CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA
(CATIE)

Departamento de Ciencias Forestales

MANAGEMENT ASPECTS OF WATER AND LAND RESOURCES IN THE REVENTAZON RIVER BASIN - COSTA RICA

Iván H. Mojica
Specialist - Watershed Management

Turrialba, Costa Rica

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I N T R O D U C T I O N

As with many tropical wet areas the Peventazón River Basin is experiencing rapid population growth which affects natural resources. Native forest cover has been reduced by increasing agricultural and urban demands, and as a result, the balance of natural forest of the area has been altered. Changes in forest covers and alteration of existing land use patterns have produced annual and seasonal hydrological imbalances, which are manifested by frequent overland flows and floods in the Middle lower elevations of the Basin.

Due to the nature of soils, high rainfall intensities, and land use changes, erosion and sedimentation problems have become serious in the area. Over recent years these problems have cost the people living in the Basin thousands of dollars. Accordingly, a better undestanding of the social and physical aspects of the area, and the hydrological phenomena can lead to better defined and more practical management practices of the Peventazón River Basin.

PHYSIOGRAPHIC AND CLIMATIC CHARACTERISTICS OF THE AREA

The Middle and the Upper Peventazón River watershed has an area of 1367 square kilometers ($km.^2$) on the Atlantic slopes, Cartago Province, Costa Rica; it is situated between 10°17' 30" North, and 9° 32' 00" South (Figure 1).

The Basin is bounded in the northwest by the Central Mountains; in the southwest by the Talamanca Range; and in the east by the lower slopes of the Talamancas.

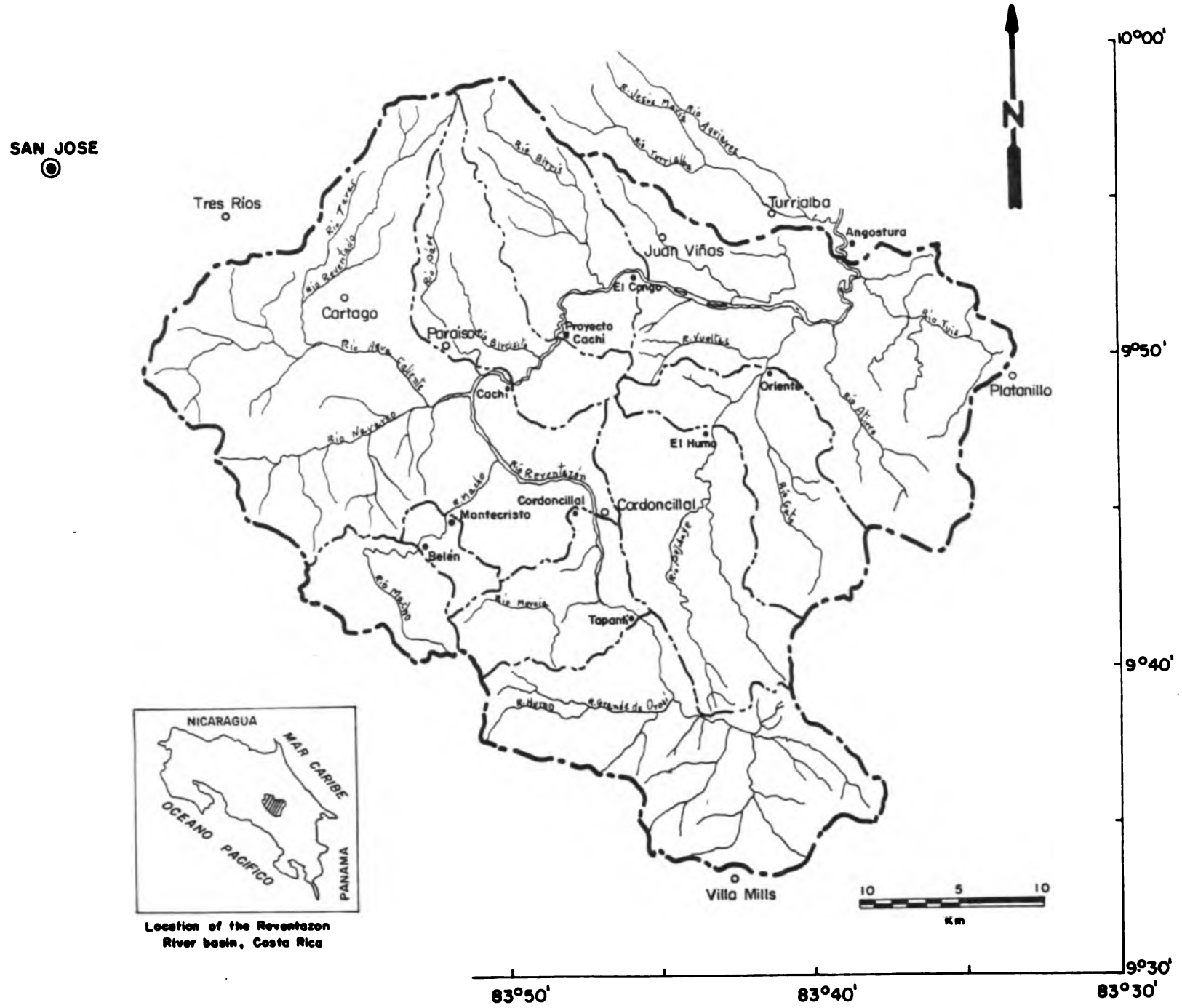
The climatic, topographic, and geological conditions have impressed a rectangular drainage pattern in the Area. The northern portion of the Basin contains both young and ancient lava formations. Active volcanoes exist in the Central Mountains and frequently discharge large amounts of debris onto the land and into the streams. The balance of the watershed is largely sedimentary, consisting of agglomerate and calcareous sandstone types.

