TROPICAL REGIONS: INFLUENCES ON MILITARY OPERATIONS, PART 1

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EDITOR'S NOTE: This article is Part 1 of a two-part series on the tropical regions of the world and their environmental effects on military operations. It discusses climatic and meteorological conditions, the terrain and vegetation, and the military aspects of the terrain. Part 2, scheduled for the May-June 1993 issue, will discuss the effects of a tropical environment on soldiers, on equipment and facilities, and on combat and support operations.

This series continues Colonel Clegg's INFANTRY articles on the various regions of the world, which include "Environmental Influences on Desert Operations" (May-June 1992), and the two-part "Cold Regions: Environmental Influences on Military Operations," co-authored with Brigadier General Peter W. Clegg (July-August and September-October 1992). Colonel Clegg's two-part series on the temperate regions will follow.

Colonel Clegg's intention in writing this series, and INFANTRY's intention in publishing it, is to provide a complete reference that military leaders can use in preparing to operate in any part of the world to which their units may be deployed in the future.

Tropical regions make up about 20 percent of the earth's surface, primarily along the equator but also extending 20 degrees to the north and south. The tropics have been areas of conflict for centuries, for various reasons, and the involvement of the United States Army in such areas dates back at least to the Seminole Wars. The Army now has an extensive and successful history of jungle operations, both in counterinsurgency situations and in more conventional mid-intensity campaigns.

At the beginning of the 20th century, the Moro insurrection in the Philippines tested the Army's ability to adapt to the jungle. During World War II, jungle combat occurred in the Southwest Pacific, and in Burma, Malaya, and Indo-China. In addition, both the Army and the Marine Corps have also been involved in Central America and the Caribbean throughout this century. More recent deployments include those to the Dominican Republic (1965), Granada (1983), El Salvador, Honduras, and Panama (1989). In addition, conflicts in Cuba, Nicaragua, and El Salvador increased tension between the United States and the Soviet Union throughout the "cold war" years.

After wars of independence in tropical Africa, struggles among tribes in Zaire, the Congo, Nigeria, Ghana, Liberia, and other new countries required increased readiness and often the involvement of the U.S. Army. In tropical India, Bangladesh, and Sri Lanka, the U.S. armed forces have followed events closely and have become involved for humanitarian reasons. The Army's longest tropical war, of course, was in Southeast Asia, and conflict continues in that region. Other tropical countries, such as Indonesia, continue to be involved in guerrilla warfare in jungles.

Today, tropical areas continue to be volatile, and it is a safe bet that the Army will again be involved in jungle operations. When or where these operations may be will not be known until it is too late to prepare for them. Therefore, we must not forget the lessons we have learned about jungle operations and must continue to train for such operations.

The first step is to understand the fundamental characteristics of the tropical environment.

Climatic and Meteorological Conditions

Tropical regions are hot and wet with very little variation in conditions. It is the amount of precipitation rather than the temperature that differentiates the three sub-climates of

tropical regions—the tropical rain forest, the monsoon, and the savanna. The average monthly temperature is mostly around 80 degrees Fahrenheit and never below 64.4 degrees.

The *tropical rain forest* sub-climate is found along the equator in the Amazon River Basin, eastern Central America, the Congo River basin and west Africa, the South Pacific (Indonesia, Philippines, Malaya), and Hawaii. Conditions in these areas are best characterized as monotonous. The average monthly temperature is 80 degrees Fahrenheit with only a two- or three-degree range in year-round averages. Humidity is consistently high, with rain falling nearly every day at about the same time and totalling 60 to 100 inches a year. Generally, there is little wind.

The second tropical sub-climate is the *monsoon*, which is seasonal, based on precipitation. It includes a distinct wet season that averages from 20 to 30 inches of rain a month and a dry season that averages only two inches a month. Average temperatures remain high (80 degrees Fahrenheit). Winds are significant—in fact, the term *monsoon* means "reversal of winds"—bringing on the seasonal variation. The monsoon climate is found mostly in coastal regions, such as the east coast of Indo-China, the west coasts of Southeast Asia (Burma and Bangladesh) and of India and Africa, and the east coast of Brazil.

