EVALUATION OF FOREST SITE POTENTIAL IN THE
NORTHWEST DEPARTMENT OF THE
REPUBLIC OF HAITI

by

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INTRODUCTION

The Republic of Haïti represents the extreme of environmental degradation in the New World. Burdened with a cumbersome political system and an ever-increasing population, the country is struggling to rise above its present-day subsistence economy. More than eighty-five percent of Haïti's approximately 5 million inhabitants depend upon agriculture for their entire family income.

Haïti occupies the mountainous western end of the island of Hispaniola (Figure 1). Farms in this rugged terrain are small, averaging less than 0.2 hectare in size, and nearly all are intensively cultivated each year (Conservation Foundation, 1977). Over 300 years of forest resources exploitation have left a patchwork of small farms over the entire country. Intensive agriculture, unchecked grazing by domestic livestock, and extensive deforestation by an active charcoal industry have resulted in catastrophic soil erosion (Whitney, 1973).

The northwest peninsula of the Republic presents particular problems for land rehabilitation due to its hot, dry climate and small proportion of arable land. Like that of the remainder of the country, the topography of the Northwest Department is very steep. Access in and around the Northwest Department is worse than that in any other region of Haïti. During the rainy seasons, passage on main roads is slow, difficult, and at times impossible. It is extremely difficult to transport equipment and supplies on a regular schedule because of this.

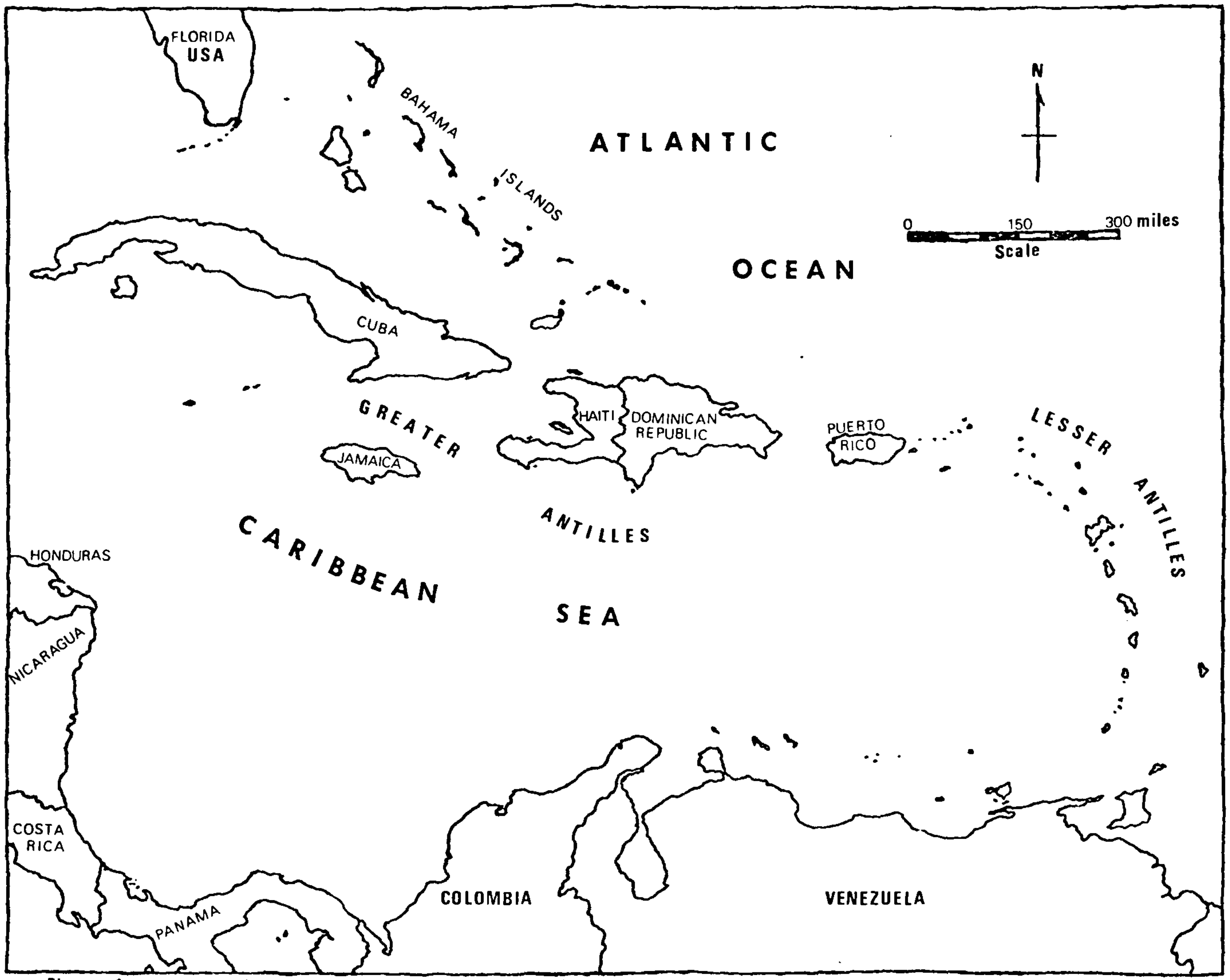

Figure 1: West Indies, showing principal islands and location of Haiti with reference to Florida, Central America, and northern South America

