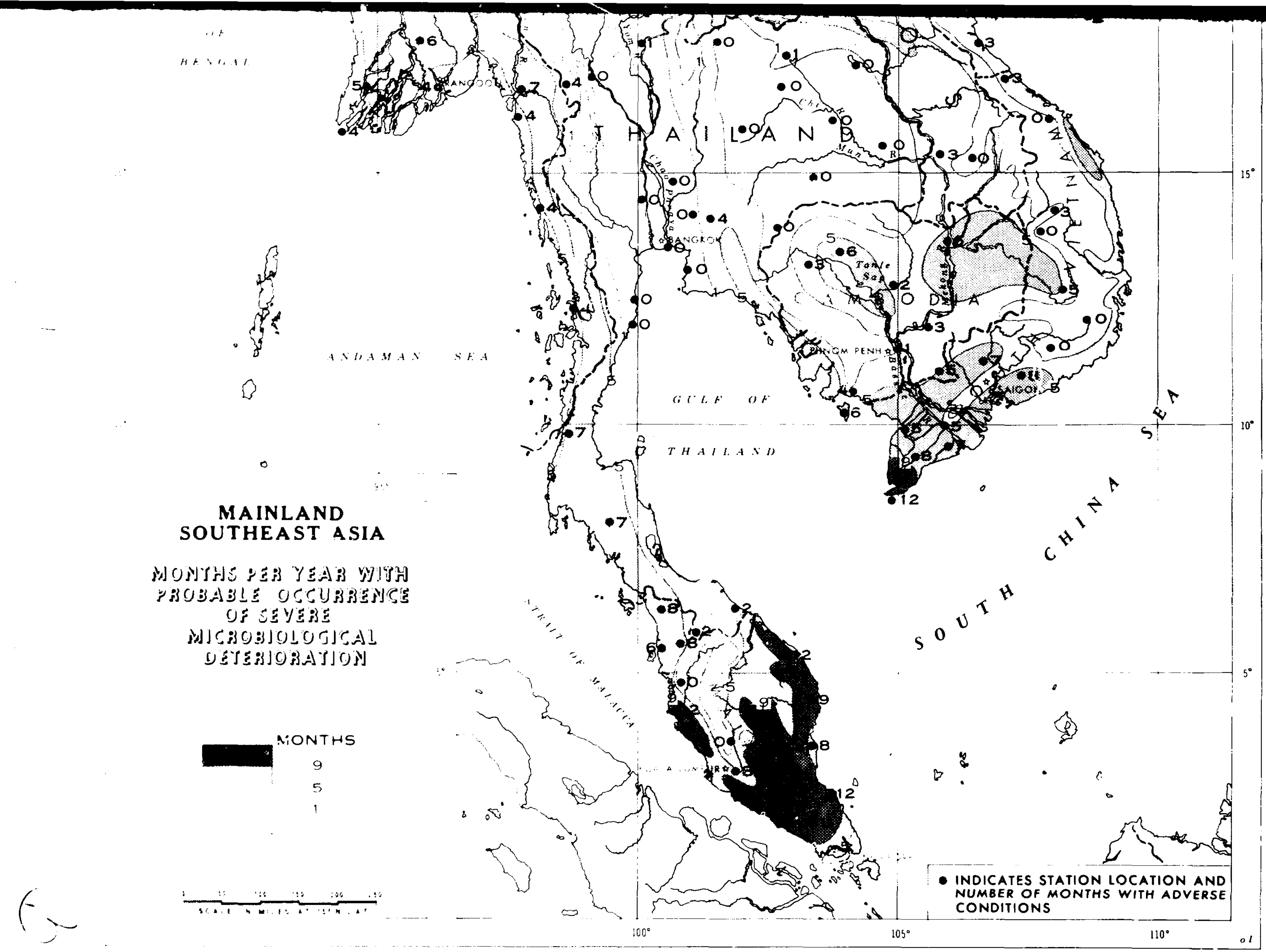


MICROBIOLOGICAL DETERIORATION
Generalized for a wide variety of susceptible materials
VAPOR PRESSURE (mm.Hg.)
44
40
35
30
25
20
15
10
Wet-bulb Temperature (°F.)
88°
73°
70°
63.5°
60.5°
100% RH
85% RH
70% RH
SEVERE
MODERATELY SEVERE
MODERATE
MODERATE
MODERATE
LIGHT
Curves represent Relative
Humidity at specified percents
60
65
70
75
80
85
90
95
DRY-BULB TEMPERATURE (°F.)

Figure 6

MAP 11


95°
100°
105°
110°
25°
20°
15°
BHUTAN
INDIA
CHINA
BURMA
NORTH VIETNAM
HANOI
LAOS
THAILAND
CAMBODIA
VIENTIANE
RANGOON
BANGKOK
GULF OF TONKIN
BAY OF BENGAL
Red R.
Mekong R.
Yangtze R.
Irrawaddy R.
Sittang R.
Salween R.
Chao Phraya
Yom R.
Chi R.
Mun R.
Tonle Sap


MAINLAND
SOUTHEAST ASIA
MONTHS PER YEAR WITH
PROBABLE OCCURRENCE
OF SEVERE
MICROBIOLOGICAL
DETERIORATION
MONTHS
9
5
1
● INDICATES STATION LOCATION AND NUMBER OF MONTHS WITH ADVERSE CONDITIONS
THAILAND
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
BANGKOK
PHNOM PENH
SAIGON
Tonle Sap
Mun R.
Chao Phraya
15°
10°
5°
100°
105°
110°

CLOUDINESS REGIMES

The incidence of cloudiness, depicted on Map 12, may have important implications in planning and conducting military operations. Cloudiness can seriously restrict aerial activity and aerial surveillance capabilities. Also, cloudiness might temper the physiological stress conditions predicted for direct sunlight situations, as shown on Map 10.

Map 12 shows regional patterns in the annual march of mean monthly cloudiness. Each inset graph represents a subregion and is based upon compos te data from a cluster of 2 to 12 stations of comparable elevation and exposure within the subregion. Monthly cloud cover percentages from these several stations have been averaged and the resulting march of twelve monthly values has been further smoothed by taking three-month running means. The product of this smoothing is therefore a generalized, composite curve which is regarded as reasonably typical of the annual range and trends of cloudiness for that particular valley section or upland locality. The periods of record and mean annual cloud amounts have been similarly averaged among the stations in each subregion.

From these 27 subregional curves, seven basic families of patterns, called "regime types", are distinguishable according to criteria established in Table IV. Within each regime type, variations of magnitude, amplitude, and timing of maxima and minima are largely influenced by the time of onset, intensity, and duration of the monsoon seasons.

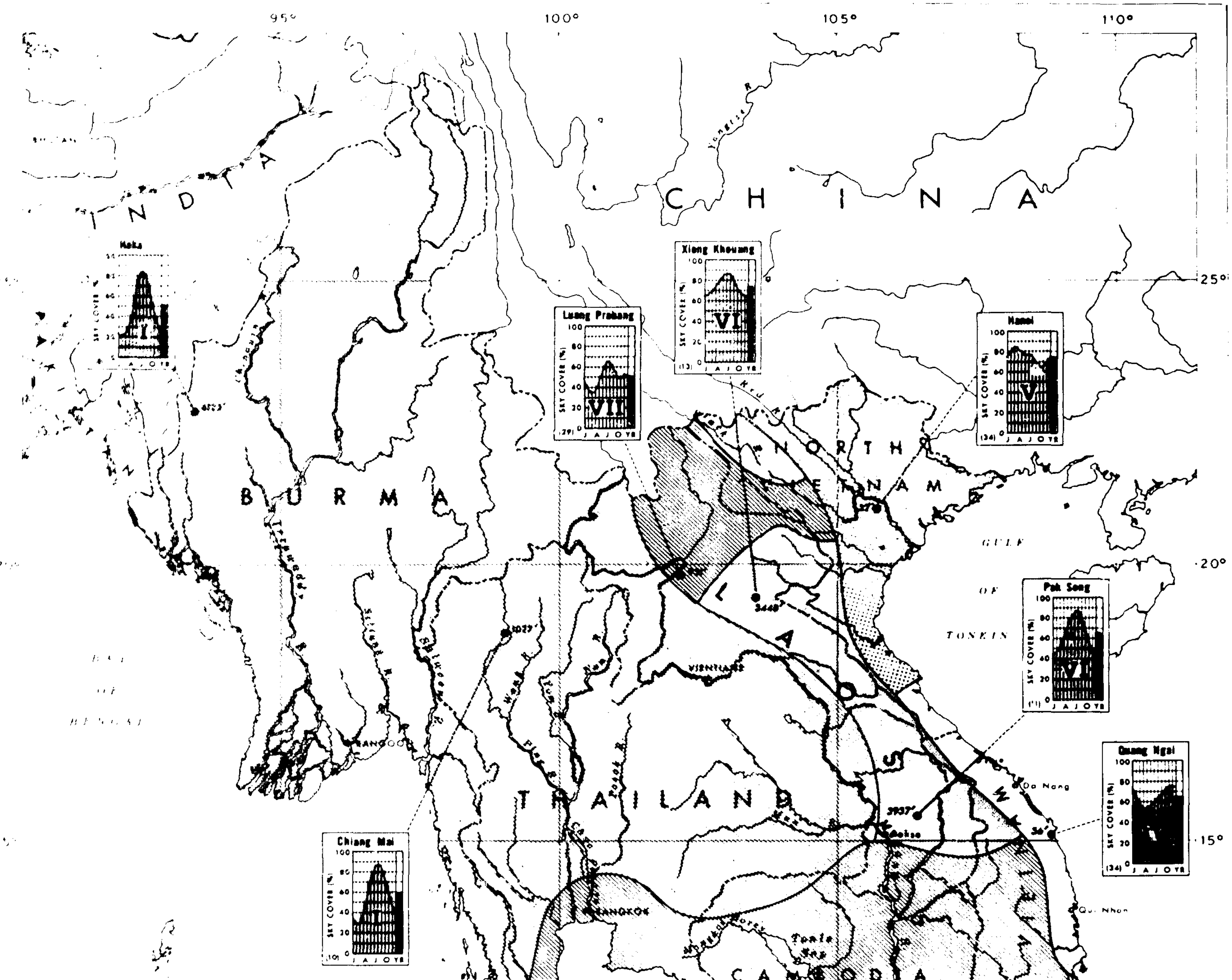
TABLE IV: REGIONAL CLOUDINESS REGIME TYPES

Type I	(Burmese) Found throughout Burma and interior Thailand; maximum in July or August at least doubles the minimum in January or February; mean annual amount averages about 55 percent (considerably less in the Chin Hills of Burma).
Type II	(Cochin) Common over Cambodia and south coastal areas of Thailand and The Republic of Vietnam; maximum in August with a tendency toward a secondary peak in June with no intervening drop; minimum in February; annual mean is about 65 percent.
Type III	(Malayan) Covers all of the Malay Peninsula south of the 7th Parallel, maximum in October or November with a tendency toward a secondary peak in July; minimum in February or March (within the Highland Variant the maximum is delayed until December and the minimum until April or May, with no suggestion of tendency toward a secondary peak); total annual amplitude less than 20 percentage points; annual mean about 68 percent.
Type IV	(Annamite Lowlands) Very similar to Type III except that the monthly amplitude is greater, the minimum is delayed until May or June, and the tendency toward a secondary peak occurs in August.
Type V	(Tonkin) Inverted Malayan Type wherein seasonal extremes are reversed; occurs throughout the Tonkin lowlands and hills and northward into the Kwangsi Hills of China; maximum in February or March with a tendency toward a secondary peak in July, minimum in October or November; annual mean about 72 percent.
Type VI	(Annamite Highlands) Occurs throughout most of the eastern mountain chain from the Red River in the north to the Boloven Plateau of Laos where there is strong evidence of transition toward Type I; maximum in July, minimum in January with some tendency toward a secondary minimum in March in the extreme northern section; annual mean about 65 percent.
Type VII	(North Indochina Hills) Double maximum with high in July and secondary peak in December; double minimum with low in March and secondary dip in October or November; annual mean about 55 percent.