In general the Basin is characterized by steep to undulating topography (4). Approximately 72 per cent of the area has slope greater than 20 per cent; and the remaining area sustains slopes greater than 40 per cent. The steeper regions include some areas with slopes over 100 per cent. These steep slopes are located in an east-west belt, between 1400-2500 meters above sea level (m.a.s.l.). Gentle slopes, 5-10 per cent, are distributed in the lower watershed in the Cartago and Turrialba Valleys (Fig.1).

CLIMATE

The Reventazón River Basin is a wet region. Annual average rainfall exceed 2500 milimeters (mm) in the lower valleys, and range from 4000 to 7500 mm. on the upper slopes. The upper Basin is covered by dense rain forest vegetation, typical of areas with diurnal fog cover. Damp conditions are in part perpetuated by fog drip as moisture is intercepted and retained by the forest.

Fig. 1 Upper and middle section of the Reventazon River watershed



Location of the Reventazon River basin, Costa Rica

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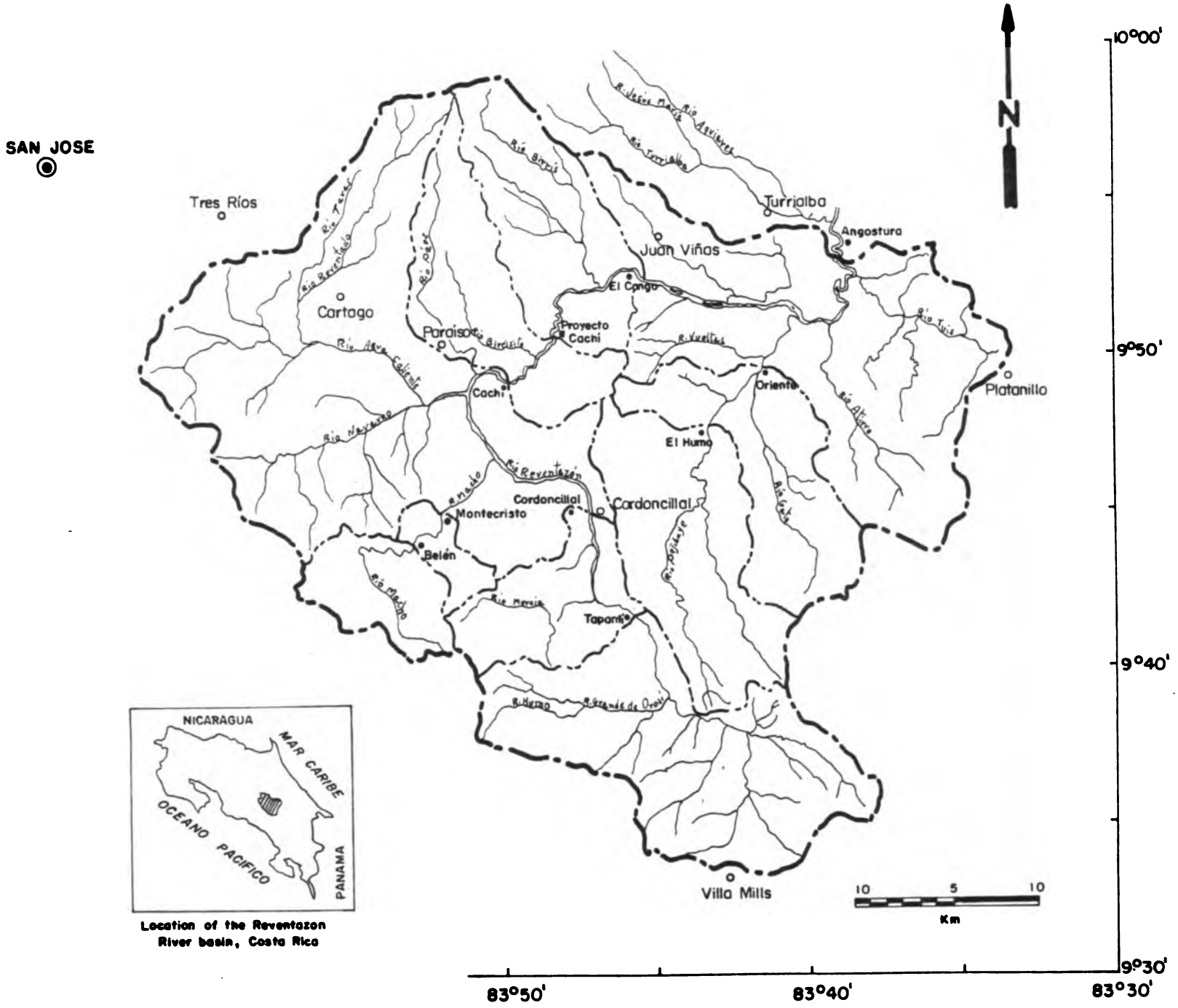