The *savanna*, the third tropical sub-climate, is a transitional climate between the tropical and the arid. There is a slight variation in temperature by season in this sub-climate, with ranges of 15 to 30 degrees Fahrenheit from the monthly average of 80 degrees. Like the monsoon, the savanna includes distinct wet and dry seasons.

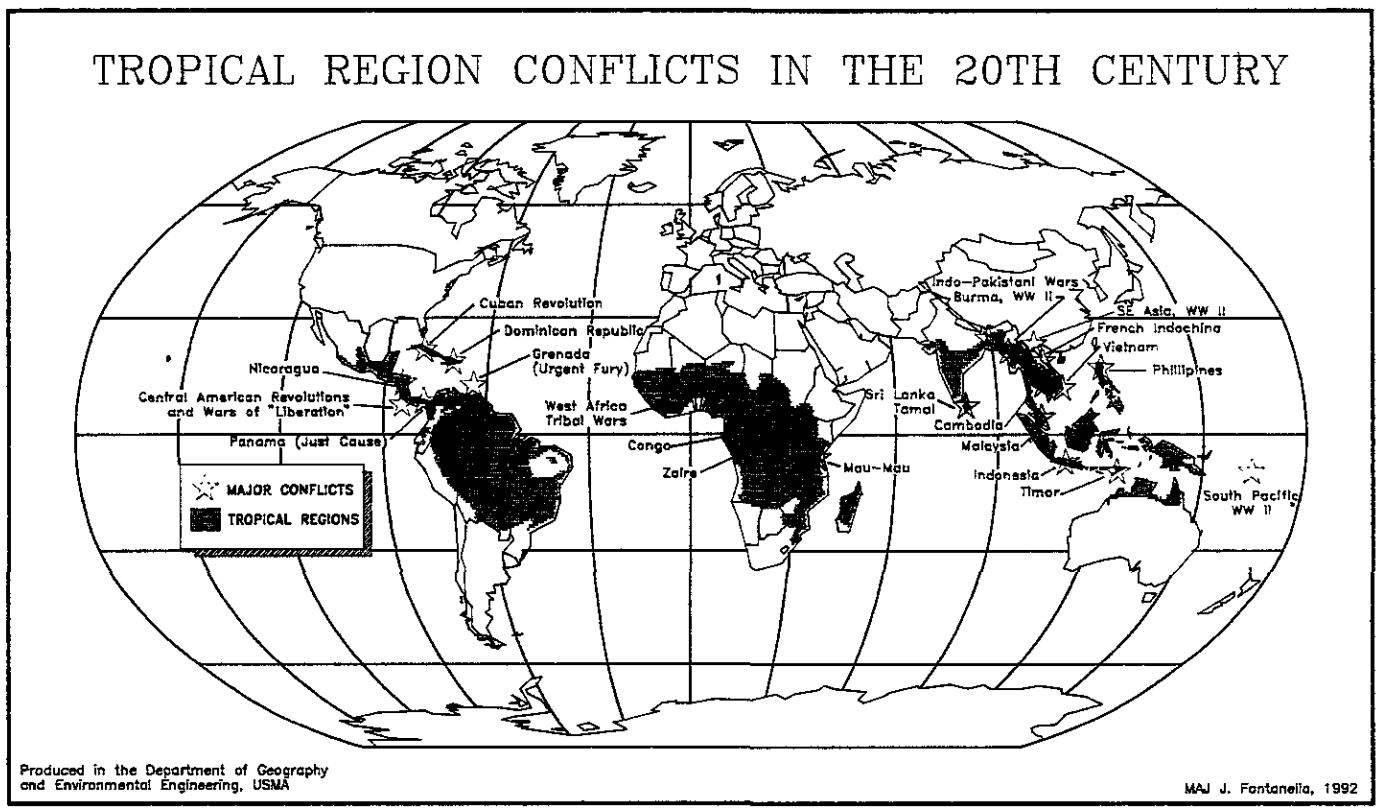
The savanna wet season brings 35 to 70 inches of rainfall a year, much drier than the monsoon wet season. The savanna is found in southern Mexico, the west coast of Central America and Cuba, Central Southeast Asia, southern India, northern Australia, and in Africa and South America between 5 degrees and 20 degrees South latitude and between 5 degrees and 10 degrees north latitude.