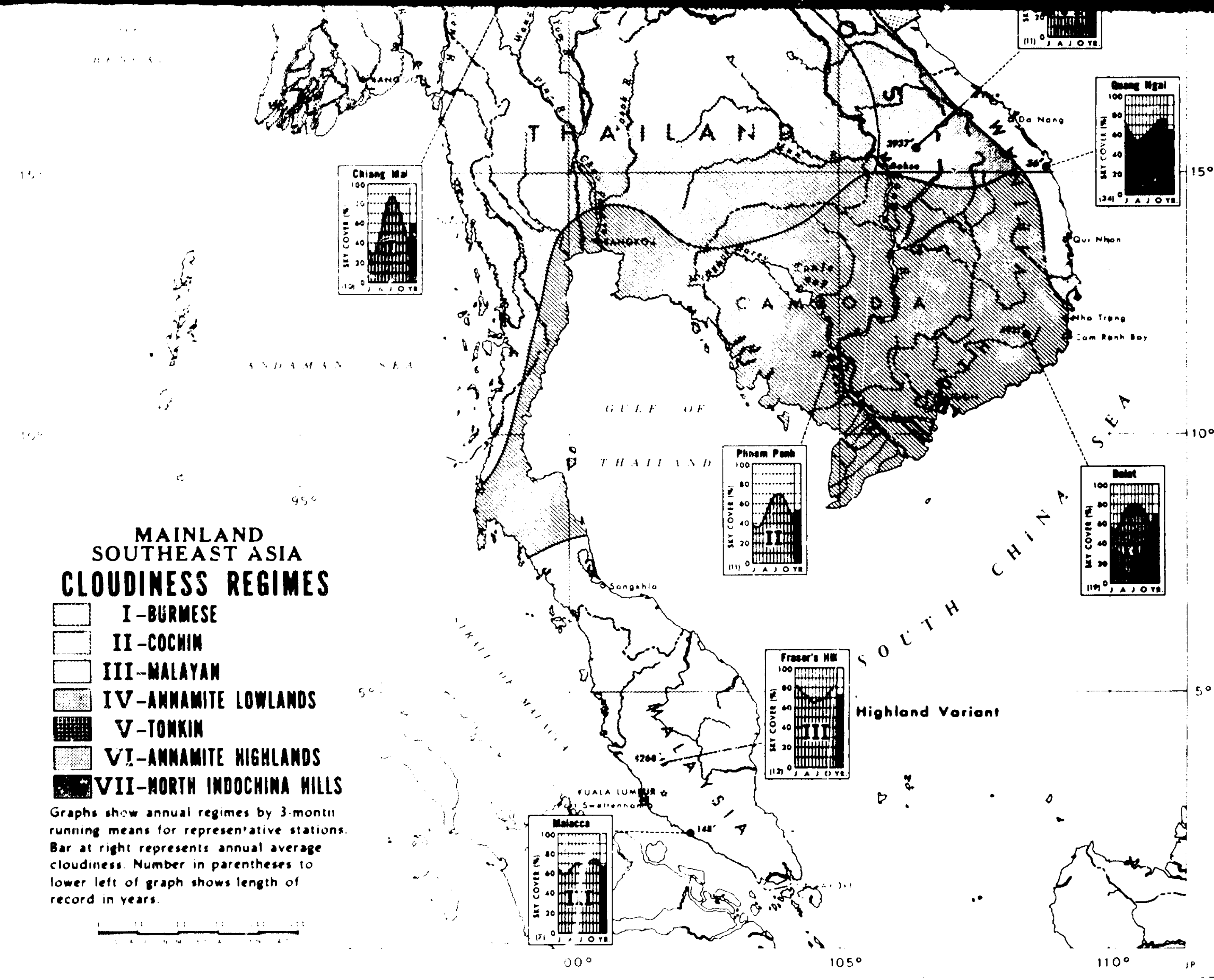
On the right side of each subregional graph a histogram bar shows mean annual cloudiness to emphasize the fact that most of Southeast Asia averages well above 50 percent. The only area where the annual average is below 50 percent is confined to northern Burma where, because of a strong rain-shadow effect, annual precipitation is the lowest in Southeast Asia.

Used in conjunction with Map 10, this cloudiness map allows determination of the likelihood of encountering direct sunlight during the month of highest dewpoint. For example, if the mean cloud cover for August is approximately 65%, one may infer that there will be about a 35 percent chance that an attacking force will be totally exposed to direct sunlight or that direct sunlight may be expected for about 35 percent of the duration of a mid-day attack. However, the normal increase in cloud cover from early morning to late afternoon should be considered. Thus, it may be assumed that, in general, with the passing of each daylight hour, periods of exposure to direct sunlight become less frequent, and shorter in duration.

MAP 12



95°
100°
105°
110°
25°
20°
15°
CHINA
INDIA
BURMA
NORTH VIETNAM
LAOS
THAILAND
CAMBODIA
GULF OF TONKIN
Yangtze R.
Irrawaddy R.
Salween R.
Mekong R.
Hanoi
Xieng Khouang
Luang Prabang
Chiang Mai
Pak Song
Quang Ngai
Haka
VIENTIANE
BANGKOK
RANGOON
Da Nang
Qui Nhon
Pakse
Tonle Sap
SKY COVER (%)
J A J O YR


MAINLAND
SOUTHEAST ASIA
CLOUDINESS REGIMES
I-BURMESE
II-COCHIN
III-MALAYAN
IV-ANNAMITE LOWLANDS
V-TONKIN
VI-ANNAMITE HIGHLANDS
VII-NORTH INDOCHINA HILLS
Graphs show annual regimes by 3-month running means for representative stations. Bar at right represents annual average cloudiness. Number in parentheses to lower left of graph shows length of record in years.
THAILAND
CAMBODIA
MALAYSIA
GULF OF THAILAND
SOUTH CHINA SEA
ANDAMAN SEA
Chiang Mai
Phnom Penh
Quang Ngai
Dalat
Fraser's Hill
Malacca
SKY COVER (%)
J A J O YR
Highland Variant
Da Nang
Qui Nhon
Nha Trang
Cam Ranh Bay
Songkhla
Kuala Lumpur
Pakse
Bangkok
15°
10°
5°
95°
105°
110°

EFFECTS OF VEGETATION ON VISIBILITY

Maps 13, 14, and 15 illustrate the relationship between vegetation and visibility in Southeast Asia. The natural and cultural vegetation of an area is one of the most important determinants of the soldier's ability to see and be seen. Because vegetational characteristics differ greatly in different areas, the effects that vegetation has on visibility likewise vary considerably from place to place. In some areas vegetation is either lacking or is too sparse to influence visibility; in other areas it may be so dense that visibility is reduced nearly to zero.

Several general statements concerning the nature of the vegetation in Southeast Asia might help to clarify this series of maps. Of basic importance is the fact that Southeast Asia was primarily a forested area, only very limited areas having been devoid of trees prior to the arrival of man. However, much of the land has been cleared and there is little forest remaining that has not been modified in some manner. The areas of most dense forest and lowest visibility tend to coincide with the areas of heaviest rainfall; the areas of lightest rainfall usually support open woodlands or grasslands which do not greatly restrict visibility. In areas of heavy to moderate rainfall, where the primary forest has been removed and subsequently allowed to regenerate, the resultant vegetation is usually a very dense scrub (dwarf) forest with jungle-like undergrowth. Visibility may be very poor in this type of plant cover.

In terms of effects on visibility, the physiognomy of vegetation, or its structure and life form, is the most important characteristic. Physiognomy may be described by reference to plant height, stem diameter, branching habit, spacing, leaf characteristics, thickness of undergrowth, and stratification (Kuchler, 1966). The four most important physiognomic traits influencing visibility are stem diameter, stem spacing, leaf characteristics, and density of undergrowth. These traits vary considerably from one vegetational type to another. Stem diameters of trees range from a few inches to over 7 feet. The spacing of trees is also highly variable. In the dense to moderately dense forests, trunks tend to be from 5 to 20 feet apart. In the savannas trunks are usually more widely spaced, although trees may grow close together in clusters separated by open grassland. Leaves of different species vary considerably in size, shape, and arrangement. Deciduous species lose their leaves during the dry season, whereas evergreen species retain at least part of their leaf cover during the entire year. The density of undergrowth varies with a host of factors, including rainfall, topography, drainage, and recency of last cutting. (If other factors are favorable, a cutover area will quickly regenerate into very dense growth.)

Map 13 is a physiognomic classification of Southeast Asian vegetation, with horizontal (ground-to-ground) visibility data, derived from previous studies, indicated for each type (Neal, 1967; and U.S. Army, Corps of Engineers, 1963). The horizontal visibility measurements are given in terms of ranges (e.g., 100-150 feet) which represent the best available estimates of the average distance that a man walking away from an observer remains visible. The measurements of visibility in forests were taken in undisturbed vegetation and, consequently, are not reliable in those areas where the vegetative cover has been substantially altered by man. Also, within a given vegetational type, the spacing of plants and thickness of undergrowth vary with differences in drainage, landforms, and other physical conditions. Nevertheless, the range of visibility distances established for each vegetational type encompasses much of this variance.

Several important kinds of vegetation were not classified as separate types in this study, either because their distributions are too scattered to be mapped at this scale or because they are uniformly distributed throughout Southeast Asia. Bamboo fits the latter category, inasmuch as it is found in nearly all parts of this region. Bamboo grows in thickets, the stems in an individual cluster being very close together. The thickets are spaced from 10 to 100 feet apart. In addition to its restrictive effects on visibility, bamboo also affects mobility adversely, and, when dry, increases the possibility of troop detection because of its extreme noisiness when disturbed. Scrub (dwarf) forest reduces horizontal visibility to less than 60 feet, but it is not differentiated on the map because its areas of occurrence are too small to show at this scale. Other kinds of vegetation, tall enough to affect visibility and found throughout Southeast Asia, include various vines (many with thorns or barbs), elephant grass, and ferns.

As indicated on Map 13, agricultural lands generally have visibility distances in excess of 300 feet. However, some crops, covering only a relatively small proportion of the total area, restrict visibilities to a greater degree: e.g., mature cassava, approximately 60 feet; banana groves, 50-85 feet; and fruit orchards, 150-180 feet. In rice fields, which occupy by far the larger part of the agricultural land, visibilities are usually over 300 feet. In grasslands, visibilities are greater than 300 feet, except where tall grass prevails, as in areas of giant grass or elephant grass. In rubber plantations visibility varies from over 300 feet in well-maintained groves to less than 50 feet in areas where the undergrowth has been allowed to become dense (U.S. Army, Corps of Engineers, 1963).

Map 13 should be interpreted with the following important qualifications in mind:

a. Thailand is the only country in Southeast Asia for which actual measurements of visibility distance are available. For the other countries, the data are based on measurements made in vegetationally analogous regions of Thailand.

b. Because of the lack of a satisfactory vegetation map encompassing the entire study area, it was necessary to develop a composite regional map from various source materials. As a result of inconsistencies in these sources, many estimates and judgments had to be made to complete the regional map, thereby introducing a probable source of error. In terms of the reliability of vegetation mapping, the countries may be ranked approximately in the following descending order: Thailand, Malaya, Vietnam, Cambodia, Laos, and Burma.

c. A map based on the relationship between vegetation and visibility, even if highly accurate, does not give a complete picture of the visibility characteristics of any area. Vegetation, although obviously of major importance, is only one of many factors that determine visibility. Other environmental factors that influence visibility are weather, light, landforms, atmospheric pollution, and sunglare. Also, because of human differences in eyesight, experience, and general alertness, not all observers have the same ability to see objects at a given distance. In addition, visibility measurements depend on the method used to obtain them. Methods other than the man-walk procedure used in the Thailand study have been applied in different areas resulting in different visibility distances for the same general types of vegetation.

Maps 14 and 15 are derived from Map 13. In Map 14 the vegetation types are consolidated into three classes representing the general effects of vegetation on horizontal visibility. Areas are classified as zones of poor (50 to 85 feet), fair (125-300 feet), and good (over 300 feet) visibility. (Values between 85 and 125 feet are missing because no data were found in that range.) The zones of poor visibility include tropical rainforests, dry evergreen forests, and mangrove/nipa palm forests. Areas of fair visibility include swamp forests, mixed deciduous forests, dry dipterocarp forests, and savannas. The zones of good visibility comprise agricultural lands, grasslands, and rubber plantations, with exceptions as noted in the discussion of Map 13.