As severe erosion claims once arable land, farmers are forced to clear land which cannot support a productive agricultural crop. The Northwest is also the center of the charcoal production industry, and exports tons to other regions of Haïti each year. The results of these massive clearing operations have been loss of fertile top soil and degradation of municipal watersheds and irrigation structures. Reclamation of the land-based resources in this dry environment is extremely slow. Once cleared, land is only slowly reclaimed by inferior shrub and forest cover, provided the soil remains in place.

The Haïtian-American Community Help Organization (HACHO) was founded in 1966. The organization's primary objective during its early years was to assist development of the rural communities by providing nutritional and medical services. Early success of the organization resulted in diversification of its programs. HACHO is now involved in agricultural development projects in addition to its medical and nutritional programs.

Soil conservation and reforestation began as minor programs under the general title of agricultural development. The integral part which they play in agriculture resulted in expansion of both programs. In 1975, technical assistance in the area of forestry and reforestation was sought from the Virginia Polytechnic Institute and State University (VPI & SU). It was jointly decided that a network of forest tree nurseries would be established in the Mare Rouge area of the Northwest Department. The nurseries would provide planting stock for reforestation and soil conservation projects in the area.

From the day the nursery program was initiated in August 1976, production of plantable nursery stock has been the primary objective. Production has steadily increased since the project's conception. Shortly after the nurseries were operating, soil conservation programs were initiated to utilize the planting stock produced by the nurseries.

Over a period of months, the central theme of the program changed from strict reforestation to a broader policy of revegetation, utilizing grass and shrub species as well as fruit tree species and coffee. In order to stop surface erosion, a relatively permanent vegetative cover is needed. This in turn will increase the amount of rainfall which infiltrates the soil surface and reduce the damage to soil structure caused by raindrop impact. The subsequent incorporation of plant residues into the surface soil horizons will not only improve water infiltration and percolation, but also enhance soil fertility.

From the beginning, a concerted effort to develop soil conservation and reforestation programs compatible with the existing system of agriculture was made. Revegetation of key areas, such as gullies and streambanks, was of highest priority. Trees are spaced a greater distance (3 - 4 m) to insure that sufficient land is left for the production of agricultural crops.

Selection of plant species used in the project depends largely upon the desires of the local farmers. Species with two or more uses are generally favored in the selection process. For example, fruit tree species provide a permanent ground cover and root system which impede the erosion process and at the same time provide a commercial product. Coffee plantations were encouraged for the same reason. Species such as *Sweitenia* spp., *Cedrela odorata*, and *Catalpa longissima* were planted for their value in erosion control and also the high value lumber they will ultimately produce (Johnson and Gregory, 1978).

The charcoal industry of the Northwest is a major concern. This industry is an important source of income for nearly all rural inhabitants. More than seventy-five percent of the species outplanted from the nurseries are specifically selected for their utility in charcoal production. It is not the goal of the project to eliminate the one sure means of income for the people of the Northwest; the goal is to produce sufficient amounts of wood so that the industry can continue and yet not remain a threat to the conservation of the land-based resources. In order to restore this balance between utilization and conservation, outplantings must exceed by a wide margin, the rate at which forested land is cleared.

The major shortcoming of the entire program is the lack of basic environmental information for evaluating management alternatives. Production of plantable nursery stock will continue to increase according to the original working plan of the project (Gregory and Johnson, 1976). The area reforested each year will continue to expand, crossing environmental gradients such as climate and soil types. Yet, when and where a particular species is to be planted is based on only a subjective assessment of the particular environment. Seedling production will continue to have a high priority within the program; however, survival and productivity of planted nursery stock are the ultimate measure of the project's success. Success of the plantings will depend on the ability to delineate the areas where each species will reach its most rapid and best development.

Delineating the range of native species would seem relatively easy; however, due to years of cutting and soil disturbance, it is more difficult than it appears. Establishment of large plantations of introduced species without sound knowledge of the basic environment is a high-risk endeavor. The best season for planting, the proper planting technique to be used, and cultural treatments needed after planting all depend on the specific environment of an area. Proper selection of sites for each species, native or introduced, will require extensive knowledge of the various site characteristics and species adaptability.

A sound understanding of the environmental factors which control the survival, growth, and productivity of each species is required for a successful reforestation program. The objective of the research reported in this study was to collect base-line data which would ultimately assist in ecological decisions relating to the overall reforestation program. Much data of this nature have already been gathered by various organizations and is brought together and supplemented in this paper. Based on this accumulated data, an attempt is made to classify sites according to their relative productivity for forest tree growth. This information will be of value when selecting introduced species, selecting planting sites for a variety of species, and deciding on cultural techniques needed after planting. The information will also be of value to future agriculture projects. Although the data are insufficient to resolve all questions concerning the ecology of the region, they will guide current decisions and suggest requirements for future research.

