Reprinted from Military Medicine, Vol. 138, No. 5, May, 1973

A Survey to Assess Potential Human Disease Hazards Along Proposed Sea Level Canal Routes in Panamá and Colombia. II. Geography of Proposed Routes

*LTC Bruce F. Eldridge, MSC, USA**
*Graham B. Fairchild, Ph.D.***

MEDICO-ECOLOGY surveys were conducted along two proposed sea level canal routes—the Sasardi-Morti (Route 17) and the Atrato-Truando (Route 25)—as part of the engineering feasibility studies performed under the auspices of the Atlantic-Pacific Interoceanic Canal Study Commission (A-PICSC). The former route lies entirely within the borders of the Republic of Panamá, the latter entirely within the Republic of Colombia. Available geographical information relating to medico-ecological aspects of the areas traversed by the routes is scattered. By far the most detailed and extensive geographical study of the total area is that done by the geologists, hydrologists, ecologists, topographers, weathermen, and others in conjunction with the sea level canal feasibility studies. This information is available in the various reports of these groups to the Study Commission, and much of the information contained in this paper has been gleaned from these reports.[1-5] An excellent description of the climate and vegetation of the area in the vicinity of El Real, a town on the Río Tuira and immediately to the east of Route 17, is available in the report of the 1962 El Real Environmental Survey.[14]

Fig. 1 shows the location of the two routes and their relationship to one another. They run generally in a north-south direction, roughly parallel to each other, separated by an average distance of about 160 km. Although all lands between the two routes and a reasonable distance to either side are of interest and influence medico-ecological considerations, the immediate areas of interest consisted of the lands lying eight km or so to either side of the surveyed canal route center lines.

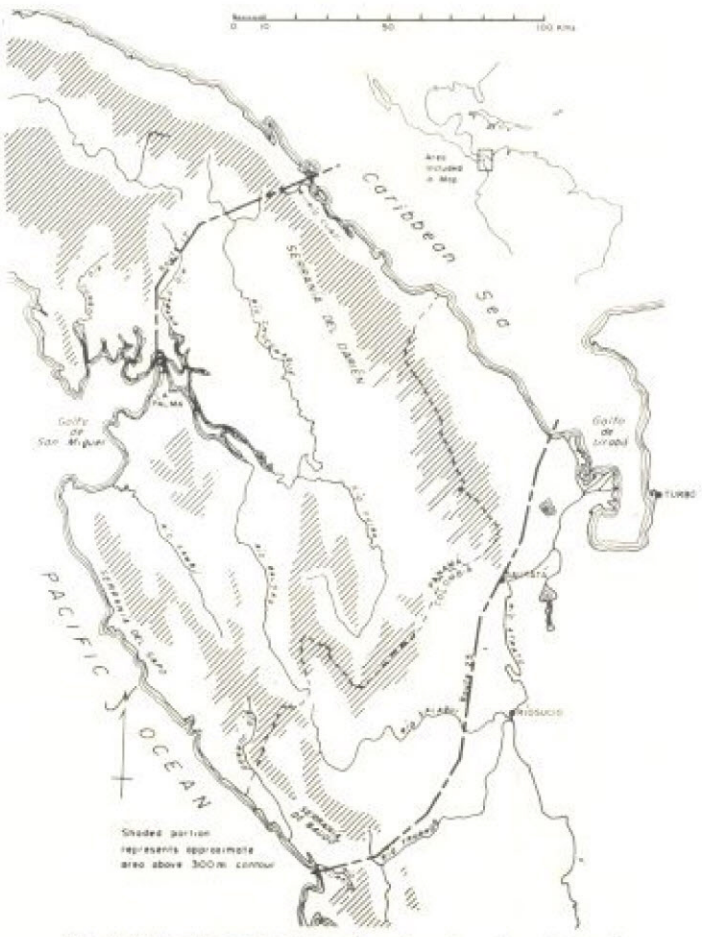

Fig. 1. Map of eastern Panamá and northwestern Colombia.