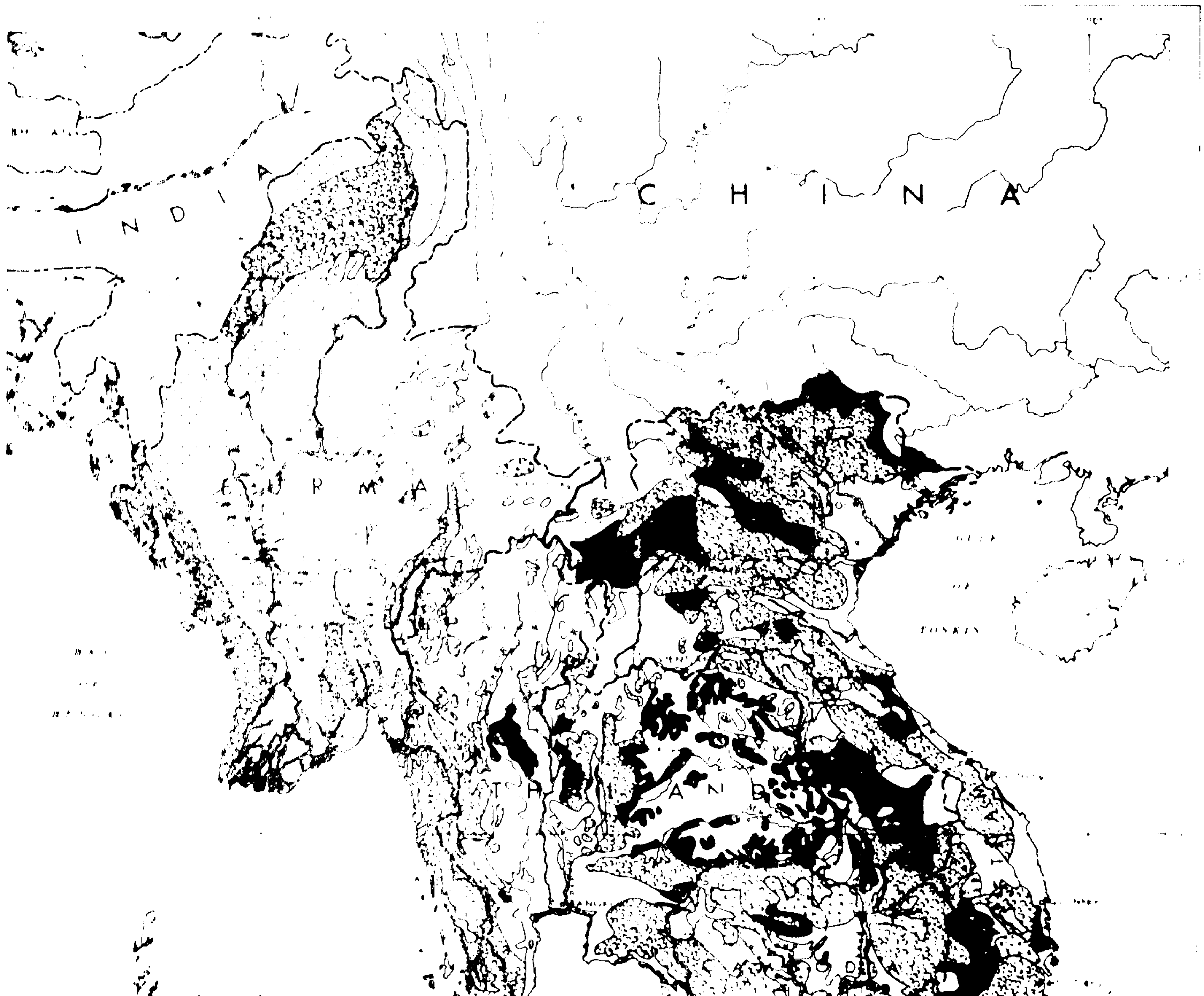
In Map 15 emphasis is shifted from horizontal visibility to vertical or air-to-ground visibility. The effects of vegetation on air-to-ground visibility are illustrated by indicating the relative obscuration of the land surface by the vegetative cover.

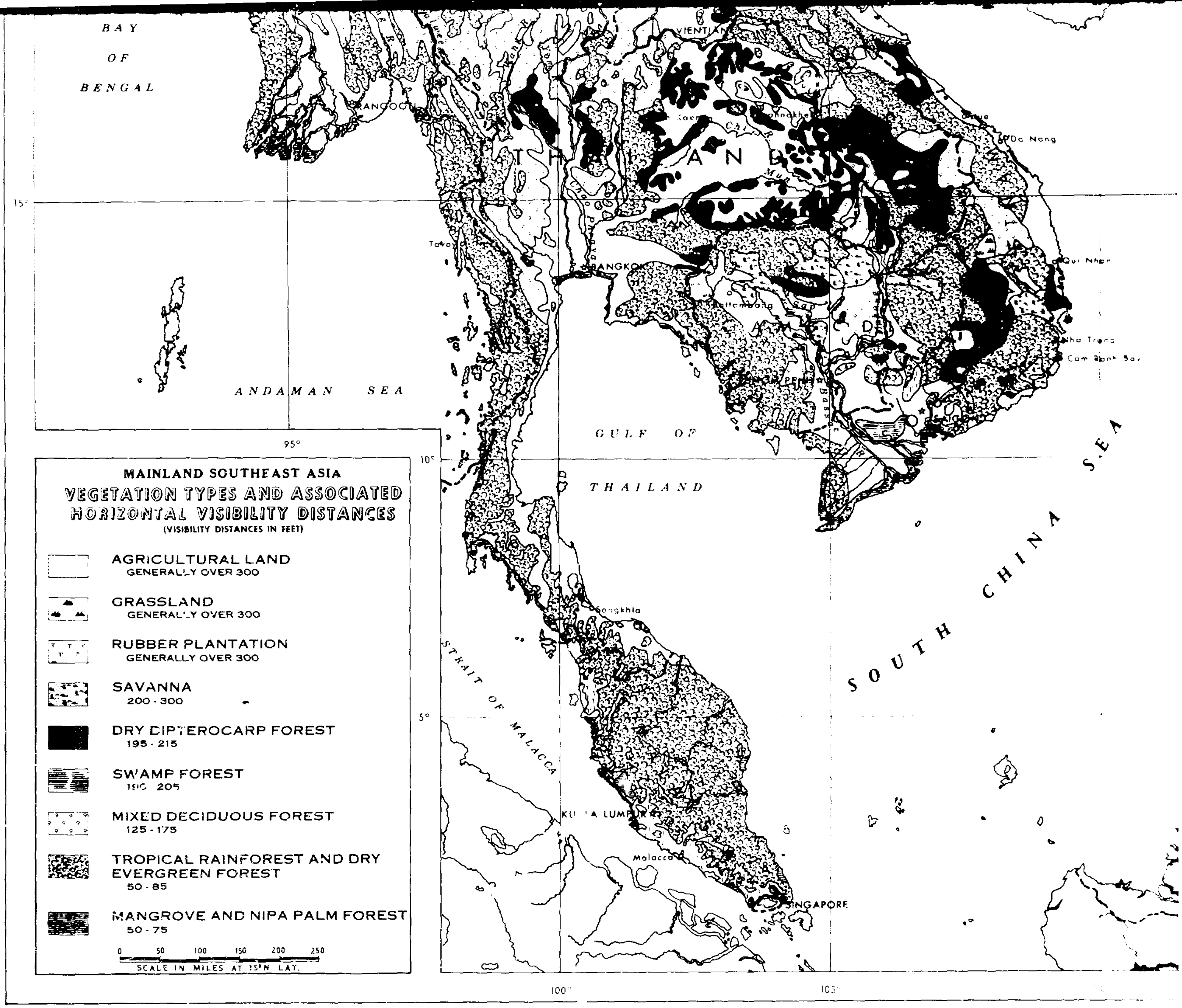
When extensive use is made of aircraft for surveillance, resupply, troop movement, and destruction of enemy installations, air-to-ground visibility is a highly relevant environmental characteristic. Although many other factors (e.g., weather, clarity of the atmosphere, time of day, angle of observation, altitude and speed of aircraft) affect the ability of an observer to determine surface conditions from the air, vegetation is probably the most common and persistent element reducing visibility. In general, the denser and more continuous the vegetative cover, the greater the degree of obscuration of the land surface. However, for maximum impairment of visibility, the uppermost layer of vegetation must be sufficiently high above ground level to provide cover for standing men and large equipment.

The "high obscuration" category of Map 15 comprises dense forests such as tropical rainforest, dry evergreen, mangrove and nipa palm. In many areas these forests are so dense that even large objects below the canopy cannot be seen from the air. In other areas occasional clearings or sparser distribution of trees provide slightly better visibility. The more open forests such as mixed deciduous, dry dipterocarp, and savanna reduce visibility less, on the average, than dense forests. (Also, many species in this class lose their leaves during the dry season and afford relatively little cover during this period.) These forests comprise the "moderate obscuration" category of Map 15. In those sections of Southeast Asia where no continuous forest canopy exists (grasslands and agricultural areas), there is only minor obscuration of the ground; exceptions are the narrow stretches of woodlot along some roads and waterways, the forests surrounding most villages, rubber plantations, and occasional isolated woodlots. Air-to-ground visibility in these scattered woodlots varies from poor to fair. For the most part, however, the grasslands and agricultural areas may be placed in the "little obscuration" category of Map 15.

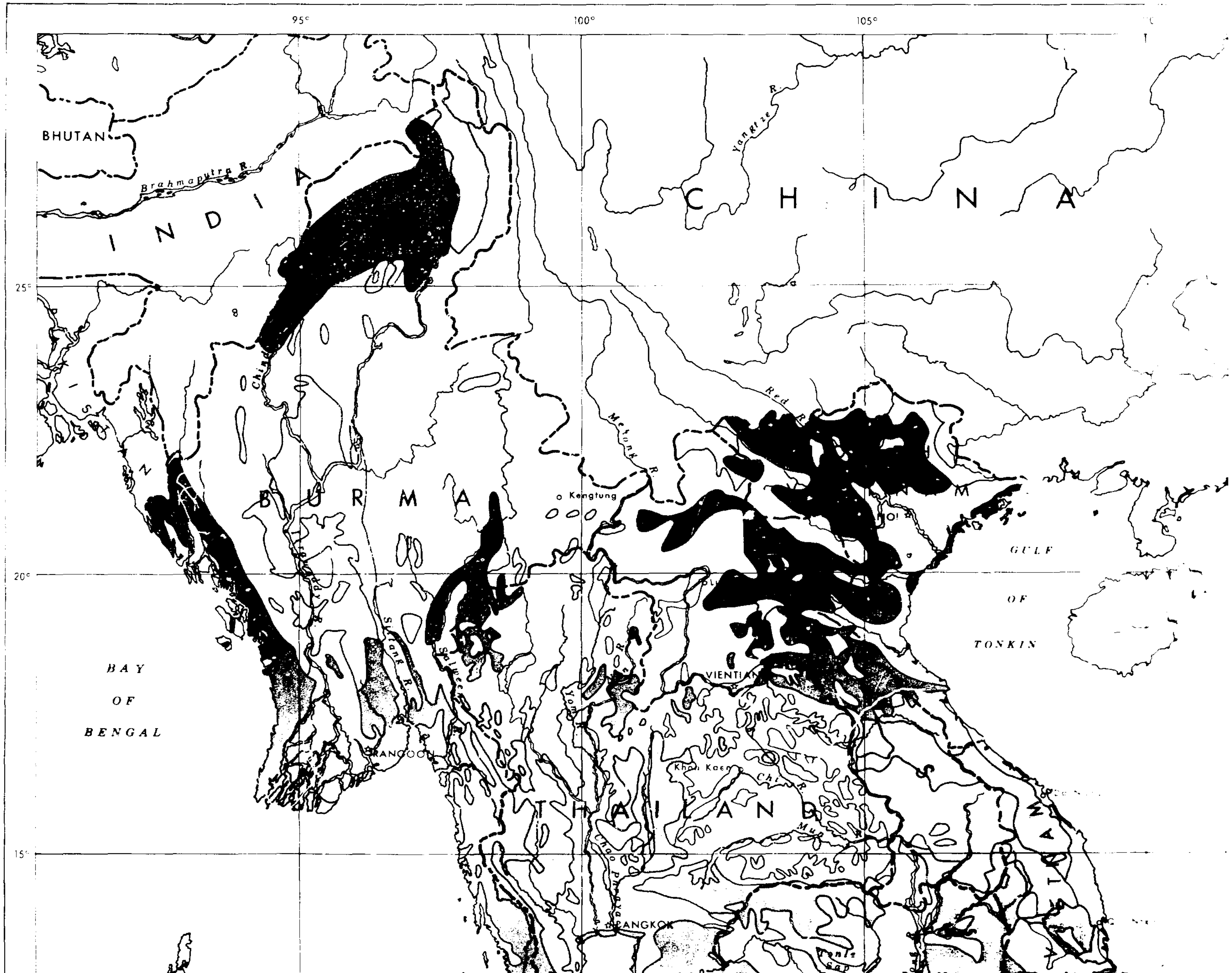
In densely forested areas controlled by enemy forces, military operations may be facilitated by removing the foliage from trees and undergrowth, thereby depriving the enemy of his cover. The two principal methods for stripping vegetation are burning and chemical defoliation. Neither method is completely successful in the Southeast Asian environment, and each has problems associated with its use. Of the two methods, chemical defoliation has proved more effective; particularly in the mangrove forests (Tschirley, 1969). Map 15 may be considered as an illustration of the extent of the military problems associated with vegetation density.