STUDY AREA

The study area was restricted to the region surrounding the Mare Rouge Plateau and the four existing nurseries. The shape is roughly triangular with the towns of Môle St. Nicolas, Bombardopolis, and Jean Rabel forming the three apices of the triangle. The Atlantic Ocean serves as the northern boundary of the area. Figure 2 shows the study area in relation to other points within Haïti. Figure 3 is an enlargement of the area showing the general relief of the area and location of sample points, species trial plots, and nurseries.

The total area within the boundaries is approximately 220 sq. km (85 sq. mi). The study area encompasses several major soil units according to the Organization of American States (OAS) and three major ecological life zones according to the Holdridge world life zone classification system (OAS, 1972) (Figures 6 and 8). As can be seen from the overlays of soil units and ecological life zones (Appendices F-1 and F-2), the study area covers several differing environments. The area is representative of much of the Northwest Department of Haïti. The findings may have some applicability to zones outside the study area in the Northwest.

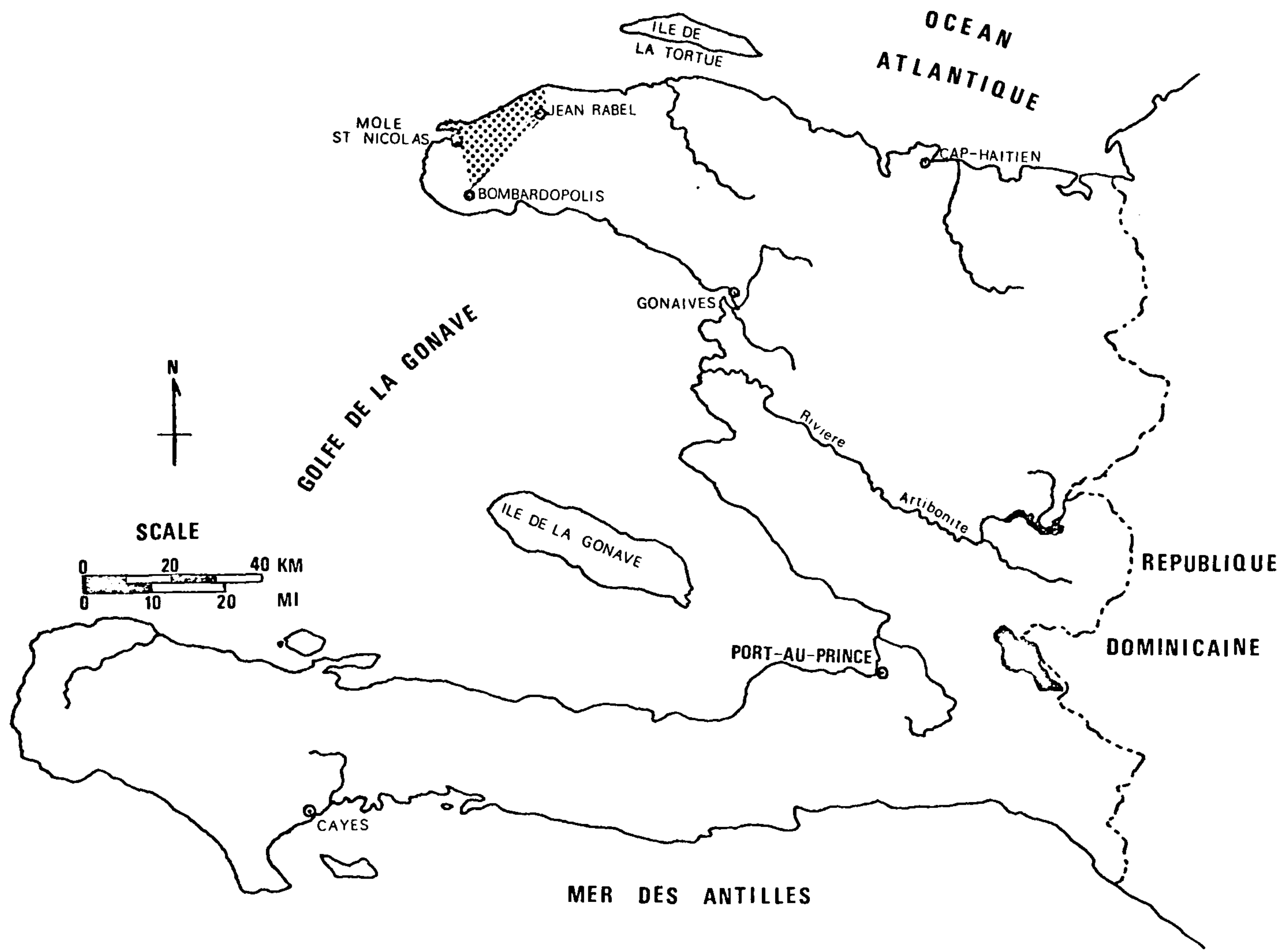

Figure 2: Map of the Republic of Haiti showing the study area (shaded)