Climate Controls

Latitude is the dominant climate control in tropical areas, because it controls the amount of solar radiation. Both the intensity and the duration of sunlight determine temperature, and the angle of incidence of the solar rays influences their intensity and duration. This variation is least at the equator, where each day of the year has exactly 12 hours of light and 12 hours of darkness. The highest solar intensity occurs when solar rays hit the earth at right angles (head on). Because the earth revolves around the sun and because of its tilt, these perpendicular rays "migrate" north and south to 23.5 degrees latitude (the angular tilt of the earth's axis). This region, known as the tropics, experiences high solar intensity. This solar intensity, combined with uniform solar duration, results in hot temperatures. Because temperatures are high, evaporation occurs readily. In tropical areas, the oceans provide the moisture source for evaporation, which explains why the tropics are hot and wet.

Ocean currents also affect tropical climates because they move warm, moist air as well as water toward the west and the poles along the eastern coasts of the continents, bringing high precipitation.

Most tropical areas are coastal, and the *oceans* exercise still another control on the climate. Large bodies of water moderate conditions and keep them relatively stable, compared to interior land masses where there are temperature extremes and increased dryness. This land-water contrast



largely accounts for the differences between the drier savanna inland (away from the water source) and the moist rain forest and monsoon areas along the coasts.

Mountains are especially influential in controlling moisture. As warm, moist air from the oceans hits land and rises, it cools, allowing condensation and then precipitation. Coastal mountains cause a rapid elevation of this air. As the air rises and cools, the moisture precipitates out in large quantities, creating heavy rains. It is warm moist wind hitting land that creates the wet monsoon.

In the summer, the oceans are relatively cooler than the land (which absorbs solar energy faster), and this causes higher pressure over the oceans. Air moves from high pressure to low pressure (from the oceans to the land). In winter, the opposite occurs, because the land loses heat more quickly than the water; thus the high pressure (colder) air is created over the land. Air then moves from the cooler drier land to the oceans, creating the dry monsoon (no rain).

This seasonal reversal of winds changes the precipitation pattern. The equatorial region, where it is relatively calm with stable conditions (no seasons), does not experience typical monsoon weather. It is north and south of the equator at about 10 degrees latitude where the monsoon climate is found. In some locations, such as northern Vietnam, the monsoon cycle is reversed. This occurs because in the winter cooler drier air moves southward out of China (warming) across the South China Sea (picking up moisture) and then hits the Tryong Son (Annamite) Mountains causing elevation, cooling, and precipitation, hence the wet winter monsoon. Farther inland on the back side of the coastal mountains and away from the moisture source (the ocean), less moisture is available and drier savanna conditions prevail.

The final climatic control is *altitude*. Although altitude plays a lesser role in the tropics, it still changes the temperature (a drop of three degrees Fahrenheit for every 1,000-foot rise). Therefore, temperatures are cool in the higher mountains of the tropics. In fact, snow occurs on Mounts Kenya and Kilimanjaro, which are practically on the equator.

Climatic Elements

Temperature, the dominant climatic element, directly determines moisture, pressure, and wind. The average temperature in the tropics is 80 degrees with daily ranges of up to 30 degrees and monthly average ranges of only two to three degrees. No monthly average temperature is below 65 degrees.

The daily sequence begins with cool temperatures of 60 to 70 degrees in the dark morning hours. With sunrise, temperatures steadily increase to more than 90 degrees and may hit 100 by 4:00 p.m. As dusk draws near, temperatures decrease. The daily variation is greater in the high mountains because of the cooling effect of altitude.

For military purposes, the critical temperature value is 85 degrees, the point at which heat injuries become more likely, mental capacity deteriorates, engines overheat, batteries lose capacity, and aircraft performance diminishes. The critical temperature on the low side is 50 degrees. This is a concern only in the dark early morning hours in the mountains, but there is a definite chill, made worse by wetness.