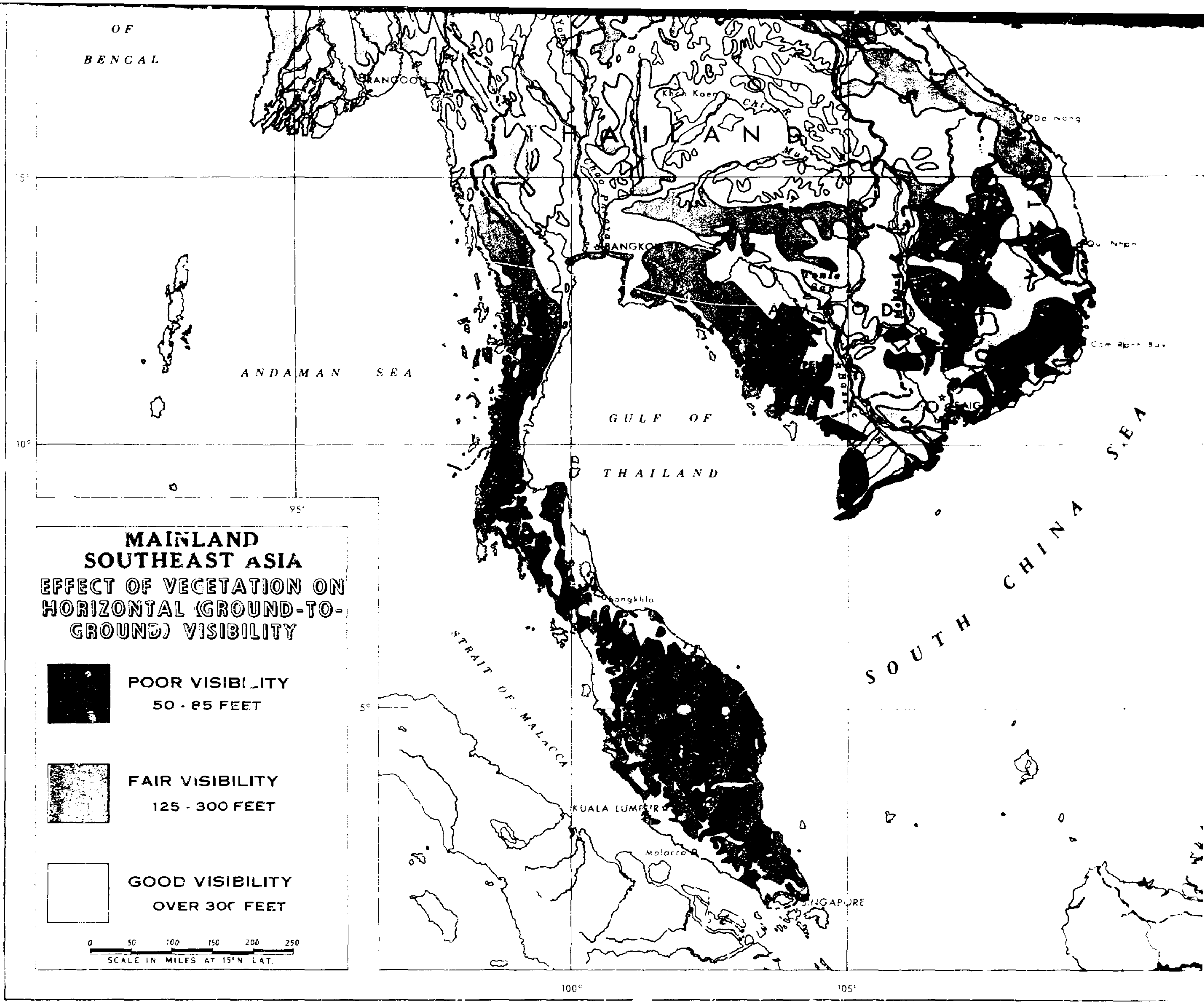
MAP 13



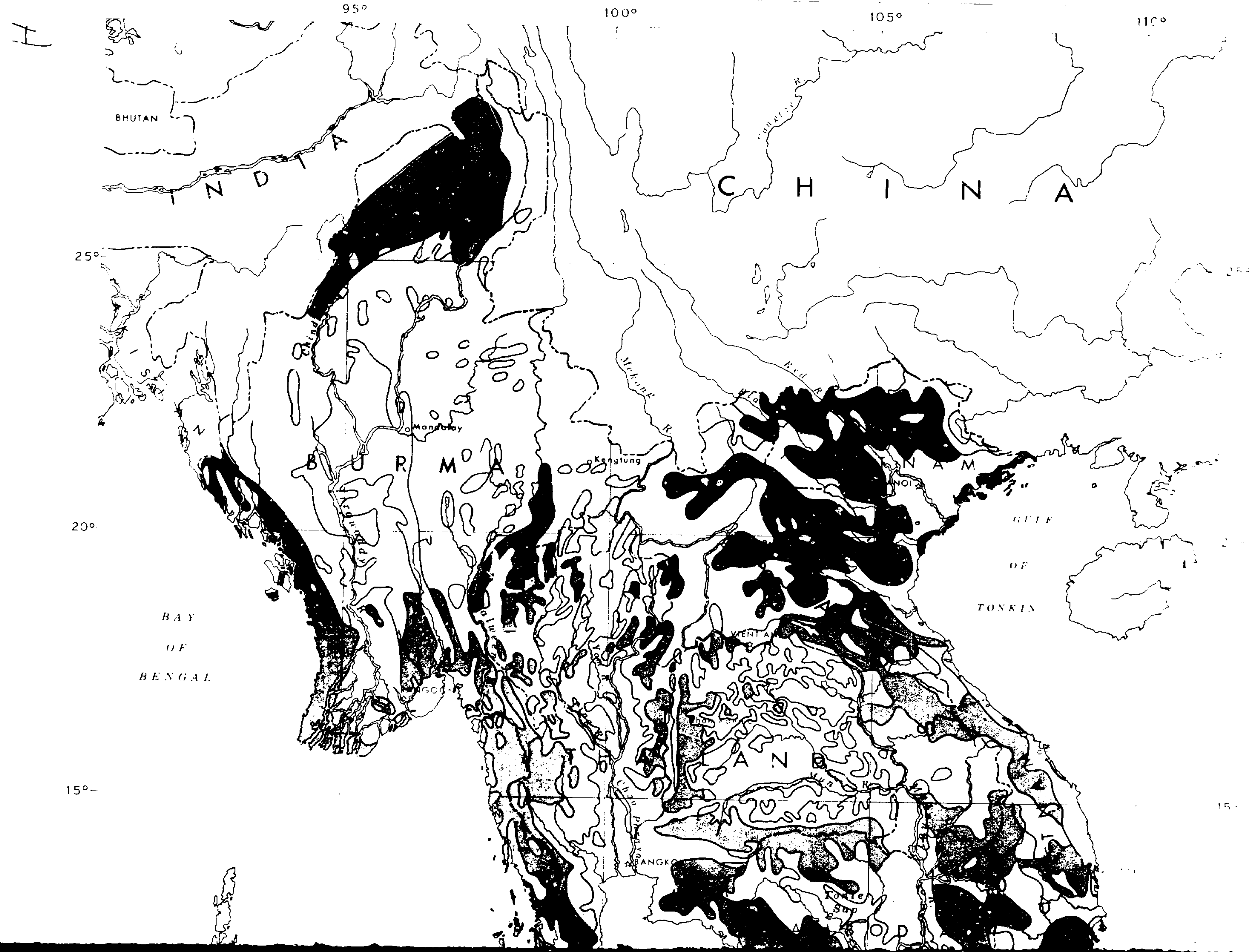

MAINLAND SOUTHEAST ASIA
VEGETATION TYPES AND ASSOCIATED HORIZONTAL VISIBILITY DISTANCES
(VISIBILITY DISTANCES IN FEET)
AGRICULTURAL LAND
GENERALLY OVER 300
GRASSLAND
GENERALLY OVER 300
RUBBER PLANTATION
GENERALLY OVER 300
SAVANNA
200 - 300
DRY DIPTEROCARP FOREST
195 - 215
SWAMP FOREST
150 - 205
MIXED DECIDUOUS FOREST
125 - 175
TROPICAL RAINFOREST AND DRY EVERGREEN FOREST
50 - 85
MANGROVE AND NIPA PALM FOREST
50 - 75
0 50 100 150 200 250
SCALE IN MILES AT 15°N LAT.
BAY OF BENGAL
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
BANGKOK
VIENTIANE
Da Nang
Qui Nhon
Nha Trang
Cam Ranh Bay
Songkhla
Malacca
SINGAPORE
Tavoy
15°
10°
5°
95°
100°
105°

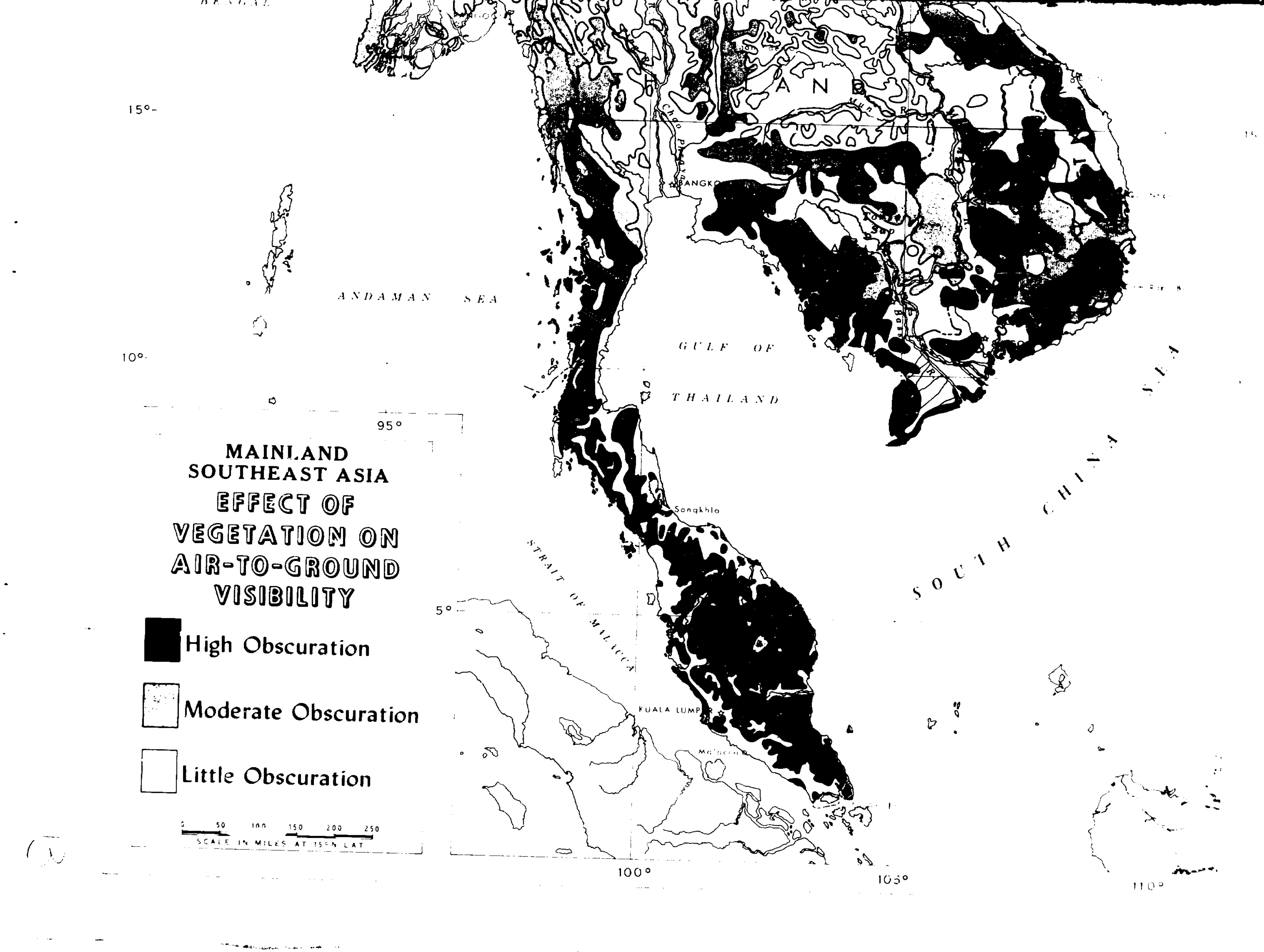
MAP 14


95°
100°
105°
25°
20°
15°
BHUTAN
Brahmaputra R.
INDIA
CHINA
Yangtze R.
Red R.
Mekong R.
Chindwin
BURMA
o Kengtung
Irrawaddy R.
Sittang R.
Salween
RANGOON
BAY OF BENGAL
GULF OF TONKIN
VIENTIANE
Khon Kaen
Chi R.
Mun R.
Yom R.
Chao Phraya
BANGKOK
THAILAND


MAINLAND
SOUTHEAST ASIA
EFFECT OF VEGETATION ON HORIZONTAL (GROUND-TO-GROUND) VISIBILITY
POOR VISIBILITY
50 - 85 FEET
FAIR VISIBILITY
125 - 300 FEET
GOOD VISIBILITY
OVER 300 FEET
0 50 100 150 200 250
SCALE IN MILES AT 15°N LAT.
BAY OF BENGAL
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
THAILAND
BANGKOK
RANGOON
Da Nang
Qui Nhon
Cam Ranh Bay
Songkhla
KUALA LUMPUR
Malacca
SINGAPORE
Chao Phraya
15°
10°
5°
95°
100°
105°

MAP 15


95°
100°
105°
110°
25°
20°
15°
BHUTAN
INDIA
CHINA
BURMA
Mandalay
Kengtung
Mekong R.
Red R.
Chindwin
Irrawaddy
Salween
VIENTIANE
BANGKOK
Chao Phraya
Mun R.
Tonle Sap
GULF OF TONKIN
BAY OF BENGAL


MAINLAND
SOUTHEAST ASIA
EFFECT OF
VEGETATION ON
AIR-TO-GROUND
VISIBILITY
High Obscuration
Moderate Obscuration
Little Obscuration
0 50 100 150 200 250
SCALE IN MILES AT 15°N LAT
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
BANGKOK
Songkhla
KUALA LUMPUR
Chao Phraya
15°
10°
5°
95°
100°
105°
110°

LOWLAND RICE REGIONS AND REGIMES

The annual cycle of lowland rice cultivation in Southeast Asia is marked by seasonal changes which have important military implications. Of particular significance are variations in water level and crop maturity (height and density) as related to such factors as trafficability, cover, visibility, and camouflage requirements.