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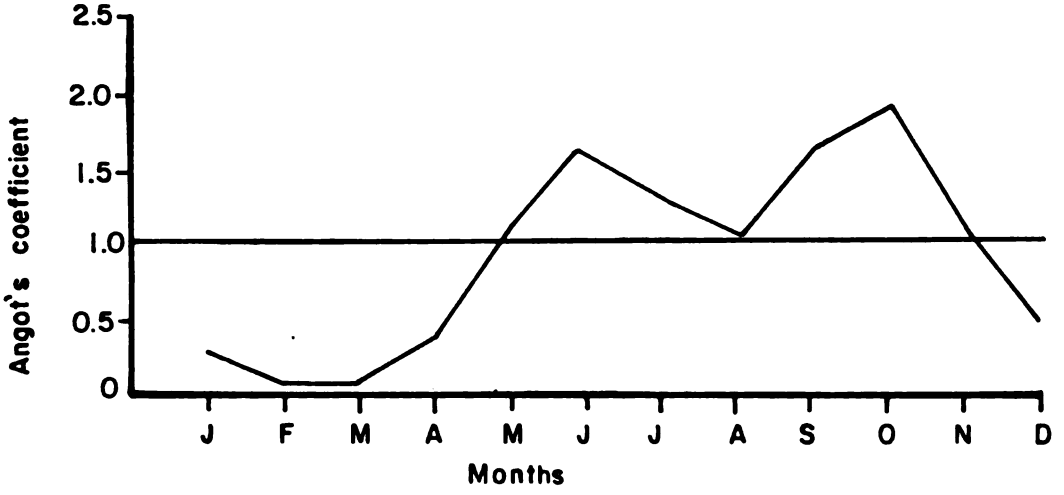
Recent studies in the area, have more accurately defined local climates (4). Areas with similar topography show corresponding seasonal patterns of wind, rainfall, and temperature. Rainfall patterns, however, do not follow a typical orographic influence, which would be expected from complex drainage systems. As a result, certain sub-basins receive extreme amounts of rainfall; other sub-basins have a scarcity of rain. Rainfall is quite variable seasonally as typified by five months of dry weather (December to April); the rest of the year is wet (Fig.2).