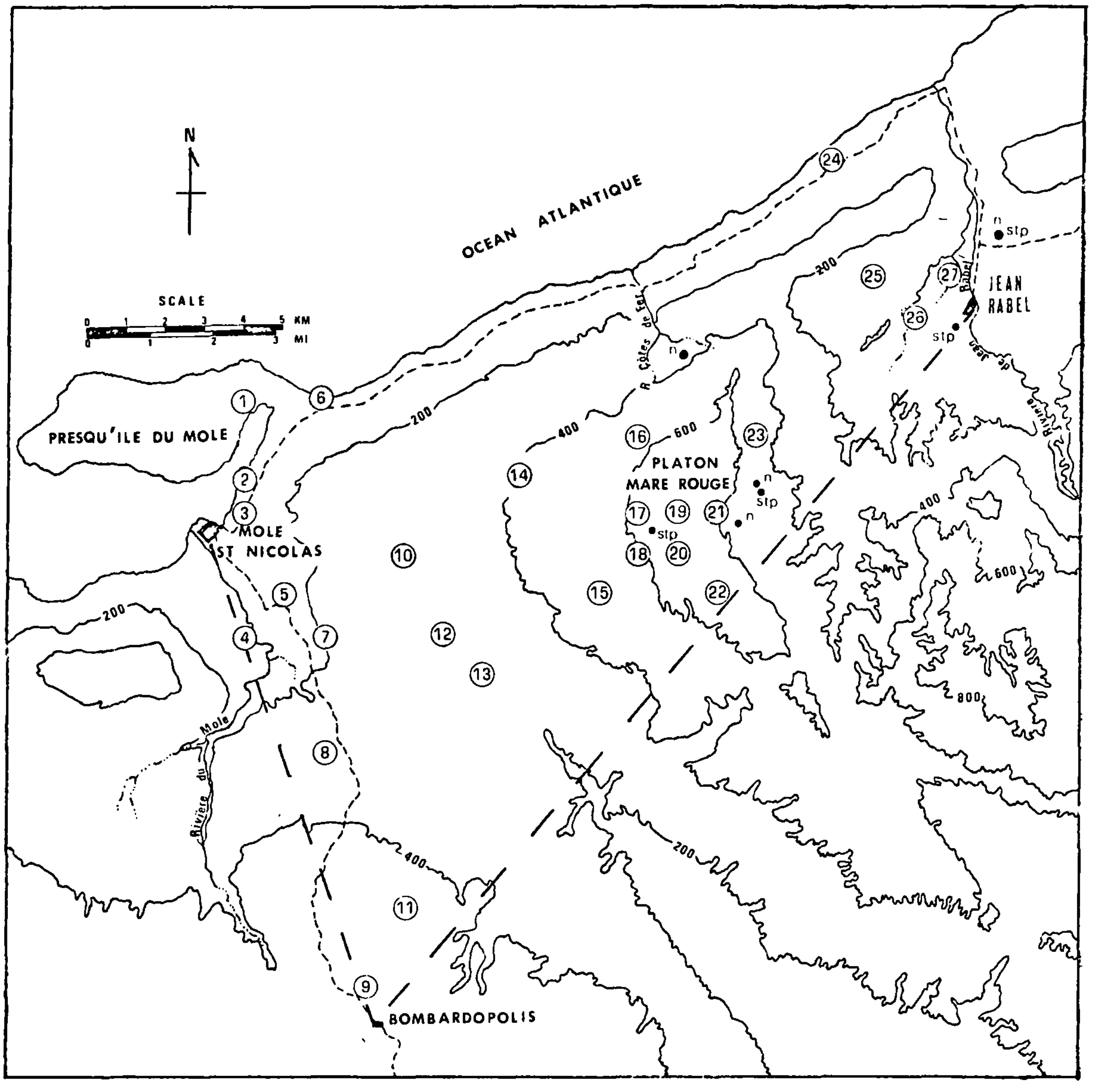

Figure 3: Base Map of Study Area Showing Sample Points, Nurseries (n) Species Trial Plots (stp), and Major Land Features (200 m intervals)

FIELD METHODS

Background

Several approaches were used to delineate relative productivity. The entire Republic of Haïti was classified according to the Holdridge ecological life zone model (OAS, 1972). This survey was used as the basis for classification of the study area. Surveys of the native vegetation and major soil units were used to supplement and refine this classification. Chemical analysis of soils and native vegetation were also completed. The data have made it possible to improve the existing life zone classification by more accurately locating the boundaries.

Soils and vegetation classifications completed by other organizations have been brought together to provide additional clarification of the environment. Species trial plots have been established in the area and will provide definite survival and growth data for native and exotic species in the various environments within the Northwest Department of Haïti.