Map 16 is designed to show the distribution of lowland rice-growing areas in Indochina, and to illustrate an idealized portrayal of annual rice regimes within fourteen regions through the use of superimposed graphs. Because the information on which this map is based varies in detail from place to place, areal distribution of specific rice regimes is shown for some parts of the region and not for others. Thus, graphs having a screen pattern overprint are keyed to areas on the map with the same pattern. Where no pattern is shown, the rice regime portrayed has not been areally delimited, but is known to occur in the vicinity of the location pin-pointed on the map. In the case of the two graphs relating to Laos it is known only that the regimes shown are common to the southern Laotian lowlands. The growth in height of the rice is traced on the graphs from planting to harvest, with crop height at maturity averaging 36 inches . The actual height of a mature crop depends upon such variables as the type of rice planted, the availability of water during the growing season, and the fertility of the soil. Mean monthly temperature (curve) and precipitation (bars) are also included on the graphs. The station named on each graph indicates the source of these climatic data.

Regional Descriptions

a. Red River Delta (North Vietnam)

Ricelands of the Red River Delta are intensively cultivated, employing about 80% of the labor force. Individual land holdings average less than two acres and per-capita production is relatively low, contributing to a subsistence rice economy in a region of rapidly increasing population. The "tenth-month" crop is the most important, yielding more than 2.5 million tons of rice from 3.4 million acres. More than two million acres are double cropped (about one-half the total ricelands of the delta), yielding a "fifth-month" harvest of 1.5 million tons. Poor drainage accounts for the absence of a wet-season crop in the western part of the Delta. A third crop, limited to about 240,000 acres, has been introduced. Supplementary food crops are corn, sweet potatoes, taro, manioc, and beans. Corn, a dry season crop, is the most important of these, and is planted where irrigation is inadequate for a second rice crop. Rice fields in the Red River Delta region are subject to serious flooding, caused by rapid increases in the level of the Red River during the rainy season. To protect the fields, high dikes have been constructed along the waterways of the Delta.

b. Coastal Annam (North Vietnam and The Republic of Vietnam)

This region includes the deltas and alluvial plains of the coasts of North Vietnam and The Republic of Vietnam, between the Red River and Mekong Deltas. Here, two million acres are intensively cultivated, with multiple cropping timed to avoid harvesting during the fall typhoon season. Elaborate but technically primitive irrigation methods are used to take advantage of the warm-season precipitation in the Annamite Chain, and the winter rains on the coast.

c. Mekong Delta

This is the largest and most productive agricultural region of Indochina, with more than 5-1/2 million acres planted in rice. Although less care is devoted to cultivation here than in the Red River Delta or in coastal Annam, and double cropping is seldom practiced, it is normally a surplus rice producing area--in part because of a relatively low population density.

Flood waters of the Mekong do not rise as rapidly or to such high levels as those of the Red River in North Vietnam. This is attributable to the fact that, during the period of high water, the rising Mekong causes the Tonle Sap River to reverse its flow, diverting waters of the Mekong into the Great Lake basin of Cambodia.

Rice cultivation in the Mekong Delta Region differs in several respects from that of the Red River Delta and Coastal Annam. Rising flood waters are allowed to inundate the rice fields without control by high dikes or embankments. The flow is controlled rather by low dikes and an extensive network of channels, natural and artificial, which normally prevent overflooding and provides adequate drainage. Individual land holdings are larger than in the north, most exceeding 2-1/2 acres.

About 75% of the rice crop is transplanted only once. Areas with two transplantings are located near the larger distributaries, in fields which are subject to deeper flooding. Here, well established seedlings are required to survive the effects of deep flooding, as well as to compete with lush weed growth in the rich alluvial soils. Where the Mekong floods to a depth of 10 feet or more, floating rice is sown on dry ground, usually between rows of nearly mature corn, a dry season crop which is harvested before the fields are flooded. No nursery is used for floating rice and little care is required between planting and harvest. Floating rice grows rapidly, keeping its head above the rising flood waters, and the plant may attain a length of 18 feet. As waters subside, the plant stretches out on the mud, and develops new root systems at nodes along the stalk, which in turn mature like ordinary rice plants (Gulick, 1948).

d. Cambodia

Approximately 3 million acres are devoted to rice cultivation in Cambodia, 80% of which is planted to a single rainy-season crop. Intensive cultivation is not common to the Cambodian rice economy, largely because of relatively low population pressure on the land. About one-fourth of the ricelands are allowed to remain fallow each year.

A dry-season crop is grown on poorly drained lands, in low depressions (bengs) near rivers where flood waters remain much of the year. The area planted in dry-season rice depends upon the success of the rainy-season crop. Cultivation of floating rice in Cambodia is similar to that described for the Mekong Delta Region.

Nurseries generally are used for starting both the rainy-season and the dry-season crops. However, in some areas near Battambang and Kompong Chhang, broadcast sowing of rice is practiced.

e. Laos

A little more than one million acres are devoted to lowland rice cultivation in Laos. In growing rainy-season rice, two principal methods are used: (1) the employment of irrigation canals to distribute the water; and (2) the use of dikes and terraces to retain rain water and silt deposits. In southern Laos, as in Cambodia, a dry-season crop is planted after floods have subsided.

Upland Rice

Although only lowland rice regions are mapped here, brief mention should be made of upland rice cultivation, a form of agriculture which is variously referred to as ray, swidden, slash and burn, or shifting cultivation. Upland rice culture is a primitive subsistence form of agriculture, practiced throughout the sparsely populated highlands of Indochina. Because of the short-term use of upland rice fields, it would be virtually impossible to prepare a map showing specific areas under this type of rice cultivation. Because of the rapid depletion of soil nutrients, upland rice fields are cultivated for only two or three years and are then allowed to remain fallow for about 20 years.

Upland rice cultivation involves the following steps (Gulick, 1948):

a. A plot of forest land (about 2-1/2 acres) is selected as close to the farmer's house as possible.

b. Trees are cut down or girdled.

c. Vegetation is burned near the end of April, leaving ashes and some of the largest trunks and stumps.

d. Rice seed is planted in May or July in holes made by a pointed stick (no tillage is involved).

e. The crop is left to mature by itself, with fencing as the chief means of protecting the fields from animals.

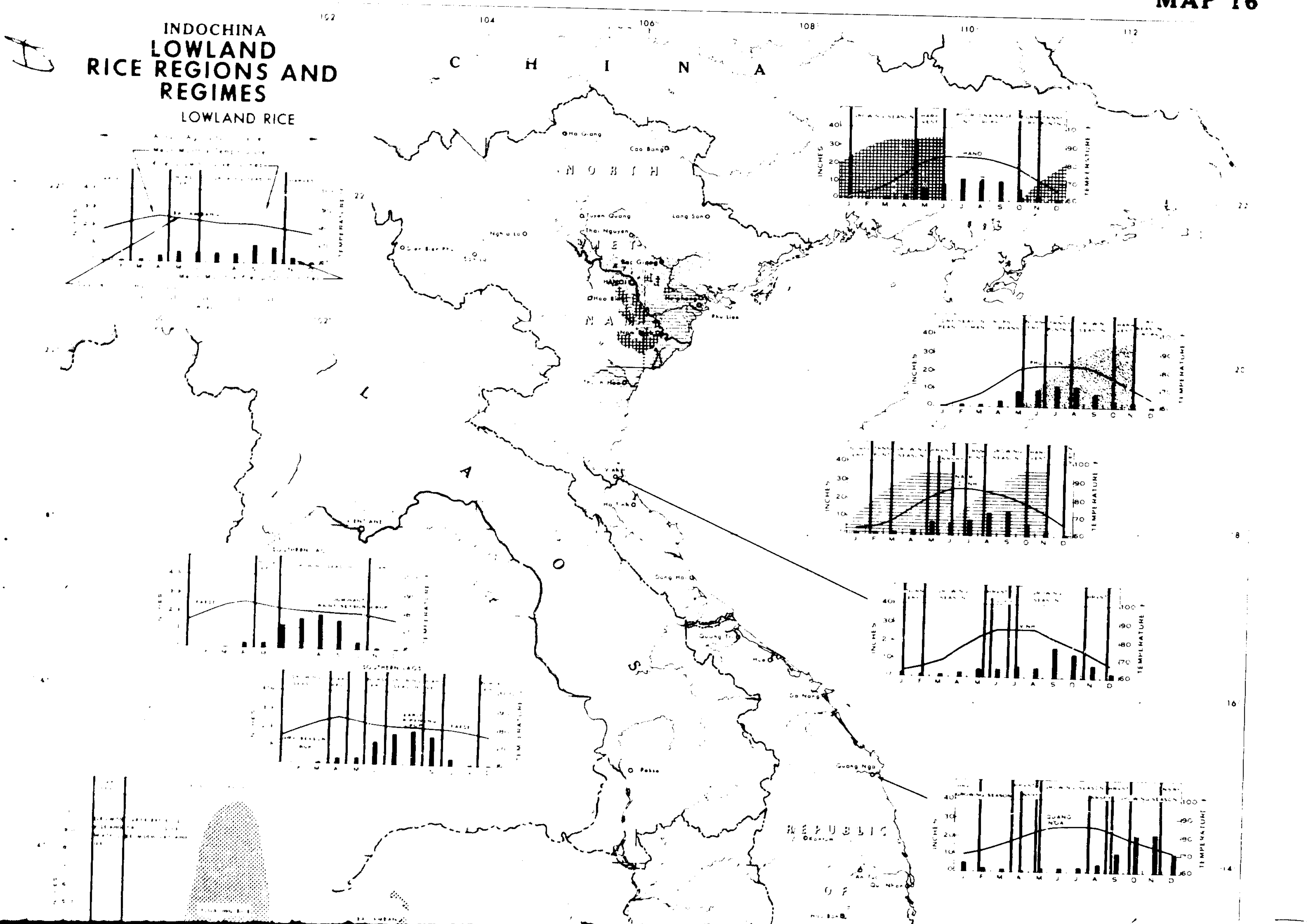
f. Rice is harvested in October.

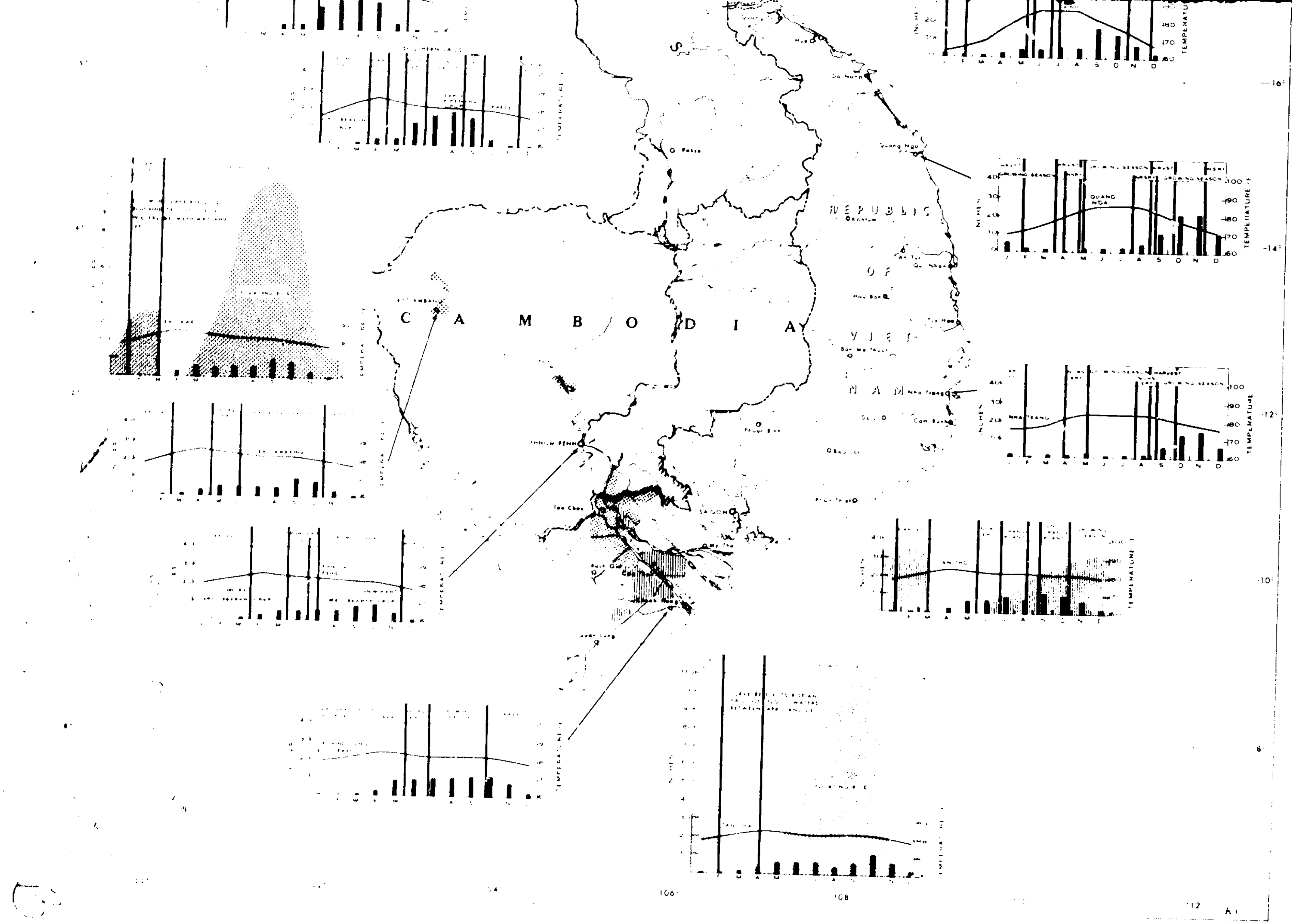
MAP 16

INDOCHINA

LOWLAND RICE REGIONS AND REGIMES

LOWLAND RICE




CAMBODIA
REPUBLIC OF VIET NAM
SAIGON
Phnom Penh
Quang Ngai
Nha Trang
Da Nang
Hue
QUANG NGAI
NHA TRANG
TEMPERATURE °F
INCHES
J F M A M J J A S O N D
16°
14°
12°
10°
8°
104°
106°
108°
112

The continued effectiveness of any human effort, and especially that required in military activities, is directly related to the availability of adequate supplies of unspoiled foodstuffs. It has been determined through laboratory and field tests that the storage life expectancies of semi-perishable food items is significantly reduced when exposed to high temperatures. Such tests have also shown that some items deteriorate much faster than others.