The temperature alone is not the problem. Because all temperatures are on the high side, evaporation causes high humidity. This moisture in the air, together with relatively high temperatures, makes the comfort level fall, especially in the tropical rain forest and monsoon climate regions, where the relative humidity hovers around 100 percent. When the wet bulb globe temperature (WBGT)—the index of comfort used by the Army—is 75 degrees and higher, precautionary measures are required. In the 80-degree range, exercise imposes greater strain on the human body. In the rain forest and monsoon areas, 80-degree wet bulb readings occur daily.

With large quantities of water in the air, it rains almost every day in the rain forest and in the monsoon during the wet season. Heavy rains of up to eight inches in one day can occur, and yearly totals of 80 to 200 inches are possible. The savanna is considerably drier with only 35 to 70 inches annually (still high, compared to other regions of the world). Staggering amounts of rain fall in the monsoon areas, with more than 200 inches in less than six months. In monsoonal India, 84 inches of rain in three days has been recorded, more than the continental United States might get in two years.

In the rain forest, cumulus clouds build in the afternoon and clear after the daily rain. The wet monsoon may provide a constant cloud cover; fog and dew are also common. Dew collects on everything. For example, the "fog factory" of Khe Sanh (Vietnam) almost provided the North Vietnamese another Dien Bien Phu (exactly what they hoped for). Khe Sanh, an old French fort similar to Dien Bien Phu, was occupied by U.S. Marines to interdict the Ho Chi Minh Trail. For more than two months in 1968, the 304th, 324th, and 325th North Vietnamese Divisions besieged the Marine camp. The monsoon isolated the camp and aerial resupply became impossible. Close air support could not be provided. The plateau on which Khe Sanh is located was plagued by a persistent thick fog that resulted in zero ceiling and zero visibility. Even when conditions in the vicinity of the camp were excellent, it was covered with fog. The 26th Marine Regiment, supported by attached units, was outnumbered six to one. When the attack came on 21 January 1968, the fog precluded adequate resupply or tactical air support, but high-flying B52 bombers dropped almost 60,000 tons of bombs to ward off the attackers. The Marines held, and the weather cleared in early April. The 1st Cavalry Division then made the first division-sized air assault into the area, defeated the enemy, and relieved the camp.

Atmospheric pressure is also directly related to temperature. Heat causes low pressure; therefore, the tropics have a series of low pressure cells called equatorial lows. Low pressure is less stable than high pressure. With the hot air rising, a vacuum of sorts is created that is filled by cooler air moving from the north and south where higher pressure prevails. Along the equator, winds are calm because the air is rising. The high winds occur at about 10 degrees North and South latitude. It is here that tropical storms and hurricanes

occur, with winds up to 120 miles per hour.

Tropical Storms

Storms in the tropics range from short-duration thunderstorms to Sumatras, with winds of 50 knots, to typhoons, with winds over 100 knots. Thunderstorms result from the convectional lifting of hot moisture-laden air throughout the day.

As heat and humidity increase, so does the intensity of thunderstorms. Massive, dark nimbo-cumulus clouds form, creating strong winds, heavy rains, and lightning. Each of these elements is a danger by itself: Winds overturn vehicles, destroy structures, and displace debris, which causes injury. Heavy rains immediately fill streams and increase the speed of their flow, and floods are an ever-present danger. And lightning causes fires and injury.

Typhoons (also known as hurricanes or cyclones) are the most dangerous storm in the tropics. These result from extremely low-pressure centers, which allow for high winds. As high winds cross the ocean, great waves form. It is when the hurricane hits land that the high winds, the surf, and the heavy rains become particularly hazardous. The greatest danger is the storm surge, a huge wave of up to 25 feet. When it crashes onto the land, everything in its path is uprooted, and flooding follows. Typhoons are most common in late summer or early fall when the oceans are the warmest. The east coasts of continents are the most vulnerable.