Land Forms

The general configuration of the land forms in the vicinity of the canal routes can be seen in Fig. 1, in which the areas above 300 m are shaded. Where Route 17 crosses the Isthmus of Panamá, the continental divide is located at the crest of the Serranía del Darién, which runs parallel to the long axis of the isthmus and very close to the Atlantic coastline. The divide gradually swings away from the coast as it forms the Panamá–Colombia border, runs in an irregular fashion toward the southwest, then proceeds south, close to the Pacific coast, along the Serranía de Baudó. Route 25, then, crosses the continental divide within a few kilometers of the Pacific coast.

The greatest elevations present in the area under consideration here are at the Panamá-Colombia border, where several peaks lie above the 1,500 m contour (e.g. Tacarcuna, 1884 m). In the immediate vicinity of either canal route, however, elevations rarely exceed 700 m.

Because of the placement of mountains at the junction of South and Central America, the two canal routes are somewhat physiographic mirror images of one another. Each crosses a narrow band of sharply rising mountains adjoining a long, flat alluvial plain. Route 17 originates, at its Pacific end, at the Gulf of San Miguel. It cuts across several streams and their separating ridges of between 150-180 m in elevation, then crosses a broad plain of about 30 km in width produced by the Río Sabana and Río Chucunaque and their many tributaries. The land between these rivers basins is only about 75 m in elevation. Once past the Río Chucunaque, Route 17 rises quickly to the crest of the Serranía del Darién at an elevation of 335 m, then descends even more rapidly to the narrow rim of land

*Entomologist, Office of the Field Director, Atlantic-Pacific Interoceanic Canal Study Commission, Balboa Heights, Canal Zone. Presently, Chief, Department of Entomology, Walter Reed Army Institute of Research, Washington, D.C. 20012.

**Entomologist, Gorgas Memorial Laboratory, Panamá, R. P. Present address: Department of Entomology, Univ. of Florida, Gainesville, Fla. 32601.

about eight km in width before reaching the Caribbean Sea.[1]

Route 25, on the other hand, at its Pacific terminus, crosses a very narrow strip of land before ascending the steep western slope of the Serranía de Baudó. Peaks of 300 m and more (e.g. Alto Curiche, 302 m) lie within five km of the coast here. The route then descends the more gradual eastern slope of this range, reaching the very wide and long flood plain of the Río Atrato. Route 25's northern terminus is a few kilometers to the west of the mouth of this river.

Rivers

There are a number of major rivers draining the study areas which have considerable influence on the distribution of human disease (Fig. 1). The Pacific slope of eastern Panamá in the vicinity of Route 17 consists mainly of a broad plain drained by the Río Chucunaque and its tributaries, and the Río Sabana. Both river systems have extensive estuaries. The narrow Atlantic rim, in the area crossed by this route, is drained by the Río Cuadi, a short steep stream subject to frequent flooding during the rainy season.

The short Pacific slope of the Serranía de Baudó is drained by many short, small streams. Closest to Route 25 is the Río Curiche. The long Atlantic slope is drained by a number of major streams, all of which flow into the Río Atrato. The most important of these streams is the Río Truando, which joins the Río Atrato at the town of Ríosucio. Another major tributary is the Río Salaqui, which flows into the Río Atrato at the same place.

The Río Atrato, fed by many rivers of the eastern slope of the Serranía de Baudó, completely dominates the ecology of the northern two-thirds of Route 25. The river flow exceeds the stream-bed capacity during the wet season, causing flooding of the alluvial plain for many kilometers on either side of the river.[5] The width of the flood plain varies along the length of the river; in some places, however, it exceeds 30 km in width. The tremendous flow of this river is due also to the very great amount of precipitation falling upon the southern Atrato watershed, well to the south of the canal route. In some areas of this region, mean annual precipitation exceeds 8000 mm.[2]

Climate

The climates of both routes are similar, being typical tropical rainy. The temperature at all points is moderately high, with little seasonal and daily variation. An average temperature of about 80°F prevails on both routes, with a daily variation of only 2-3°F. The seasonal variation is usually about the same, with the lowest temperatures occurring in November, when precipitation is greatest, and highest temperatures occurring in April, when the sun is directly overhead at noon.[2]

The most significant climatic difference between localities on the routes are due to differences in amount and seasonal distribution of rainfall. The year is divided at all locations on both routes into a long wet season, lasting from mid-April to mid-December, and a shorter dry season, occupying the intervening months. The mean annual precipitation varies somewhat between the routes, ranging from 2,000 to 3,000 mm on Route 17,[3] and from 2,000 to 4,000 mm or more[4] on Route 25. Along Route 17, the highest annual precipitation occurs at the continental divide, decreasing considerably toward the Pacific coast. Along Route 25, maximum precipitation occurs at the steep Pacific slope and continental divide and decreases toward the Atlantic coast.