Map 17 delimits food storage life areas in Southeast Asia. This map is based on mean annual temperatures, with isotherms (drawn at intervals of 10 Fahrenheit degrees) subdividing the map into four food storage life areas. These areas are identified by Roman numerals, numeral "I" representing the hottest regions and, consequently, the area having the shortest food storage life expectancy. This map is designed for use in conjunction with Table V (adapted from TM-743-200, Storage and Materials Handling) which lists the approximate keeping time for selected packaged food products within each temperature range. The table is constructed to give approximate food storage life expectancies in the humid tropics in areas having mean annual temperatures between 50 and 90°F. The shaded columns represent the predicted values for the mid-point temperatures in each area, i.e., 55, 65, 75, and 85°F. In the region mapped, none of the stations have a mean annual temperature exceeding 83°F. Therefore, in using the table to determine food storage life within Area I, interpolation should be made between storage life [illegible]ates for 80°F and for 85°F.

Food storage life, as presented here, has been determined only on the basis of dry storage and does not take humidity into consideration as a factor in food deterioration. The map is most reliable for the extensive lowland regions where large areas are exposed to the same environmental conditions, and is least reliable in the mountains where temperatures may vary significantly with elevation over a short horizontal distance. All figures are based on open dump or ventilated warehouse storage. If storage dumps are tightly covered with paulins or the warehouse is tightly closed, storage life may be reduced to that corresponding to the adjacent, more severe storage life area. The inherent error in laboratory storage life determination is 25 percent. In estimating the safe keeping time of any item, its storage history between packaging and delivery to a particular geographic region must be considered.

TABLE V: SAFE STORAGE TIME FOR SELECTED FOOD ITEMS

		SAFE STORAGE TIME (Months)								
			I		II		III		IV	
Product	Packaging	*90°	85°	80°	75°	70°	65°	60°	55°	50°
Apple										
regular pack	can	24	26	29	32	36	40	45	51	57
dehydrated (juice)	can	18	22	26	32	36	40	45	50	54
Apricots										
regular pack	can	12	16	22	27	33	38	43	47	52
freeze dehydrated	can	5	6.5	8	10	12	14	16	18	20
Asparagus	can	12	18	24	30	36	41	46	51	55
Bacon (sliced)	can	12	13	14	16	[illegible]	20	23	27	32
Bakery mixes	can	9	16	23	30	36	40	43	46	47
	bag ctn.	3	3.5	4.5	5	6	7	7.5	8.5	9.5
Baking powder	can	6	7	8.5	[illegible]	12	[illegible]	15.5	17	19

* Mean annual temperatures

SAFE STORAGE TIME (Months)

Product	Packaging	90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
Barley, pearl	bag/ctn.	12	**14**	17.5	**20**	24	**27**	30	**32**	34
Beans (dried)	bag/ctn.	9	**9.5**	10	**11**	12	**13**	14.5	**16**	18
green regular	can	12	**18**	24	**30**	36	**41**	46	**51**	55
green dehydrated	can	24	**32**	41	**50**	60	**67**	74	**80**	83
kidney	can	24	**30**	36	**42**	48	**54**	59	**63**	67
lima	can	24	**30**	36	**42**	48	**54**	59	**63**	67
lima, dehydrated	can	18	**22**	26	**32**	36	**40**	45	**50**	54
wax	can	18	**22**	26	**32**	36	**40**	45	**50**	54
Beef, chunks w. natural gravy	can	30	**33**	36	**39**	42	**45**	48	**51**	55
corned	can	30	**33**	36	**39**	42	**45**	48	**51**	55
Beef steak, raw, dehydrated	can	18	**22**	26	**32**	36	**40**	45	**50**	54
Beets, regular pack	can	10	**13**	16.5	**20**	24	**28**	32	**36**	40
Berries, black, etc.	can	9	**11.5**	14.5	**18**	22	**26**	29.5	**33**	36
Beverage base										
cocoa, liquid	can	6	**10**	15.5	**19**	24	**26**	31	**33**	35
cocoa, powder	can	12	**14.5**	17	**20**	24	**29**	33	**39**	45
Blueberries	can	9	**10**	13	**15**	18	**21**	24	**27**	30
Candy										
caramel	box	4	**5**	6.5	**8**	9	**10**	11	**11.5**	12
hard	can	12	**14.5**	17	**20**	24	**29**	33	**39**	45
Carrot										
regular pack	can	24	**28**	33	**37**	42	**45**	53	**59**	64
Catsup										
regular pack	bottle	12	**15**	17.5	**21**	24	**27**	31	**35**	38
dehydrated	env/can	6	**9.5**	14	**18.5**	24	**31**	38	**45**	54
Cereal										
quick cooking	ctn.	6	**9**	10.5	**11.5**	12	**12**	12	**12**	12
ready to eat	pkg	6	**8**	10.5	**11.5**	12	**12**	12	**12**	12

Product	Packaging	SAFE STORAGE TIME (Months) 90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
Cheese										
cheddar, processed	can	12	**18**	24	**30**	36	**41**	46	**51**	55
processed, American dehydrated	can	6	**7.5**	10	**12**	15	**18**	22	**25**	29
Chewing gum	ctn.	2	**2.5**	3	**3.5**	4	**4.5**	5.5	**6**	7
Chicken										
dehydrated or regular pack	can	18	**22**	26	**32**	36	**40**	45	**50**	54
Chile con carne										
w/o beans	can	24	**27**	30	**33**	36	**39**	41	**43**	45
dehydrated/beans	can	18	**22**	26	**32**	36	**40**	45	**50**	54
Chocolate, cooking										
semi-sweet chips	pkg	6	**8.5**	11.5	**15**	18	**21**	25	**28**	31
unsweetened	ctn.	12	**15**	17.5	**21**	24	**27**	31	**35**	38
Chocolate sirup, beverage	can	12	**14.5**	17	**20**	24	**29**	33	**39**	45
Cocoa, natural	ctn.	9	**10**	13	**15**	[illegible]	**21**	24	**27**	30
Cocoanut, prepared sweetened	can	6	**8.5**	11.5	**15**	18	**21**	25	**28**	31
Coffee										
instant	env.	9	**10**	13	**15**	18	**21**	24	**27**	30
roasted & ground	pouch	1	**1**	1.5	**1.5**	2	**2.5**	3	**4**	5
	can	5	**6.5**	8.5	**10**	12	**14**	15	**16**	17
Cookies	ctn.	2	**2.5**	3.0	**3.5**	4	**4**	4.5	**5**	5.5
Corn, cream, and whole grain styles	can	24	**28**	33	**37**	42	**48**	53	**59**	64
Corn, dehydrated, LPPD, Cooked or uncooked	can	6	**9.5**	14	**18.5**	24	**29**	34	**38**	42
Corn meal	pkg	6	**7**	8.5	**10**	12	**14.5**	17	**21**	25
Crackers										
Graham	ctn.	1	**1.25**	1.5	**1.75**	2	**2.25**	2.5	**3.0**	3.5
oyster, soda	ctn.	2	**2.5**	3.0	**3.5**	4	**4**	4.5	**5**	5.5
Cranberry sauce	can	12	**15**	17.5	**21**	24	**27**	31	**35**	38

Product	Packaging	90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
		SAFE STORAGE TIME (Months)								
Cream										
coffee type, 18% fat	container	3	8	10.5	11.5	12	12	12	12	12
substitute	can/env	12	18	24	30	36	41	46	51	55
Dessert powder										
gelatin, based, all flavors	can	12	18	24	30	36	41	46	51	55
instant, all flavors	can	6	8	10.5	14	18	23	28	35	43
Egg mix, dehydrated	can	15	19	23	28	34	39	44	48	53
Eggs, whole, dry	can	18	22	26	32	36	40	45	50	54
Fish, dehydrated										
patties	can	18	22	26	32	36	40	45	50	54
Flour										
rye	bag	3	5	7.5	9.5	12	14.5	17.5	21	24
wheat, hard or soft	can	6	8	11	14	18	22	26	31	36
Food packet										
abandon aircraft	can	20	24	29	34	40	44	49	53	56
survival, abandon ship	ctn.	72	78	81	83	84	84	84	84	84
survival, aircraft, life raft	can	72	78	81	83	84	84	84	84	84
survival, general purpose	ctn.	24	30	37	43	48	[illegible]	55	53	59
Frankfurter	can	30	35	40	44	48	[illegible]	54	57	59
Fruitcake	box	1	2	3	4.5	6	7	8	9	9.5
Fruit, candied	jar	3	3.5	4.5	5	6	7	7.5	8.5	9.5
Fruit cocktail	can	12	17	22	27	33	38	42	47	51
Gelatin, plain, edible	container	24	27	30	33	36	39	43	47	51
Grape juice										
dehydrated	can	18	22	26	32	36	40	45	50	54
single strength	can	9	10.5	13	15	18	21	23	25	27

SAFE STORAGE TIME
(Months)