Hurricanes and other tropical storms have taken their toll on U.S. military operations. In December 1944 a typhoon in the Philippine Sea caught Task Force 38 by surprise. The 86 ships were steaming to destroy Japanese airfields in support of landings on Luzon. On 17 December, the fleet was experiencing high seas and driving rains but was unaware of a building typhoon. By noon on the 18th, the barometer plummeted and winds were at 100 knots. The fleet, instead of sailing away from the storm, mistakenly headed directly into it. Within a three-hour period, the ships were scattered over a 50- to 60-mile area. Visibility had dropped to only three feet with no discernible distinction between the sky and the sea. The aircraft carrier *USS Langley* rolled heavily and, together with the *USS Altamaha,* was severely damaged by the storm.

In the short time the hurricane pounded the fleet, 800 sailors were killed, seven ships damaged, and three destroyers capsized. On the carriers, 146 planes were lost, having been blown overboard or tossed into the sides of the ship below decks. The crippled fleet had to abandon its mission; the U.S. landings had to be postponed, and the fleet headed for Hawaii for repairs and replacements.

Terrain Analysis

Landscapes in tropical regions fall into three categories: coastal regions and islands with steep volcanic mountains and thick jungle; flat river flood plains, basins, and deltas or flat atoll (coral reef) islands, again with jungle vegetation or rice paddies; and elevated "tableland" with tall savanna grasses.

Coastal and island topography with volcanic mountains is characterized by sandy beaches, a flat coastal plain that ranges from less than a mile to more than 20 miles and then steep slopes rising from near sea level to more than 10,000 feet. The slopes may be too steep to be negotiated, even on foot. Because of jungle vegetation, movement is extremely slow—it can take days to go only a few miles. This terrain is found in Central America, Southeast Asia, and the islands of the South Pacific (Indonesia, the Philippines, Hawaii).

During World War II, the Japanese forces that landed on New Guinea had to face this type of landscape, as well as the combined forces of the 32d U.S. Infantry Division and the 7th Australian Division. Control of New Guinea was key to protecting the U.S. convoys that were delivering equipment to Australia for General Douglas MacArthur's impending campaign. The allied force occupied the southern side of the

This is an example of the multicanopy jungle with heavy vines that is found in tropical regions.

This area of tall grass and mud is typical of the Mekong Delta region of Vietnam.

island at Port Moresby, while the Japanese landed on the north side at Gona and Buna. The Owen Stanley Mountains separated the two forces.

The Japanese generals' plan was to attack Port Moresby by crossing the 10,000-foot range, a distance of 140 miles of thick jungle, and the march began on 22 July 1942. The construction of steps assisted the crossing, where even pack animals were useless. The Japanese soldiers vigorously accepted the challenge, but the tropical conditions (sweltering temperatures, constant rain, thick vegetation, steep slopes, flooded streams) took their toll. Exhaustion led to sickness, which was exacerbated by a change to cool, wet nights in the high mountains. At the halfway point some 43 days later, the attack force of 4,000 had been reduced by one-third.

MacArthur ordered a defense 20 miles north of the port. The Japanese attack materialized, but malnutrition, fatigue, sickness, and long, easily interdicted supply lines led to defeat as the allies routed the crippled Japanese force. Now the Japanese withdrew across the treacherous and forbidding terrain, pursued by the combined force. Only 500 effectives returned to Buna. Even the commander became a casualty of the terrain when he drowned in the swamp.

Not all the islands of the South Pacific have steep volcanic mountains, however. Some are flat (only a few feet above sea level), the result of coral forming a reef around ancient volcanoes that are no longer present. As the volcanoes subsided and collapsed inward, they left coral reefs as islands with lagoons in the center.

Other flat coastal areas include the floodplains and deltas of some of the world's greatest rivers (the Amazon, Ganges, Congo, Niger, Orinoco, and Mekong), which meander across wide areas and create backwater swamps. Thick vegetation predominates upstream and inland while agriculture is prevalent near the coast, where greater access exists. Because rice paddies are highly productive in such areas, finding solid ground can be difficult.

During the Vietnam war, combat occurred in the steep mountainous jungle areas north of the Mekong Delta as well as in the flat paddies and tall grasses of the delta itself. In the flat, waterlogged swamps and paddies, foot movement was slow, fatiguing, uncomfortable, and dangerous. But the use of helicopters to overcome these obstacles proved deadly to the Viet Cong, who were then faced with highly mobile air assault infantry. Helicopters also vastly improved aerial observation so that enemy activity could be detected and countered.