In order to utilize existing site classifications, such as the Holdridge ecological life zone model and the OAS soil unit map of the Northwest, an extensive survey of the study area was needed to characterize the different environmental units and verify their locations. Ecological life zones were originally delineated on the basis of climatic data. However, the Holdridge model has two distinct advantages when compared to other classification schemes. Units can be distinguished on the basis of climatic data or the physiognomy of the native, undisturbed vegetation. Secondly, this classification has been used in several other tropical and subtropical environments, and relative productivity of the various life zones has been determined (Ewel and Whitmore, 1973; Holdridge et al., 1971).

Species lists for each of the life zones were compiled so that comparison to the same life zones in other subtropical regions could be made. These listings were also used to verify unit boundaries and assist in identifying specific associations within a particular life zone. Due to extensive clearing and subsequent erosion, the existing vegetation reflects much drier conditions than would be expected. Vegetation inventory of this area does not represent a natural, undisturbed ecosystem. However, remnant individuals served as indicator species for the various life zones.

The only extensive soil survey to cover the entire Northwest was conducted by the OAS in 1972. The soil units delineated in this survey do not correspond to soil type or series of the Seventh Approximation to a Comprehensive Soil Classification (Soil Conservation Service, 1975), and therefore it is difficult to determine specific physical or chemical properties of the soils based upon the "soil unit" name assigned to the area.

Additional soils information was desired, particularly about those factors controlling site productivity for forest tree species. Measures of soil depth, structure and permeability, fertility, and pH were made on soils throughout the study area to supplement existing surveys. Extensive observations of soil properties aided in distinguishing specific edaphic associations, which may warrant special attention for reforestation or agricultural programs in the area. These observations also assisted in verification and clarification of the existing OAS soil survey.

Design and Selection of Sample Points

Circular plots, 1/20 hectare in size (1/12 acre) were randomly located throughout the entire study area. Twenty-seven plots were completed. An attempt was made to identify all woody tree and shrub species within the plots. Present land use and site factors such as aspect, elevation, percent slope, and slope position were recorded for each site. Plots were not restricted to undisturbed communities; therefore, no attempt was made to quantify vegetation structure. In plots which were completely cleared of vegetation, due to agriculture or charcoal production, a subjective description of the vegetation surrounding the plot was made.

Soil pits were dug at each sample plot to relate depth, structure, and texture of the various soil horizons. Surface soil samples were taken from all sample plots and several subsoil horizons. These samples were returned to VPI & SU for chemical analysis.

Analysis of Data

The information gathered serves as a supplement to existing soils and vegetation surveys of the Northwest Department. Most of the data represent the type of base-line information needed to make sound forest management decisions. All measurements and observations taken indirectly represent the productivity of the site for forest crops and to a lesser extent for agricultural crops. These data can easily be extrapolated to areas of similar soils and ecological life zones within the study area.

The information is presented in tabular format so that it can be easily assessed. It should be stressed that the data are solely intended to be descriptive of the soils and ecological life zones of the study area.

PHYSICAL FEATURES OF NORTHWEST HAITI

Climate

Rainfall

The Northwest region of Haïti is exposed to two major atmospheric events each year (J. G. White Engineering Corporation, 1975). From November through March, cold fronts (Nordés) move southeast from North America across the northwest coast, bringing cool temperatures and occasional heavy precipitation. During June, July, and August, the intertropical convergence zone moves to a position just south of Haïti. Eastward-moving fronts cross over the entire island and cause atmospheric disturbances which coupled with thermal convection, create heavy afternoon thunderstorms (J. G. White Engineering Corporation, 1975). The fall and spring are times of transition in atmospheric condition. The associated instabilities cause rainfall to be highest during these periods. The northeasterly tradewinds blow across the island practically year-round and may bring additional moisture to the region.

The distribution and regime of rainfall is greatly modified by orographic characteristics of the Northwest. The major rain-bearing winds strike the high ridges of the Massif du Nord, east of Port-de-Paix, and leave nearly the entire Northwest Peninsula in a rain shadow (Woodring et al., 1924). The high mountains south of Jean Rabel intercept the remainder of the moisture-laden winds and leave the coastal areas relatively dry. Figure 4 shows the distribution of annual rainfall for the northwest peninsula. However, as Donner points out (1976:p. 22), "extreme fluctuation from month to month and also from