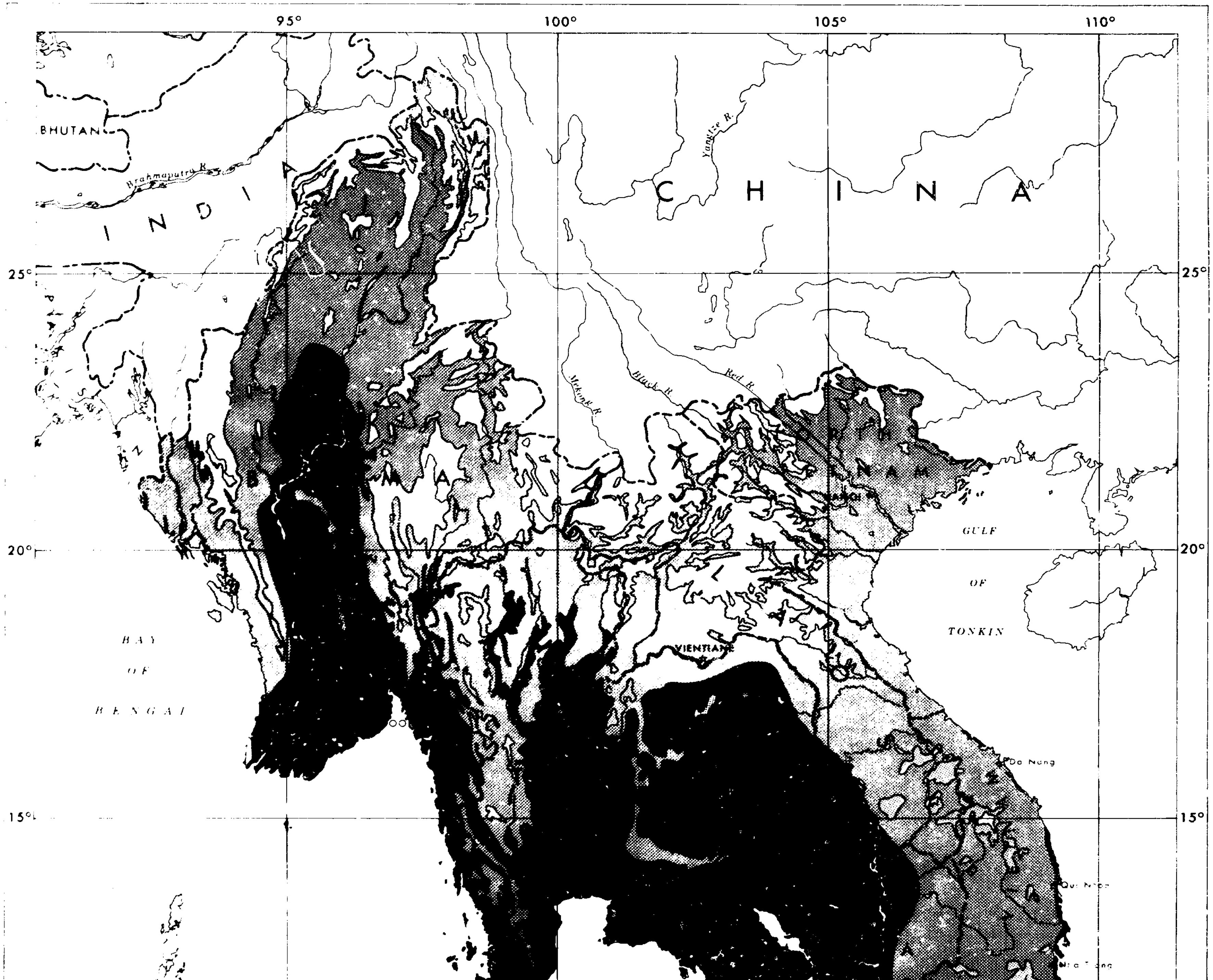
Product	Packaging	90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
Grapefruit										
regular pack	can	12	**16**	20	**25**	30	**35**	40	**45**	49
juice, single strength	can	18	**23**	27.5	**32**	36	**40**	43	**46**	47
Ham chunks	can	30	**35**	40	**44**	48	**51**	54	**57**	59
Hamburgers, without gravy	can	30	**33**	36	**39**	42	**45**	47	**51**	55
Ice cream mix										
paste	can	4	**5.5**	7.5	**9.5**	12	**14**	16.5	**19**	21
powder	can	6	**7.5**	10	**12**	15	**18**	22	**25**	29
Jam, fruit	can/jar	10	**11.5**	13	**15.5**	18	**21**	25	**29**	34
Jelly, fruit	can/jar	10	**11.5**	13	**15.5**	18	**21**	25	**29**	34
Lard, service style	ctn.	3	**3.5**	4.5	**5**	6	**7**	7.5	**8.5**	9.5
Lemon juice, dehydrated	can	18	**22**	26	**32**	36	**40**	45	**50**	54
Luncheon meat	can	24	**27**	30	**33**	36	**39**	43	**47**	51
Macaroni	ctn.	24	**27**	30	**33**	36	**39**	41	**43**	45
Margarine	can	9	**12**	16	**19.5**	24	**29**	34	**40**	46
Marmalade	jar	10	**11.5**	13	**15.5**	18	**21**	25	**29**	34
Marshmallow	container	1	**2.5**	4.5	**6.5**	9	**10.5**	11.5	**12**	12
Mayonnaise	can/jar	4	**4.5**	5	**5.5**	6	**6.5**	7	**8**	8.5
Meal combat individual	case	12	**14.5**	17	**20**	24	**29**	33	**39**	45
Milk										
chocolate (cocoa flavored)	env.	12	**14.5**	17	**20**	24	**29**	33	**39**	45
evaporated	can	6	**7**	8.5	**10**	12	**13**	15.5	**17**	19
Molasses	can	12	**13**	14.5	**16**	18	**20**	24	**29**	36
Mustard, prepared	can/jar	9	**10.5**	13	**15**	18	**21**	24	**27**	30
Mushrooms	can	12	**16**	20	**25**	30	**35**	40	**45**	49
Noodles										
chow mein	can	1	**1.25**	1.5	**1.75**	2	**2.5**	3	**3.5**	4
egg	ctn.	9	**13**	16.5	**20**	24	**27**	30	**33**	35

Product	Packaging	SAFE STORAGE TIME (Months) 90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
Nuts, shelled roasted	can	12	14.5	17	20	24	29	33	39	45
Olives, green or ripe	can/jar	12	14	17.5	20	24	27	30	32	34
Olive oil	can	4	4.25	4.75	5.5	6	7	8	9.5	11.5
Onions, dehydrated	can	12	15	17.5	21	24	27	31	35	38
Orange juice										
dehydrated (instant)	can	18	22	26	32	36	40	45	50	54
single strength	can	18	23	27.5	32	36	40	43	46	47
Packet, subsistence, long range patrol	case	12	14	17.5	20	24	27	30	32	34
Peaches, regular pack	can	18	22	26	32	36	40	45	50	54
Peanut butter	can/jar	12	18	24	30	36	41	46	51	55
Pears, regular pack	can	15	20	27	33	40	46	51	56	61
Peas										
dehydrated, cooked/uncooked	can	12	14.5	17	20	24	29	33	39	45
green	can	18	24	30	36	42	47	52	56	60
Pickles										
cucumber, cured	jar	12	14	17.5	20	24	27	30	32	34
relish	jar	12	14	17.5	20	24	27	30	32	34
Pie filling, prepared fruit, cherry, peach, apple	can	6	7	8.5	10	12	14.5	17	21	25
Pineapple										
juice, dehydrated	can	18	22	26	32	36	40	45	50	54
juice, single strength	can	12	18	24	30	36	41	46	51	55
regular pack	can	12	16.5	22	27	33	38	43	47	52
Plums, regular pack	can	12	16	20	25	30	35	40	46	49
Pork chops, raw dehydrated	can	18	22	26	32	36	40	45	50	54

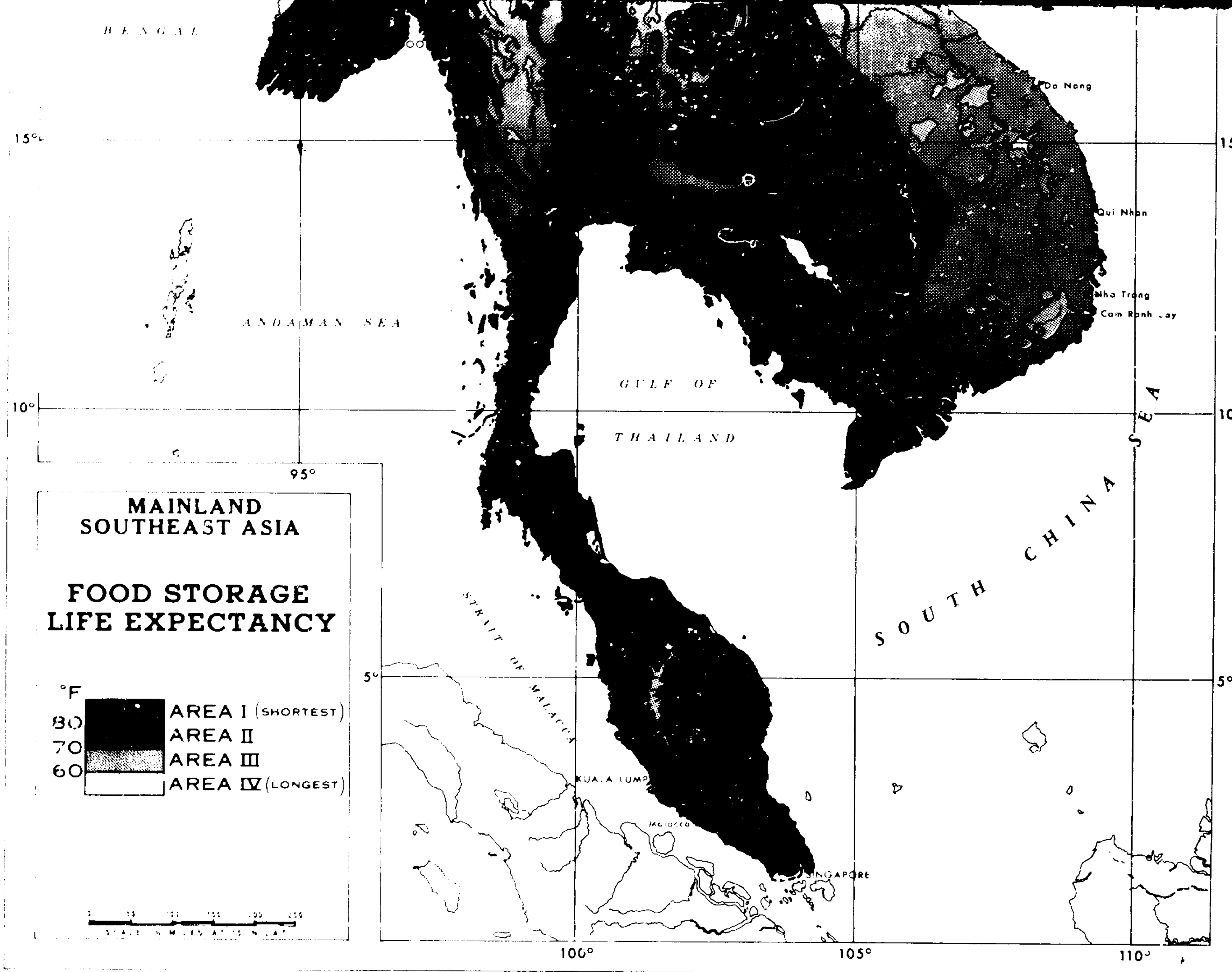
Product	Packaging	90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
						SAFE STORAGE TIME (Months)				
Potato										
white	can	11	15	20	25	30	35	41	45	50
white, dehydrated	can	18	21	24	27	30	33	37	40	43
Prunes, dried, soaked	can	5	7	9	11.5	14	16.5	19	21	22.5
Raisins, dried	can	9	10.5	13	15	18	21	24	27	30
Rice										
Instant	ctn.	6	8.5	11.5	15	18	21	25	28	31
milled	bag	9	13	16.5	20	24	27	30	33	35
Salad dressing	can/jar	3	3.5	4	4.5	5	5.5	6	6.75	7
Salad oil	can	6	7	8.5	10	12	13	15.5	17	19
Salmon	can	12	16	20.5	25	30	35	40	45	49
Sauces, Hot, Kitchen, Meat Soy or Worcestershire	bottle	12	15	17.5	21	24	27	31	35	38
Sardines	can	9	10.5	13	15	18	22	25	30	35
Sausage, pork, link	can	24	27	30	33	36	39	43	46	51
Shortening compound										
all types except high stability type	can/cube	12	14	17	20	24	29	33	39	45
general purpose, high stability	can/cube	18	21	23	26	30	34	38	43	48
Shrimp	can	9	10.5	13	15	18	22	25	30	35
Sirup, blended	can	12	14.5	17	20	24	29	33	39	45
Soup										
Beef noodle and chicken noodle, dehydrated	can	18	22	26	32	36	40	45	50	54
ready to serve	can	12	18	24	30	36	40	44	46	47
Soup & gravy base-all flavors	can/jar/env.	12	15	17.5	21	24	27	31	35	38
Spaghetti	ctn.	24	27	30	33	36	39	41	43	45
Spices, seasonings, herbs	can	12	18	24	30	36	41	46	51	55

Product	Packaging	90°	I 85°	80°	II 75°	70°	III 65°	60°	IV 55°	50°
		SAFE STORAGE TIME (Months)								
Spinach, regular pack	can	12	17	22	27	33	38	42	47	51
Starch, tapioca	ctn.	24	30	37	[illegible]	48	51	55	57	59
Sugar, brown	ctn.	4	6.5	10	13.5	18	22	27	30	33
Tea										
black, bags or loose	can/ctn.	12	13	14.5	16	18	20	22.3	25	28
instant	env.	9	10.5	13	15	18	21	24	27	30
Tomato										
juice, single strength	can	15	17	19	21	24	26	29	31	33
regular pack	can	12	16	21	25	30	34	37	41	44
Tuna										
oil pack	can	12	16	20.5	25	30	35	40	45	49
water pack	can	12	15	17.5	21	24	27	31	35	38
Turkey										
dehydrated, or regular pack	can	18	22	26	32	36	40	45	50	54
Vinegar, liquid	bottle	18	21	24	27	30	33	37	40	43
Yeast, bakers, active dry	can	1/4	1/2	3/4	3/4	1	2.5	3	3.5	4

MAP 17



95°
100°
105°
110°
25°
20°
15°
BHUTAN
Brahmaputra R.
INDIA
CHINA
Yangtze R.
Mekong R.
Black R.
Red R.
GULF
OF
TONKIN
VIENTIANE
Da Nang
Qui Nhon
BAY
OF
BENGAL


MAINLAND
SOUTHEAST ASIA
FOOD STORAGE
LIFE EXPECTANCY
°F
80
70
60
AREA I (SHORTEST)
AREA II
AREA III
AREA IV (LONGEST)
ANDAMAN SEA
GULF OF
THAILAND
SOUTH CHINA SEA
STRAIT OF MALACCA
Da Nang
Qui Nhon
Nha Trang
SINGAPORE
15°
10°
5°
95°
100°
105°
110°

SELECTED BIBLIOGRAPHY

1. Addor, Eugene E. "Vegetation Description for Military Purposes," in Military Evaluation of Geographic Areas. U.S. Army Engineer Waterways Experiment Station, Misc. Paper No. 3-610, 98-128, Vicksburg, Miss., April 1963.