STREAMFLOWS

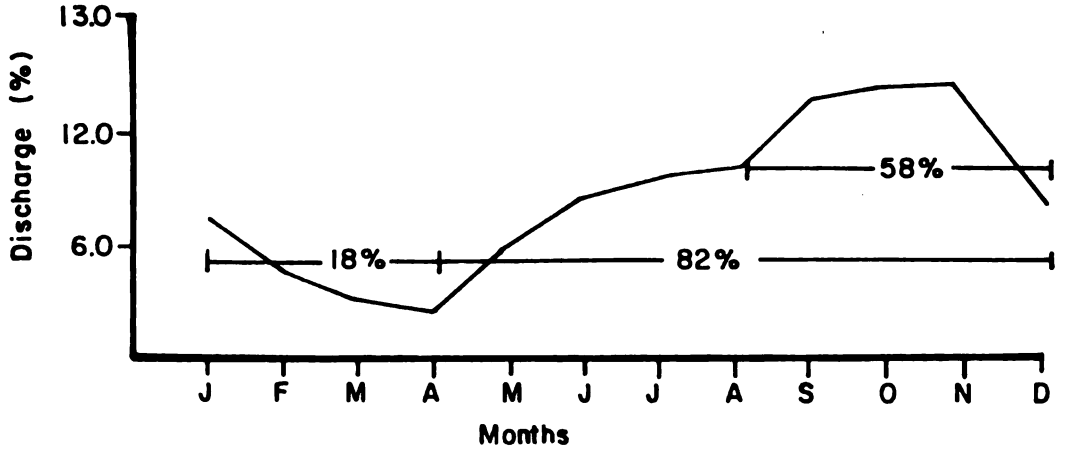
Data taken during a 15 year observation period presents a mean annual discharge of 101.88 cubic meters per second (m^3/sec) at Angostura, the lowest recording station in the area.

Table 1 presents the mean monthly and annual discharge for every station in the area for various time periods. Streamflow values for Angostura are plotted in Fig.3. Minimum streamflows occur in March, while maximum flows are recorded in October. Maximum and minimum flows at other stations in the upper Reventazón are influenced by their unique physical characteristics and the rainfall pattern to which they belong.

Graphical representations of the Reventazón streamflow indicate a general relationship between times of maximum flows and the rainy season (Fig. 2). The greatest differences between maximum and minimum monthly flows occur in May and December; smaller differences occur in March and April.



Average rainfall pattern of the upper Reventazon River Valley, Costa Rica



Average discharge (%) of a typical gauging station of upper section of the Reventazon watershed

Fig. 2 Rainfall and streamflow patterns in the upper section of the Reventazon River basin (Mojica, I., 1967)