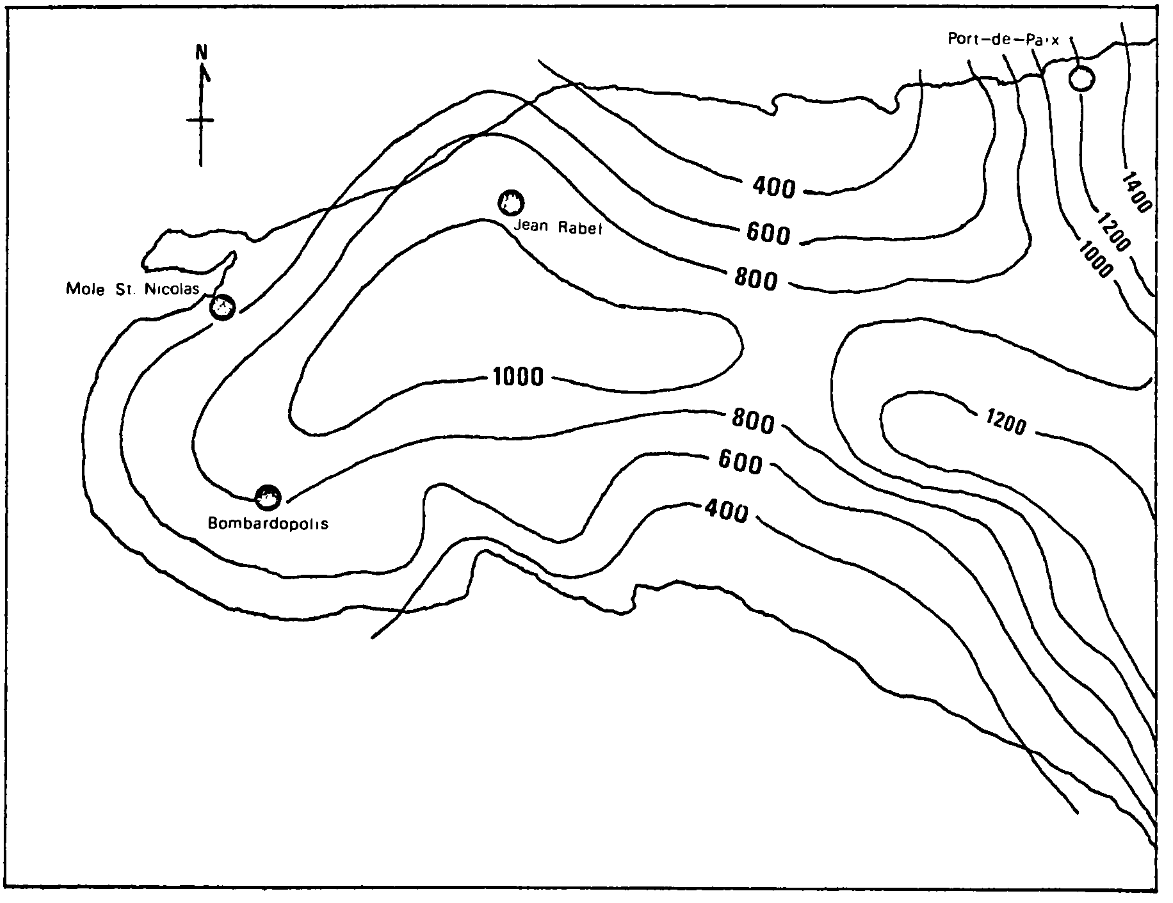

FIGURE 4: ANNUAL RAINFALL (mm), SHOWING MAJOR WEATHER STATIONS (DONNER, 1976)

year to year render the annual average data a rather fictitious figure." Our own observations show enormous fluctuations in the amount and regime of rainfall which in part explains the periodic droughts and extended dry seasons common to the region. Table 1 shows the large annual variation in rainfall for several locations in the Northwest.

The fashion in which the majority of rainfall is delivered to the surface, combined with the great variability in regime and quantity, creates severe problems for reforestation efforts as well as agriculture. The rains are generally localized, of short duration, and extremely intense. Due to the severe disturbance of vegetative cover and the altered surface soils of the region, very little rain infiltrates the soil surface. The direct impact of the falling rains has puddled and sealed the soil surface and created impermeable conditions in many areas. Surface flow, sweeping away surface soil at an incredible rate, is the rule rather than the exception. The soil dries rapidly after heavy rains. Soil pits have revealed that even after heavy rains, moisture did not penetrate the lower soil horizons on several soils within the study area.

Temperature

Rainfall alone does not determine the amount of moisture available for plant growth. Temperature and dominant wind patterns, which in turn affect humidity and evaporation, have an important influence. Information about these last two variables is either nonexistent or not continuous enough to make definite statements about their influence upon the environment of the Northwest. Temperature data, however,

Table 1. Variation in annual rainfall in Northwest Haïti (FAO/SF:45/HAI-3, 1966).

Rainfall Station	Period	Annual Maxima (mm)	Annual Minima (mm)
Gonaïves	1907 - 1966	1316.0	360.4
Port-de-Paix	1907 - 1966	2345.1	614.5
Jean Rabel	1921 - 1966	1506.7	382.9
Môle St. Nicolas	1916 - 1951	1226.7	295.5
Ile de la Tortue	1940 - 1966	2438.5	667.0
Terre Neuve	1923 - 1966	2609.2	901.4
Gros Morne	1921 - 1966	2290.3	399.0

have been collected discontinuously throughout the Northwest and may be of some benefit to analysis of the environment. Table 2 shows the mean monthly maxima, minima, and monthly mean temperatures of two stations within the study area and two other stations to the east of the study area. As might be expected for an island within these tropical latitudes, the temperature is relatively constant throughout the year, with fluctuations in monthly means rarely exceeding 5°C. Diurnal fluctuations exceed monthly mean fluctuations by a wide margin.