2. Adolph, E.F. Physiology of Man in The Desert. Interscience Publishers, New York, 1947.

3. American University. Center for Research in Social Systems. Minority Groups in the Republic of Vietnam. Washington, D.C., 1966.

4. Anstey, Robert L. Visibility Measurement in Forested Areas. Special Report S-4, Earth Sciences Division, U.S. Army Natick Laboratories, Natick, Mass., November 1964.

5. __________. Visibility in a Tropical Forest. Special Report S-3, Earth Sciences Division, U.S. Army Natick Laboratories, Natick, Mass., August 1963.

6. Annuaire Statistique du Laos. Vientiane, 1961.

7. Atlas of Southeast Asia. Macmillan, London, 1964.

8. Bingham, Edgar. Environmental Conditions Relating to Harmful Insects of Mainland Southeast Asia. U.S. Army Natick Laboratories, Natick, Mass., Technical Report ES-38, June 1968.

9. Boyd, Mark F. (ed.). Malariology (2 vols.). Saunders, Philadelphia and London, 1949.

10. British Admiralty, Naval Intelligence Division. Indo-China, B.R. 510, 1943.

11. Broek, Jan O.M. "Diversity and Unity in Southeast Asia." Geographical Review 34, 175-195, 1944.

12. Buchanan, Keith. The Southeast Asian World. Taplinger Publishing Co., New York, 1967.

13. Census of India 1931. Volume II, Burma. Rangoon, 1933.

14. Christiansen, K., J.W. Kelley, Jr., A. Nalampoon, and S. Sukhawong. Rubber Plantations of Thailand: Environmental Characteristics of Military Interest. Joint Thai-U.S. Military Research and Development Center, Bangkok, Thailand, January 1966.

15. Copeland, Edwin B. Rice. Macmillan, London, 1924.

16. Dobbins, D.A. and M. Gast. Jungle Vision: I. Effects of Distance, Horizontal Placement, and Site on Personnel Detection in a Semideciduous Tropical Forest. U.S. Army Test and Evaluation Command, Fort Clayton, Canal Zone, April 1964.

17. __________. Jungle Vision: II. Effects of Distance, Horizontal Placement, and Site on Personnel Detection in a Evergreen Rainforest. U.S. Army Test and Evaluation Command, Fort Clayton, Canal Zone, November 1964.

18. Dobbins, D.A., M. Gast, and C.M. Kindick. Jungle Vision: III. Effects of Seasonal Variation on Personnel Detection in an Evergreen Forest. U.S. Army Test and Evaluation Command, Fort Clayton, Canal Zone, May 1965.

19. Dobbins, D.A. and C.M. Kindick. Jungle Vision: VI. A Comparison between the Detectability of Human Targets and Standard Visibility Objects In an Evergreen Rainforest. Research Report No. 6, U.S. Army Test and Evaluation Command, Fort Clayton, Canal Zone, February 1966.

20. Dobby, E.H.G. Monsoon Asia. Quadrangle Books, Chicago, 1961.

21. __________. Southeast Asia. University of London Press, London, 1956.

22. Edwards, M.V. Burma Forest Types According to Champion's Classification. India Forest Records-Silviculture 7, No. 2, 1950.

23. Fisher, Charles A. Southeast Asia: A Social, Economic, and Political Geography. Methuen, London 1964.

24. Ginsburg, Norton and Chester F. Roberts, Jr. Malaya. University of Washington Press, Seattle, 1958.

25. Ginsburg, Norton (editor). The Pattern of Asia. Prentice-Hall, Englewood Cliffs, New Jersey, 1958.

26. Goldman, R.F. "Energy Expenditure of Soldiers Performing Combat Type Activities." Ergonomics. 8, 321-327, 1965.

27. Gould, Douglas J., John E. Scanlon, and Ronald A. Ward. "Anopheles Vectors of Malaria in Southeast Asia." Army Science Conference Proceedings. Office, Chief of Research and Development, Dept. of the Army, June 1966.

28. Greathouse, G.A. and C.J. Wessel (editors). Deterioration of Materials and Preventative Techniques. Rheinhold Publishing Corp., New York. 1954.

29. Grist, D.H. Rice. Longmans, Green & Co., London, 1953.

30. Gulick, Luther H., Jr. Rice Regions of French Indochina. Unpublished Masters Thesis, University of Chicago. June 1948.

31. Hedgkin, Ernest P. The Transmission of Malaria in Malaya. Studies from the Institute for Medical Research, Kuala Lumpur, 1956.

32. Howard, Lee M. Report of an Assessment of The National Malaria Eradication Project of Thailand. Bangkok, 1963.

33. Indo-China, A Geographical Appreciation. Foreign Geography Information Series, No. 6, Department of Mines and Technical Surveys, Geographical Branch, Ottawa, Canada, 1953.

34. Indo-China. Map 1:1,000,000, Viet Nam (South). Population and Administrative, 1964.

35. Joy, R.J.T. and R.F. Goldman. "A Method of Relating Physiology and Military Performance: A Study of Some Effects of Vapor Barrier Clothing In a Hot Climate." Military Medicine. 133 (6), 458-470, June 1968.

36. Kuchler, A.W. "Analyzing the Physiognomy and Structure of Vegetation." Annals of the Association of American Geographers. 56, 112-127, 1966.

37. __________. Vegetation Mapping. Ronald Press, New York, 1967.

38. Kunstadter, Peter (ed.). Southeast Asian Tribes, Minorities and Nations. (2 vols.), Princeton University Press, Princeton, New Jersey, 1967.

39. LeBar, Frank and Adrienne Suddard (editors), Laos: Its People, Its Society, Its Culture. Human Relations Area Files Press, New Haven, Connecticut, 1960.

40. LeBar, Frank M., Gerald C. Hickey, and John K. Musgrave. Ethnic Groups of Mainland Southeast Asia. Human Relations Area Files Press, New Haven, Connecticut, 1964.

41. Lee, D.H.K. "Terrestrial Animals in Dry Heat: Man In the Desert." In, Handbook of Physiology, American Physiology Society. Washington, 1964.

42. Leithead, C. and A.R. Lind. Heat Stress and Heat Disorders. F.A. Davis, Philadelphia, Pennsylvania, 1964.

43. Lysenko, A.Y. and Tien Byu Nguien. "Epidemiological Investigations into Malaria in North Viet-Nam." Meditsinskaia Parazitologiia 30, 642-651, 1961.

44. Lysenko, A.Y. "The Malariological Zones of North Viet-Nam." Meditsinskaia Parazitologiia 34, 189-194. 1965.

45. Macdonald, George. "The Analysis of Equilibrium in Malaria." Tropical Diseases Bulletin 49, 813-829, 1952.

46. "Malaria: a World Problem." Chronicle of the World Health Organization 9, 31-100, 1955.

47. Malaya (Federation), Department of Statistics, 1957 Population Census of the Federation of Malaya. Kuala Lumpur, 1960.

48. National Research Council, National Academy of Sciences, Division of Medical Sciences. Tropical Health. Washington, 1962.

49. Neal, D.G. Statistical Description of the Forests of Thailand. Joint Thai-U.S. Military Research and Development Center, Bangkok, Thailand, May 1967.

50. Niedringhaus, Thomas E. The Food Geography of Mainland Southeast Asia. U.S. Army Natick Laboratories, Natick, Mass., Technical Report ES-38, June 1968.

51. Nuttonson, M.Y. The Physical Environment and Agriculture of Vietnam, Laos, and Cambodia, American Institute of Crop Ecology, Washington, D.C., 1963.

52. Ohman, Howard L. Climatic Atlas of Southeast Asia. U.S. Army Natick Laboratories, Natick, Mass., Technical Report ES-19, December 1965.

53. Ooi, Jin-Bee. Land, People and Economy in Malaya. Longmans, Green & Co., Ltd., London, 1963.

54. Pietrantoni, Eric "La population du Laos en 1943 dans son milieu geographique." Bulletin de la Société des Études Indochinoises, n. s. 32, 223-234, 1957.

55. Spencer, Joseph E. Shifting Cultivation In Southeastern Asia. University of California Publications in Geography, Volume 19, University of California Press, Berkeley and Los Angeles, 1966.

56. Steinberg, David J., Chester A. Bain, Lloyd Burlingham, Russell Duff, Bernard B. Fall, Ralph Greenhouse, Lucy Kramer, and Robert S. McLellen. Cambodia: Its People, Its Society, Its Culture. Human Relations Area Files Press, New Haven, Connecticut, 1957.

57. Thailand (Royal Government), National Malaria Eradication Project Thailand, Plan of Operations. Bangkok, 1965.

58. Tromp, S.W. Medical Biometeorology. Elsevier, Amsterdam, London, New York, 1963.

59. Tschirley, R.H. "Defoliation in Vietnam." Science 163, 779-786, February, 1969.

60. United States Agency for International Development Vietnam, Office of Joint Economic Affairs, Annual Statistical Bulletin No. 10. Saigon, 1967.

61. U.S. Army. Area Handbook for Burma. Foreign Areas Studies Division, Special Operations Research Office, The American University, Washington, D.C., 1968.

62. __________. Area Handbook for Cambodia. Foreign Areas Studies Division, Special Operations Research Office, The American University, Washington, D.C., April 1963.

63. __________. Area Handbook for Laos. Foreign Areas Studies Division, Special Operations Research Office, The American University, Washington, D.C., 1967.

64. __________. Area Handbook for North Vietnam. Foreign Areas Studies Division, Special Operations Research Office, The American University, Washington, D.C., June 1967.

65. __________. Area Handbook for Thailand. Foreign Areas Studies Division, Special Operations Research Office, The American University, Washington, D.C., September 1962.

66. U.S. Army. Area Handbook for Vietnam. Foreign Areas Studies Division, Special Operations Research Office, The American University, Washington, D.C., September 1962.

67. ________. Environmental Factors Affecting Ground Mobility in Thailand: Appendix D - Vegetation. Technical Report No. 5-625, Corps of Engineers, Vicksburg, Miss., May 1963.

68. ________. Southwest Asia: Environment and its Relationship to Military Activities. Technical Report EP-118, Environmental Protection Research Division (EPRD), Quartermaster Research & Engineering Center, Natick, Mass., 1959.

69. U.S. Army Special Warfare School. Montagnard Tribal Groups of the Republic of Viet-Nam. Fort Bragg, North Carolina, 1965 (2nd ed.).

70. United States Operations Mission, Department of Local Administration, National Statistical Office, Changwat-Amphoe Statistical Directory. Bangkok, 1965.

71. University of Michigan. Analysis of Geographic and Climatic Factors in Coastal Southeast Asia. U.S. Army contract DA19-129-QM-1655, Ann Arbor, March 1963.

72. Viet Nam (Republic). Department of Health, Malaria Eradication Program, Report of Activities. Saigon, 1962.

73. Williams, L. Vegetation of Southeast Asia: Studies of Forest Types 1963-1965. U.S. Department of Agriculture, Agricultural Research Service, Washington, D.C., December 1965.

74. Withington, William A. "The Density of Population in Southeast Asia." Journal of Geography 64, 14-23, 1965.

75. Wyatt-Smith, J. "Some Vegetation Types and a Preliminary Vegetation Map of Malaya." Malayan Journal of Tropical Geography 18, 200-213, 1964.

76. You Chhim. Complexe épidémiologique et lutte antipaludrique au Cambodge. Arnette, Paris, 1957.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Natick Laboratories Natick, Massachusetts 01760	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE Mainland Southeast Asia: A Folio of Thematic Maps for Military Users	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)	
5. AUTHOR(S) (First name, middle initial, last name) R. J. Frodigh, A. D. Hastings, Jr., T. E. Niedringhaus, J. M. Planalp	
6. REPORT DATE October 1969	7a. TOTAL NO. OF PAGES 78 / 7b. NO. OF REFS 76
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062112A129 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 70-21-ES 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) ES-51
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Natick Laboratories Natick, Massachusetts 01760

13. ABSTRACT

Militarily important environmental factors within Mainland Southeast Asia are topics of seventeen thematic maps in this report. The relationships between military operations and selected natural and cultural phenomena have been analyzed and mapped. Supplementing the cartographic coverage are narrative discussions, graphs, and tables.

Nine of the maps relate directly and quantitatively to predictable physiological stress conditions, to food storage life expectancies, and to estimated visibility distances within different vegetational types. These maps are based on laboratory and/or field test determinations. Other maps in the series are concerned with the distributional relationships of such environmental factors as ethnolinguistic groups, ethnic minority types, malaria endemicity, and cloudiness regimes.

This study has been developed with the expectation that it will serve as a useful aid in military planning for Southeast Asia, and that it may also serve as a prototype for similar studies of other regions.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Environments	8		6			
Southeast Asia	9		6			
Military planning	4		4			
Stress (Physiology)	8		7			
Food Storage	8		7			
Visibility	8		7			
Vegetation	8		7			
Ethnic groups	8		7			
Languages	8		7			
Malaria	8		7			
Cloud cover	8		7			
Maps	8		8			

Unclassified
Security Classification