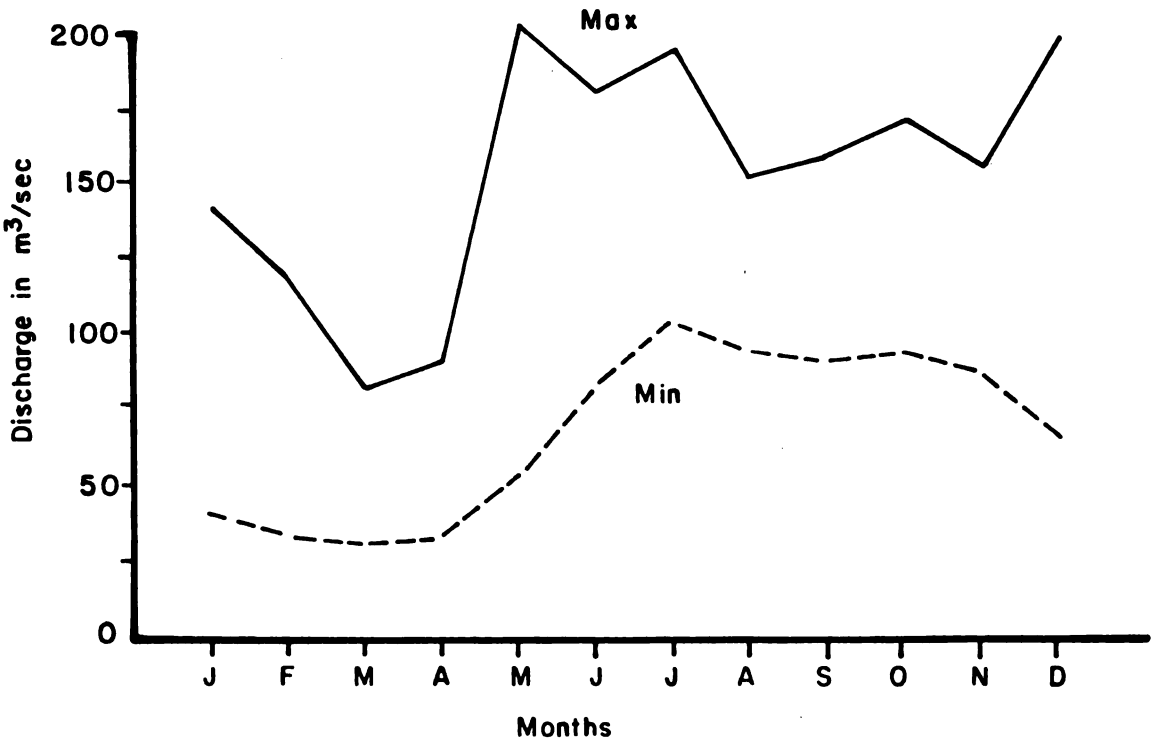


Fig. 3 Maximum and minimum monthly discharge at Angostura (Reventazon River, Costa Rica).

TABLE 1. Mean monthy and annual discharge for the stations at the Upper part of the Reventazón River Basin, C.R. (Data in m^3/sec). 1967*

STATIONS	JAN	FEB	MAR	APP	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
Angostura	85.2	60.6	47.5	49.5	88.0	117.9	131.1	111.3	133.3	145.5	133.5	118.9	101.8
Cachí	36.5	22.2	18.4	18.1	38.7	51.0	65.1	55.7	70.5	77.4	68.8	56.8	48.3
Cordoncillo	17.9	10.4	10.1	8.9	16.2	23.6	26.8	26.5	27.1	28.1	28.7	21.2	20.5
Oriente	26.1	14.8	13.6	15.1	32.3	40.0	53.1	42.5	51.7	50.7	51.7	28.6	35.0
Tapantí	11.7	6.4	5.2	5.4	9.1	12.7	16.0	14.9	21.3	23.7	26.7	15.8	14.1
Humo	17.4	13.8	10.5	12.8	28.5	30.0	35.7	29.7	32.2	37.4	29.9	25.5	25.3
Montecr.	3.7	2.7	2.0	1.7	2.9	5.1	6.2	6.3	7.9	7.2	6.8	5.4	4.8
Belén	2.0	1.1	1.0	.9	1.3	3.1	4.0	4.7	6.3	4.5	5.0	3.6	3.1

* Basic data taken from: Boletines Hidrológicos del Instituto Costarricense de Electricidad (ICE). Costa Rica.

POPULATION AND LAND USE

Population on the Reventazón River Basin is about 200,000 people, of which 30 per cent are urban and 70 per cent rural. The urban population is settled in a few cities, the most important being Cartago, Turrialba and Juan Viñas. A paved road and a railroad join these cities with the capital, San José. The Pan American highway skirts the southwest boundary of the watershed stimulating population growth along this route. The rural population dependes on agricultural and forestry employment, while the urban population is employed mainly in sugar and coffee processing. The excessive precipitation of the Central portion of the Basin has discouraged permanent farming on the steeper slopes. Accordingly, shifting agriculture has been the main settlement pattern. As the Pan American highway was located over the top of the Talamanca Range, people were able to colonize these heretofore inaccessible areas. Although this region is in the process of being densly colonized, the area is still predominantly forest. Fig.4 indicates that 48 per cent of the Upper Reventazón Basin is covered with native forests (4). These forests are generally of the broad-leaf type where species Quercus (Oak) and Podocarpus (pine) grow in relatively pure stands. These forests are distributed between 1200 to 3400 m. a.s.l., but in some areas they occur below 800 m.a.s.l. where agricultural lands have been abandoned and a secondary forest type has appeared. This secondary forest accounts for 8.5 per cent of the total watershed ranging from the low land to the upper slopes.