The savanna regions are characterized by hills and table land covered by tall grasses. Such regions are found in tropical east Africa, eastern South America, and central Southeast Asia. The topography in these areas is characterized by flat plateaus and rolling hills with deeply cut gorges and channels. With much less rainfall, these areas have no standing water like that found in rain forest and monsoon areas.

The surface in tropical environments ranges from standing water to thick, deep clay (laterite) soils to volcanic rock debris. In the rain forest and monsoon areas, along the river valleys and coastal deltas, there are swamps up to hundreds of square miles in size. The water depth varies from a few inches to several feet. With elevation, thick lateritic soil becomes common. This soil is reddish and fine-textured due to its high iron content and heavy leaching due to high rainfall. Soil depth can be over 20 feet, and this depth, coupled with heavy rain, makes for very unstable slopes. When wet, the clay particles produce a slick surface that reduces trafficability.

In the monsoon areas where there is a dry season, the red clay soil becomes so compact that it is ideal for airfields and roads. In Vietnam, engineers constructed hundreds of dirt airfields and miles of roads on this kind of soil. With high use of these areas, dust reduces visibility and clogs engine air filters. Where volcanoes have been active, lava rock is the surface material. In the hills and plateaus of the savanna, soils are likely to be coarser in texture. The floor of the savanna does not have the vegetation debris and litter that

characterizes the rain forest floor.

Vegetation in the tropics is predominantly, though not exclusively, jungle. Jungle includes closely spaced, broadleaf evergreen trees. Tropical rain forest jungle has multicanopies or layers of vegetation and tall trees. Coconut palms are found along coastal areas. Bamboo and elephant grass grow in thick patches. Vines hang from the taller trees in the enclosed tent-like facade. The canopy reduces the sunlight that penetrates to the jungle floor, limiting underbrush. In some thick jungles, the floor is relatively free of growth. Where the canopy is not continuous, however, shrubs, bushes, and grasses quickly grow and impede trafficability. The jungle floor is likely to be littered with rotten trees. Tree stem diameter is generally less than with mid-latitude hardwoods, but there are exceptions. Softwood trees prevail, and mangroves are common in the swamps. In the drier savanna, tall grass (up to 15 feet) interspersed with short trees covers vast areas. Cultivated vegetation of the tropics includes plantations of banana and rubber trees, and sugar cane and rice fields.

Because of the high levels of precipitation, the drainage features consist of numerous small streams that cut the landscape and join large river systems. In the mountains, the streams begin as small creeks, but heavy runoff cuts deep into the soft soil. Even in relatively small streams, water flow is rapid and dangerous to cross because of the heavy rain and steep slopes. In flatter areas, the streams join large meandering rivers that dominate the terrain.

Backswamps along the river's floodplain and coasts contain still water, except during the monsoon floods. In the drier savanna, drainage can be similar, but the gullies are dry most of the year. They are still deep, though, and can require bridging. Floods are a frequent problem in most tropical areas and cause great loss of life and property, especially in delta areas where the most people live.

The tropics are heavily populated; the vast majority of the people are crowded into dense cities along coastal areas. Villages surround the cities in flat areas where agriculture is productive. In Central America and many other tropical areas, the capital city holds most of the population. As dis-

This area, northwest of Bien Hoa near the Saigon River, is a typical flood plain.

tance from the coast and urban areas increases, population becomes sparse; often the overall density is less than one person per square kilometer (especially in the Amazon basin of South America and in coastal west Africa where there are no major cities). In Africa, the cities of Lagos and Kinshasa hold practically the entire regional population.

Very few people actually live in the jungle. Even in Asia, large tracts of territory have only ten people per square kilometer, yet some of the world's most densely populated areas (100 people per square kilometer) are also in tropical Asia (Java, the Vietnamese coast, southern Thailand, the Philippines, along the Irrawaddy River in Burma, and in all of tropical India).