Evaporation and Water Budget

Evaporation and transpiration are controlled by several factors, including insulation, temperature, relative humidity, and wind. As already stated, information of this nature is sparse. However, in 1965 and 1966, the Food and Agriculture Organization of the United Nations (FAO) established pan evaporation stations to determine potential evapotranspiration in the area. These results are presented in Table 3.

Real evapotranspiration (actual evapotranspiration) represents the amount of water evaporated under existing conditions. In the FAO study, the vegetation cover above which this real evapotranspiration occurred received only rainwater (Donner, 1976). The occurrence of both water surplus and deficit at the Port-de-Paix station represents the few situations in which more water is added to the soil than soil and plant roots are able to utilize.

The water budget of the Northwest was determined by using the Thornthwaite system (Donner, 1976). Mean monthly rainfall data were

Table 2. Mean monthly and annual temperatures taken from four stations within the Northwest Department of Haïti (OAS, 1972). (Station) - (Elevation [m]) - (Period of observation)

	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Jean Rabel - 80 m - Oct. 1927 to Sept. 1931; Jan., Feb., Mar. 1932; Jan. 1933													
Mean of monthly max.	28.7	29.2	30.5	30.2	31.8	32.8	33.4	32.9	32.2	31.6	29.4	28.8	30.9
Monthly mean	22.2	22.8	23.6	24.4	25.6	26.5	26.9	26.8	26.4	26.0	24.0	22.8	24.8
Mean of monthly min.	15.8	16.4	16.8	18.6	19.5	20.3	20.5	20.8	20.6	20.4	18.7	16.9	18.7
	Absolute max. - 36.0				Absolute min. - 11.0								
Môle St. Nicolas - 10 m - Oct. 1928 to June 1931													
Mean of monthly max.	27.3	26.5	27.6	27.7	29.0	29.6	29.4	29.1	27.5	29.5	28.0	27.6	28.2
Monthly mean	24.3	24.2	25.1	26.3	27.6	28.2	26.4	26.5	23.7	28.3	26.5	25.2	26.0
Mean of monthly min.	21.3	22.0	22.6	25.0	26.2	26.9	23.5	23.9	20.0	27.2	25.1	22.8	23.7
	Absolute max. - 32.5				Absolute min. - 18.0								
Gonaïves - 5 m - June 1937 to Sept. 1945													
Mean of monthly max.	30.0	30.5	31.8	33.5	32.9	34.5	34.1	35.4	35.8	36.2	34.2	32.1	33.4
Monthly mean	25.7	25.8	26.3	28.0	28.0	29.0	24.2	30.1	29.8	30.0	29.1	27.2	28.2
Mean of monthly min.	21.3	21.0	20.8	22.4	23.0	23.6	24.3	24.8	23.8	23.9	24.1	22.3	22.9
	Absolute max. - 41.0				Absolute min. - 14.4								
Port-de-Paix - 10 m - Apr. 1927 to Dec. 1931; June 1914 to Mar. 1957 (several months missing)													
Mean of monthly max.	29.0	29.2	29.8	30.6	31.7	32.1	32.3	32.4	32.6	32.8	30.5	29.3	31.0
Monthly mean	24.1	24.3	25.0	25.8	26.8	27.3	27.4	27.7	27.7	27.4	25.9	24.7	26.1
Mean of monthly min.	19.2	19.5	20.2	21.1	22.0	22.6	22.5	23.1	22.8	22.1	21.3	20.2	21.3
	Absolute max. - 37.8				Absolute min. - 11.0								

Table 3. Potential and real annual evapotranspiration at four selected stations within Northwest Haïti (FAO/SF:45/HAI-3, 1966).

Station	Potential Evapotranspiration (mm)	Real Evapotranspiration (mm)	Water Deficit (mm)	Water Surplus (mm)
Jean Rabel	1445.0	951.8	493.2	0.0
Môle St. Nicolas	1540.2	560.2	980.0	0.0
Gonaïves	1835.1	564.5	1270.7	0.0
Port-de-Paix	1539.5	1157.3	382.2	77.0

used to construct the model. It was assumed that all rain which fell was taken up by plants (rainfall efficiency of 100%) and that a constant ground water reserve of 100 mm was maintained. These two assumptions, which are necessary to implement the model over a broad geographical area, are far from the actual situation found in the Northwest. The measurements of mean monthly rainfall are also questionable. Nevertheless, the water budget map (Figure 5) constructed from these data gives a relative idea of the moisture available for plant growth. Figure 5 shows clearly that high deficiencies are common to the coastal zone of the study area and only at the extremely high elevations north of Jean Rabel do slight water surpluses exist.

Climatic data are critically needed for the northwest region of Haïti; permanent stations to record precipitation and temperature are imperative. Additional information concerning relative humidity, wind speed and direction, incident radiation, and evaporation is needed for completion of sound agro-meteorological analysis.