Vegetation

Many schemes have been devised to classify natural vegetation and most agree well in broad outline with the picture presented to the human eye by the natural vegetation of a given locality. The system of Holdridge,[9] based on mean annual precipitation and mean annual biotemperature (temperatures above 0°C) has gained wide acceptance by ecologists, and is useful for the description of the major types of climax vegetation occurring on the routes. This vegetation has been mapped for Panamá by Holdridge and Budowski;[10] for Colombia by Rosi, Montenegro, and Espinal.[13] The descriptions and terms used here are from these sources.

Fig. 2. Tropical Moist Forest Life Zone. Pacific coast of Panamá south of Punta Garachiné.

This system of classification recognizes three altitudinal belts of vegetation: *Tropical* (sea level to 600 or 700 m, depending upon whether the slope in question faces seaward or not); *Subtropical* (600 or 700 to 1,500 m); and *Lower Montane* (1,500 to 2,600 m). Virtually all of the land traversed by the canal routes is in the tropical (basal) belt, thus most of the climax vegetation present is tropical forest of some kind. Where precipitation is heaviest—on Route 25 in the mountains and along the narrow Pacific coastal rim—the forest is *Tropical Wet Forest*. This forest occurs where mean annual precipitation exceeds 4000 mm. The climax association is very complex, having several canopy levels, the highest often reaching a height of 45-50 m. Characteristic of this association is the growth of many kinds of epiphytic plants, and as the relative frequency of deciduous trees is low, the canopy presents a relatively unbroken

ppearance, even during the dry season. Espinal and Monnegro[6] presented a detailed analysis of this forest, and cluded a list of the species of trees composing it in several eas of Colombia.

Where mean annual precipitation is between 2000 and 000 mm, the climax vegetation is *Tropical Moist Forest* (Fig.). This forest type is present along the wettest portions of Route 17—the mountains and Atlantic rim—and on well drained soil of the northern part of Route 25. The composition of this forest is similar to that of Tropical Wet Forest. Deciduous trees such as the cuipo (*Cavanillesia plantanifolia*) occur with greater frequency, so that definite breaks occur n the canopy during the dry season. Epiphytes are plentiful.

In the Holdridge system, an area with mean annual precipitation less than 2000 mm in this temperature zone would be classified as *Tropical Dry Forest*. The lands of the Pacific plain of Route 17 receive, on the average, this much rainfall. The areas lying closest to the Gulf of San Miguel receive somewhat less and the mean annual precipitation gradually increases toward the continental divide, where precipitation is at maximum on the route. This forest (Fig. 3), therefore, assumes a gradually more xerophytic appearance as one moves from the divide to the Pacific coast. Holridge and Budowski[10] consider this forest to be transitional between tropical moist and tropical dry types. The cuipo is the dominant tree, so much so that the forest can be reasonably called a deciduous forest. Epiphytes are present, but their frequency is noticeably less than in the more hydrophytic forest types discussed. The dry season appearance contrasts sharply with associations growing at wetter locations. Moving from xeric to hydric extremes, the frequency of large deciduous trees gradually decreases, while that of epiphytic plants gradually increases.

Even in areas not populated by man, various disturbances prevent the development of climax vegetation. Various subclimax associations occupy large areas within each of the life zones represented, and in many areas are more important from the standpoint of human disease distribution than are the climax forests. Few of the subclimax associations have been studied in sufficient detail to describe them in any but general terms. Holdridge[11] provides an excellent description of the edaphic associations on alluvial flats in the Tropical Moist Forest life zone. These associations are well represented on Route 17. Similar associations exists within the other life zones, but have not been analyzed in detail. In general, high water tables and other drainage disturbances have produced saline and fresh water swamp forests and marshes of similar physiognomy, if of varying floristic composition.