The man-made features that dominate the urban centers are practically nonexistent in the rain forest jungle and the vast expanses of savanna grasslands. While third-world cities have modern structures mixed with colonial buildings, makeshift huts house most of the people in the cities as well as in the sparsely populated areas. In the cities, automobiles crowd the streets, but bicycles and even water buffalo may share the roadway. The features that do exist outside the central city are not durable and are often washed away during the monsoon floods or blown away by the typhoon winds.

The tropics are plagued with many natural terrain hazards, and military planners must consider all of them. Because many of the tropical areas are along tectonic plate boundaries, volcanoes and earthquakes are constant dangers. The thick soils, steep slopes, and abundant rainfall reduce stability and result in landslides and mudslides.

Flooding is yet another hazard that frequently curtails military operations. The Burma Road was built by allied engineers in World War II to facilitate the movement of supplies through the jungle mountains that connect India to China. The road was the lifeline of General Joseph W. Stillwell's force as well as the Chinese resistance to the Japanese. The topography was extremely steep, the soil deep, and with moisture, collapse was a real danger. During the monsoon, 15 inches of rain fell in one day. Streams became impassable and overflowed their banks, sometimes by as much as 30 feet. Bridges were washed away, along with exposed earth from cleared dirt roadways. Rains and unstable slopes collapsed the road banks and washed the road down the steep slopes. Landslides cut the road, and mudslides reduced its length. During the monsoon, ground movement of materiel stopped. Supplies had to be airlifted, but dark and cloudy skies, thunderstorms, and heavy rain limited flying to one day out of three; and dirt airfields needed constant repair.

Military Aspects of Terrain

Observation and fields of fire are restricted in the tropical rain forest and monsoon areas. Observation improves in the savanna where there is less vegetation. Dense jungle, however, is clearly a major problem. In Vietnam, for example, the vegetation was often stripped away along the sides of roads and the perimeters of fire bases and other fixed positions to improve observation and fields of fire. Where this measure was not taken, the enemy could sneak up to the road and friendly positions to conduct surprise attacks.

Clearing for fields of fire and better surveillance is absolutely necessary in tropical areas. Because of the multicanopy vegetation, aerial observation is significantly reduced. The thick layers also affect remote sensors. Although radar can penetrate vegetation, small targets are difficult to identify with radar imagery.

Mountainous terrain also reduces observation and fields of fire. Deeply cut streams create dead space that must be covered by sensors, mines, observation posts, and indirect fire.

Atmospheric conditions further restrict observation. Fog and mist, ever present in the thick tropical air, can reduce visibility to a few feet and distort the readings of optical devices and other sensors. During heavy rain, reduced visibility gives the attacker an opportunity to move undetected by sight or sound. In the wet monsoon season, the rains are so heavy and constant that observation is often zero. The clouds cause shadows in the darkened jungle, further complicating ground visibility, and visibility for aircraft can be nonexistent. At night, clouds and the vegetation canopy make the jungle floor pitch black. The tall grasses of the savanna and deeply incised streams also reduce ground observation, but aerial observation is nearly unrestricted in these areas.

Key terrain in the jungle consists of those areas that provide either observation or access. The higher elevations are obvious candidates simply because they offer better observation and fields of fire. The control of ridge lines and mountain passes can effectively seal off large unit movements, but small patrols can almost always go around strongholds in the jungle.

As in other areas of the world where settlements are scarce, a village with an airfield, access roads, or fresh water gives the force that holds it an advantage in controlling the area. Rivers can be access routes, and their control often provides a marked advantage; they are therefore considered key terrain.

In the flat deltas and floodplains, any elevated area may be dominant. Urban centers may be considered key terrain on a strategic level; most of the population resides there, and control of the population and facilities associated with a city is often essential to the prosecution of a war.

Natural obstacles in the tropics are formidable, even when they have not been augmented by mines and other man-made obstacles. The vegetation, swamps, and steep slopes reduce movement to a snail's pace. The wide rivers and deeply cut tributaries add to the difficulty in traversing the terrain. Rice paddies in the wide deltas and coastal flatlands channel movement and limit accessibility. Man-made obstacles are especially effective because movement is so channeled in the jungle. The trails are the only means of ground movement, but booby traps and mines along these paths can kill and maim.