PRESENT LAND USE OF THE UPPER AND MIDDLE SECTION OF REVENTAZON

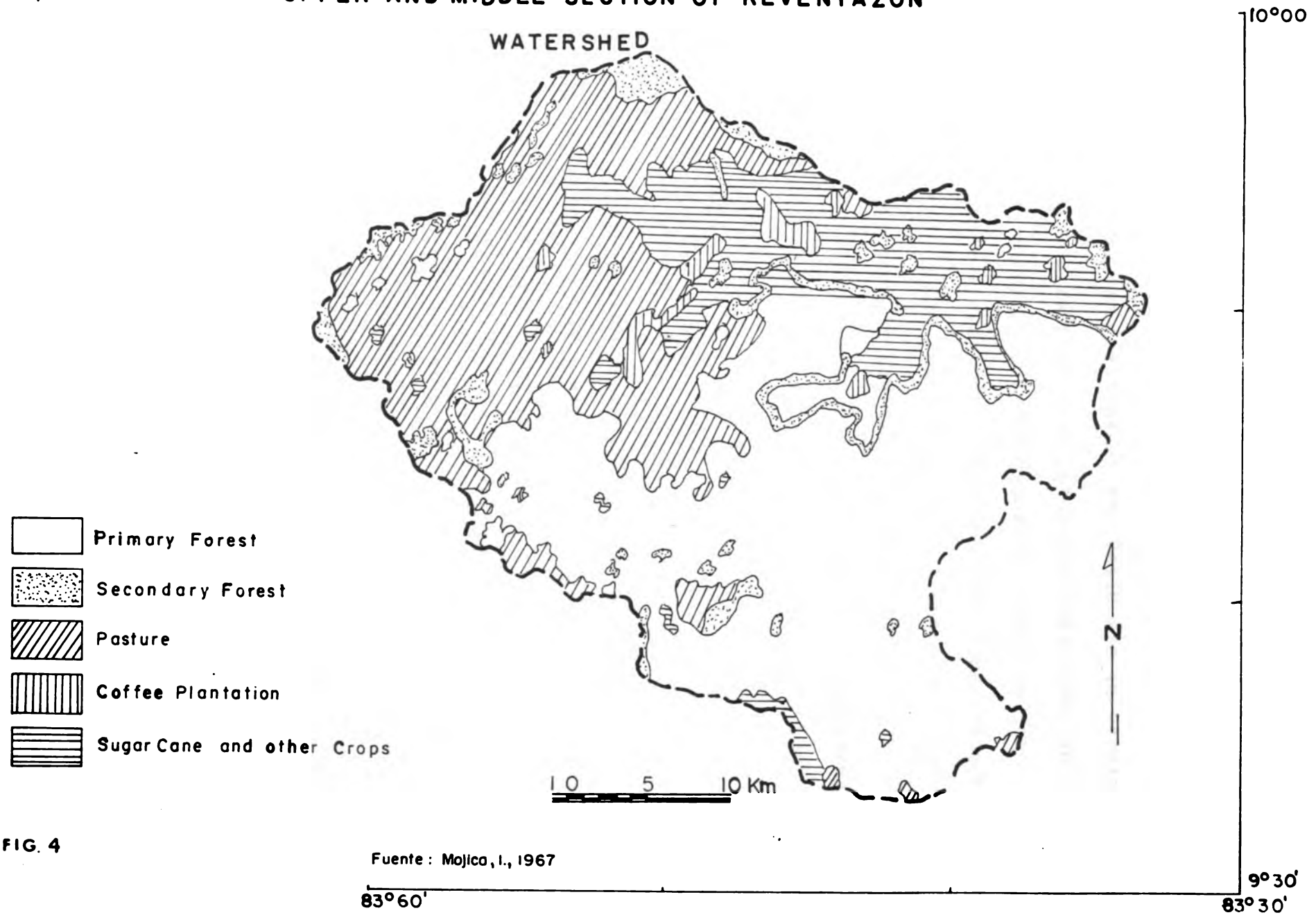


FIG. 4

Fuente : Mojica, I., 1967

The central and northern portions of the Basin are in varying stages of agricultural use ranging from intensive sugar cane and coffee cultivation to pasturing. Crops generally found in temperate lands are common at upper elevations. Over the entire Reventazón Basin, pasture covers 24.3 per cent of the area. About 15.9 per cent of the entire watershed is dedicated to agriculture; 2.9 per cent is in coffee and 13.0 per cent in sugar cane; the remaining production lies in crops like beans, potatoes, corn, wheat, bananas, etc.

ASPECTS OF MANAGEMENT ON THE AREA

Before managing Reventazón River Basin water resources, questions relating to goals and political implications of potential management plans must be taken into consideration.

From descriptions of physical and climatic characteristics of the Basin, it is noted that the area has a potential for both the development of hydroelectric power and for judicious exploitation of the water per se needed for people settling in the region.