Mangrove swamps occur on both routes, but are most extensively developed adjacent to the long estuaries of the Pacific coast of Route 17. The situation here is a broad low coastal plain associated with a very high tide (three to four m). This has produced a complex and extensive estuarine system which extends some 25 km inland in some cases. Pure stands of red mangrove (*Rhizophora mangle*) commonly grow at the water's edge, sometimes forming a band of considerable width. Behind this band of red mangrove, on ground somewhat elevated and thus not so frequently flooded by tides, are often found pure stands of mora or

Fig. 3. Transitional Moist Dry Forest Life Zone. Looking northwest from west of Santa Fé, Darién Province, Panamá. The Serranía del Darién is at the top of the picture. The prominent tree without leaves is the cuipo. Picture was taken in January, during the dry season.

alcornoque (*Mora oleifera*). Other associations also occur in these situations, and there are often definite successional series of associations between silted ground flooded by saline tides and the upland forest.

At various locations, the presence of poorly drained depressions along stream flood plains has resulted in extensive fresh water swamps. Since these often occur along both sides of streams, frequently extending for many kilometers, they are considered gallery forests by some authors.[7] At locations above tidal influence, these swamps are usually flooded only during the wet season. They are characterized by a high frequency of cativo (*Prioria copaifera*) and are thus often called cativo swamps. Alcornoque also is present in varying abundance, depending upon the edaphic situation. There is usually a lush ground cover of small palms, bromeliads, araceous plants, and other shade-resistant plants. These swamps probably represent the most important natural source of arthropod-borne disease in the study areas.

The flood plain of the Río Atrato (Fig. 4) differs from these swamps in that it is, in most places, too wet to support the growth of even hydrophytic trees. It thus assumes the form of a fresh water marsh with a characteristic growth of floating plants, such as water hyacinth in the wettest areas and of shrubby palms, grasses, and sedges in the driest areas. Where depressions are deepest, no emergent vegetation at all develops, and water stands throughout the year. Such areas are seen on maps as lakes and designated as *cienagas* (marsh or bog). Along the Río Atrato itself, and along major streams on both routes, are well developed levee forests. In the case of the Río Atrato, these forests often represent the only trees growing within a distance of many kilometers.

Along the narrow coastal rims of both routes, much of the natural vegetation has been removed for agricultural purposes. This is also true to a lesser extent at other locations. Where farming has been abandoned or temporarily suspended, areas can be found in various stages of succession. One common early successional situation encountered

is that of large fields supporting almost pure stands of wild plantain (*Heliconia* spp.). Areas in later stages of development support growth of a variety of trees and shrubs. Very commonly seen in these situations are the trumpet tree or guarumo (*Cecropia peltata*) and the balsa (*Ochroma lagopus*).

Lumbering has been carried out extensively in many areas of both routes, especially in those areas nearest to large streams. This has resulted in the virtual absence of many species of large hardwoods in such areas.

In the mountains situated between Routes 17 and 25, two other altitudinal belts of vegetation occur: the subtropical, which occupies much of the mountain crest along the Panamá-Colombia border, and the lower montane belt, found only on the highest peaks above the 1,500 m contour. The vegetation found in these belts is classified as *Subtropical Wet Forest, Subtropical Rain Forest,* and *Premontane Wet Forest.* Only the last mentioned association occupies any appreciable area in the general area under discussion. No medico-ecology collections were made in any of these associations.

Centers of Human Habitation

Route 17. The population of eastern Panamá is currently[12] given as being about 48,000. This represents only about four per cent of the entire population of the Republic of Panamá. About 20,000 of this includes Indians living on off-shore islands in the San Blas reservation. The remainder are distributed in isolated homes or in centers which vary in size from villages of a few homes to small towns of 100 or so inhabitants. The only town in the immediate vicinity of Route 17 having 500 or more inhabitants is La Palma[8] (pop. = 1,885), located on the Gulf of San Miguel. Santa Fé[6] (pop. = 446) is the only other town on Route 17 of significant size. Adjacent to Route 17, a number of small towns are situated on the Pacific coast or along major rivers which eventually flow into the Pacific. The largest of these is El Real[8] (pop. = 1,071), located near the confluence of the Río Chucunaque and the Río Tuira.