No enemy was better with booby traps than the Viet Cong, and many U.S. soldiers paid the price. (Eleven percent of the combat deaths in Vietnam were caused by booby traps.) U.S. units in Vietnam employed obstacles just as

effectively. Wire entanglements, ditches, and mines emplaced around fire bases and base camps proved deadly to the attackers. Other techniques include the use of demolitions to rupture dams and dikes, thereby inducing flooding or the collapse of slopes, sealing off corridors and denying access. In the savanna, natural obstacles are less threatening. Deeply cut gorges still present problems, but the vegetation and slopes are less restrictive. Terrain reinforcement with mines, barriers, wire, and ditches is needed in this more open terrain to restrict and fix the enemy.

Concealment in the tropics exceeds that in any other region. Natural cover is also available. The thick broadleaf vegetation and multicanopy easily conceal a small guerrilla patrol that moves undetected and establishes ambushes at will.

In the tropics during World War II and in Vietnam, the ambush was the most effective and heavily used tactic. Hide positions, such as in deep gorges and mountains, are abundant. Caves dug into the soft deep soil or in volcanic crevasses hide large elements such as logistical bases, hospitals, headquarters, and fighting positions. The Japanese and the Viet Cong used concealment and cover extremely well, and seizing terrain cost many American lives.

Concealment from ground and air observation is good in these areas. The Ho Chi Minh Trail in Vietnam allowed division-sized units with tanks to infiltrate south almost undetected. Ammunition and supply convoys were hidden from aerial and ground attack. The U.S. developed sophisticated sensors to aid in detection; these were either implanted along the trail or operated from aircraft. Interdiction of the trail was an around-the-clock operation; nonetheless, the flow continued around the clock. The multicanopy and thick jungle provided concealment that made targeting extremely difficult.

Deeply cut channels during the dry monsoon and in the savanna provide concealment. Tall grasslands also offer excellent ground concealment, but they are vulnerable to aerial surveillance. In the delta and coastal regions where rice paddies exist, concealment is limited. Dikes provide some ground concealment and cover from direct fire.

Camouflage is effective and easy to employ in most of the tropics because there is no seasonal change in coloration. Using green paint and clothing is often all that is needed. One danger, however, is the false impression that thick vegetation also provides cover. Not all vegetation is cover. Even softwood trees are not a guarantee. Cover is best in underground caves and structures.

Avenues of approach are not as clearly defined in the tropics as in other climatic regions. On the other hand, in the interior jungle and mountains, the only avenues are likely to be ancient trails and mountain passes such as those taken across the Stanley Owens Range of New Guinea by both the Japanese and the Americans. Such avenues as the Ho Chi Minh Trail and the Burma Road were painstakingly constructed—and later used—at great cost in lives.

Trafficability is so restricted by jungle, steep slopes, and swamps that foot movement is the only ground option, and it is slow. Aerial avenues are influenced by the high mountain chains, which also tend to create avenues of approach and channel ground movement. Generally, the only high-speed ground avenues are along the coastal plains where man has cleared the surface, and along beaches. Boats on rivers often provide the best approach.

Avenues of approach are seasonal in monsoon areas. During the dry monsoon, many areas are accessible, but avenues are restricted to the few hard-surfaced roads during the wet season. In Vietnam, such operations as Long Son 719 were conducted during the dry season. Even the rivers are too dangerous in the wet season, and coastal areas are normally flooded. Aerial movement is also restricted because atmospheric conditions are poor. In savanna areas, the terrain is more open, but gorges compartmentalize large unit movements, and avenues of approach are limited by local topography.

We analyze the military aspects of terrain to determine their effect on soldiers, equipment, combat operations, and support operations. In tropical areas, the vegetation, drainage, and slopes point to dependence on aircraft for mobility and to a light infantry force structure. Small-unit tactics dominate in the jungle. Large-scale operations are restricted to the savanna during the dry monsoon season, and along the developed coastal flats. In part two of this series, the focus will be on the way these various factors affect military operations.

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