In spite of the seasonal streamflow changes, a water shortage is not yet a forseeable problem in the Basin. However, sedimentation and erosion problems caused by the poor agricultural techniques, logging operations and natural causes are prevalent in the lower reaches. Mud flows in the Upper Basin area have occurred during periods of heavy rainfall.

Water resources management plans of the Basin must include soil conservation practices. Basic possibilities include provision for:

1. Improved roads.
2. Improvement of land use techniques.
3. The designation of catchment areas and critical erosion zones.
4. Plans to control human activity; in detail to
   a. Prohibit any further settlement.
   b. Encourage the re-establishment of forests.
   d. Discourage shifting agriculture and paternal land division among relatives.

A small country like Costa Rica does not have much agricultural land for colonization; for this reason the government should take the responsibility of educating settlers on principles of good resource management.

From geologic, edaphic, topographic, and climatic data of the different areas of the Basin, it is possible to classify the sub-watersheds. Using land and climatic characteristics as keys to classify potential land uses, it is evident that 50 per cent of the total land could be in forestry; 40 per cent could be in extensive and intensive agriculture; and 10 per cent exclusively to watershed protection.

Once the hydrological aspects of the watershed are understood, plans for potential land uses will have to be adjusted and new zoning probably will be necessary.

In practice, land use plans will ensure that areas prone to land slides and erosion will be under forest cover. It is essential, therefore, that hydrological characteristics of the Basin should be outlined in an useable fashion. With a better understanding of the hydrological phenomena of the Basin, new approaches can be used in the manipulation of the natural resources of the watershed.

When reasonable watershed management plans are realized, the quality of water would rank, between a high quality one, assuming full forest cover, to a low quality when forests are harvested. However, under full forest cover, evapotranspiration losses will not be significant in relation to the present water demand of the people of the area; moreover, water resources management will ensure streamflow regulation. With forests reduced, alterations on streamflow regime may occur and flood risks may become more frequent.
If intensive land use demands an increase in quality, water treatment plants and other engineering activities should be considered. If in spite of better land use, overland flows and floodings occur, then engineering structures or flood plain zoning may become necessary. Watershed management becomes more complex when we consider the impact of volcanic eruptions on water resource problems. Volcanic ash deposition in the northern section of the Basin with intensive rains, creates mud flows and floods which contribute to the high incidence of sedimentation in the Middle and Lower parts of the Basin. These volcanic factors create sudden hydrological imbalances which require

immediate controls, characterized by engineering structures, such as sediment traps, wells, ditches, etc., structures that later will be augmented with the re-establishment of vegetative covers.

Management problems are compounded when economical and cultural aspects of water resources management become important. For example, people in tropical areas have little experience in forest management. As a result, forest industries or conservation programs will not be effective under the existing political and cultural structures. Moreover, ancestoral inheritance of land and resulting use techniques have a predominant influence on subsequent generation; long established land-use customs are solidly entrenched in the life and work styles of people in the area.

Accordingly, an ever-present question is, "Can aspects of modern land management be realistically established in terms of expected results in the Reventazón River Basin? ". In the past pressures for development of engineering structures have always gained predominance after floods decimate the countryside. Hopefully, in the future, government agencies will consider all the alternatives for flood control, not only from the standpoint of emergency works, but also in terms of land management practices.

Enlightened management plans should include the moving of people from hazardous areas, a solution to the frequent human and property calamities that occur after floods. However, this approach could mean the transfer of the problem to another area, which still may be inside the watershed.

If people were to remain within the area, engineering structures and water treatment plans would be necessary.

SUMMARY

The Reventazón River Basin of Costa Rica is a wet area with high potential for both hydroelectric power and clear water production. The pressure for the utilization of natural resources, the increasing demand for agricultural and urban lands and recent hydrological imbalances manifested by seasonal overland flows, floods and accelerated erosion can be seen as direct and indirect responses to the 3.5 per cent rate of the population growth sustained by the region.

Although a land use classification scheme could be made based on general topographic and climatic considerations, it is suggested that in such classification not be initiated until a better understanding of the hydrological phenomena is obtained.
In considering the phisiographic and climatic characteristics of the area, the water resources management of the Reventazón Basin can be technically improved. Conservation practices and the control of human activities could be considered in the management of the area. However, the social and economical aspects raise a series of questions bearing on the management practices. Research in both the natural and social science is essential to the solution of the actual problem we are facing in the area.

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