Route 25. The province of Choco, through which Route 25 passes, has a population of about 152,000, which represents less than one per cent of the population of the Republic of Colombia. The largest city in the province is Quibdo,[8] the capital (pop. = 23,410), which is considerably south of the canal route. The town of Turbo[8] (pop. = 2,636), in Antioquia Province to the east of the northern terminus of the route, represents the largest population center in close proximity to the route. The majority of inhabitants within the area of interest live in towns distributed along the Rio Atrato and situated on the natural levee of the river. Riosucio[8] (pop. = 847), at the junction of the Río Atrato and the Río Truando is the largest of these. There are no towns of significant size on the Pacific coast of the route, nor in the mountains adjacent to the coast.

Fig. 4. Looking west from the Río Atrato just south of Riosucio, Choco Dept., Colombia. The stream leading to the right is the Río Salaqui. In the upper center of the picture is the Ciénaga La Poza. The Río Truando is seen entering from upper left where its presence is marked by the levee forest. The main streambed of the Río Truando enters the Río Atrato out of the picture to the left; a secondary branch is seen crossing to the Río Salaqui to a junction just below the ciénaga.

Summary

The major geographic and ecological features of eastern Panamá and northwestern Colombia are described, with special emphasis on lands immediately adjacent to proposed sea level canal routes 17 and 25. The two routes are located within about 160 km of each other, the former completely within the Republic of Panamá, and the latter within the Republic of Colombia. Although some mountain peaks along the Panamá-Colombia border attain elevations of over 1,800 m, the proposed routes cross lands of relatively low elevations, the peaks within 10 km of the route rarely exceeding 700 m. The climate and resulting vegetation of the area is relatively uniform; differences which do occur are the result of differences in amounts and seasonal distribution of precipitation, or due to edaphic conditions. The natural vegetation is discussed in terms of the Holdridge life-zone concept. The climax vegetation of the entire area at low elevations ranges from transitional tropical moist/dry forest to tropical wet forest, with no clearly defined separations between types. Several widely occurring subclimax associations occur on the routes, some of which are associated with high endemicity of human diseases. Population density is very low (< two persons per km^2) and highly dispersed. Few towns and no cities are located within the areas of interest.

References

[1]Atlantic-Pacific Interoceanic Canal Study Commission: IOCS Memorandum FD-32, Profile across the isthmus—Boca Grande to Sasardi, 9 pl., 1967.

[2]———: IOCS Memorandum JAX-50, Climatology and hydrology of the Panama Canal Watershed, 30 pp., 1968.

[3]———: IOCS Memorandum JAX-62, Analysis of Route 17 hydologic data, 16 pp., 1968.

[4]———: IOCS Memorandum FD-66, Rainfall data—Route 25 (Including Supplements 1 & 2). Unpaginated, 1968–9.

[5]———: IOCS Memorandum FD-77, Hydrology—Route 25 final report, 65 pp., 1969.

[6]Espinal, L. S. and Montenegro, E.: Formaciones vegetales de Colombia. Instituto Geografico "Agustin Codazzi", Bogota, 201 pp., 1963.

[7]Golley, F. B., McGinnis, J. T., Clements, R. G., Child, G. I. and Duever, M. J.: The structure of tropical forests in Panamá and Colombia. Bio. Sci., 19:693-696, 1969.

[8]Hammond, Inc.: Hammond Medallion World Atlas. Hammond, Inc., Maplewood, N.J., 415 pp., 1966.

[9]Holdridge, L. R.: Determination of world plant formations from simple climatic data. Science, 105:367–368, 1947.

[10]Holdridge, L. R. and Budowski, G.: Report of an ecological survey of the Republic of Panamá. Caribbean Forester, 17:92–110, 1956.

[11]Holdridge, L. R.: Ecology, *in* El Real environmental survey Darién Province, Republic of Panamá. Report AD 650-762. Wilson, Nuttall, Raimond Engineers, Inc., Chestertown, Md., 33 pp., 1962.

[12]Torres de Arauz, R.: Phase I final report: Human ecology studies. Battelle Memorial Institute, Columbus, O., IOCS BMI-6, 88 pp., 1967.

[13]Tosi, J. A., Montenegro, E. and Espinal, L. S.: Mapa ecologico, Republica de Colombia. Instituto Geografico "Agustin Codazzi", Bogota, 4 pl., 1962.

[14]Wilson, Nuttall, Raimond Engineers, Inc.: El Real environmental survey Darién Province, Republic of Panamá. Report AD 650-762. Chestertown, Md., 333 pp., 1962.