Geology and Geomorphology

The geology of the Northwest has a definite influence on the agricultural and forestry potential of the area. With few exceptions, the soils of this region of Haïti are very shallow, due either to the inherently slow rate of parent material decomposition or to massive erosion which has re-exposed the underlying parent material. In all sections of the study area, loose surface rock and bedrock extrusions are common features. The soil in many areas is composed solely of rock fragments greater than 2 mm in diameter. The chemical properties

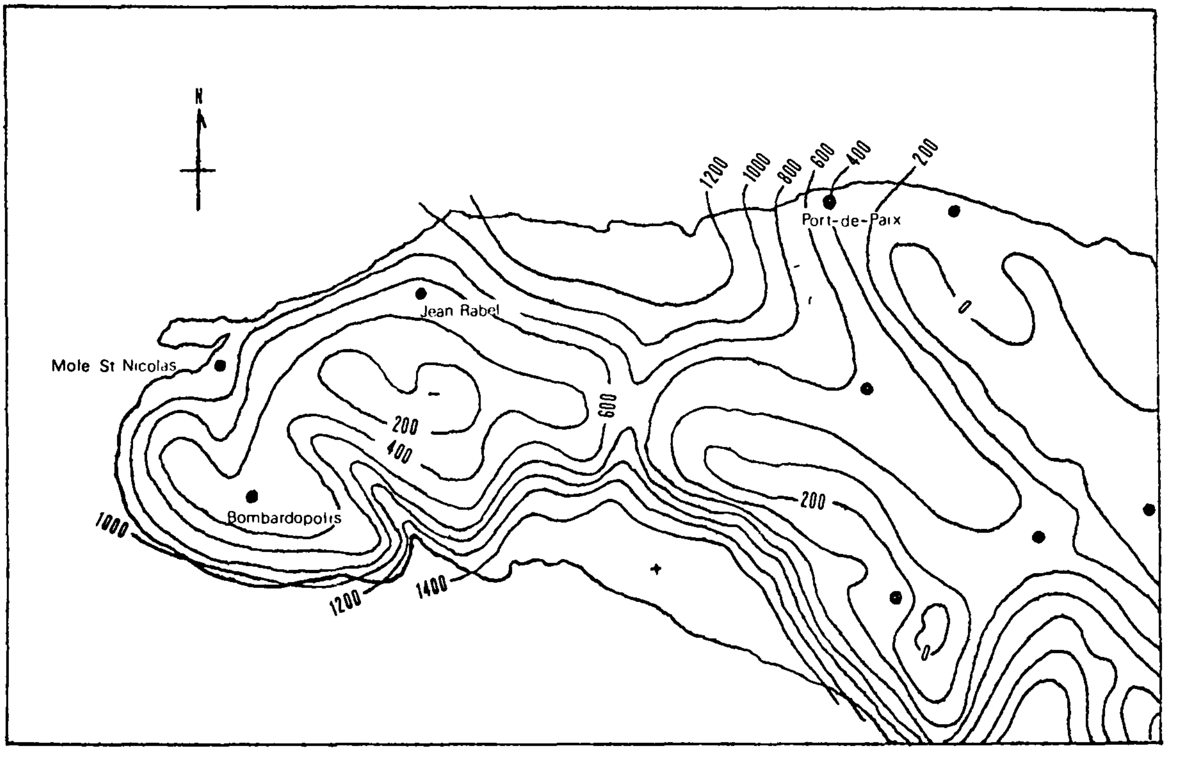

FIGURE 5: ANNUAL WATER BALANCE - WATER DEFICIT (DONNER, 1976)

of the existing soils are not distinctly different from those of the parent material. A short description of the geology and geomorphology of the region will help to clarify the physical and chemical properties of the soils which now exist in the study area.

The major geologic feature of the Northwest is the Quaternary coralliferous limestones and limestone conglomerates (Woodring et al., 1924). These materials dominate the study area north to south from Môle St. Nicolas to Bombardopolis and across the Bombardopolis Plateau to the eastern edge of the Mare Rouge Plateau. Crystalline limestones of Tertiary origin occupy the high mountains south of Jean Rabel with small areas of Mesozoic adesite exposed in the deep ravine of the Jean Rabel River. Surrounding Jean Rabel and extending east are soft Tertiary limestones. To the north of Jean Rabel, along the Jean Rabel River, are deposits of recent alluvium.

The most striking feature of the coralliferous limestones, which cover most of the study area, is the series of emerged coastal terraces. These well-preserved terraces extend from 600 m ($\sim$ 1969 ft) elevation down to the coastline in a series of steps. The lower terraces are veneered with similar but progressively younger coralliferous limestone (Woodring et al., 1924). Those terraces nearest the coast are extremely hard and resistant to erosion with a soil depth rarely exceeding 30 cm ($\sim$ 12 in).

The average relief of the coralliferous limestones generally does not exceed 20 or 30 m ($\sim$ 66 or 98 ft) (Woodring et al., 1924). The few valleys which do exist are narrow and steep-sided. According to

Woodring et al. (1924), the lack of surface streams in this formation seems to be the result of underground drainage in the limestone. The obvious karst topography. of the area supports this theory.

The range of mountains to the south of Jean Rabel is crowned with a thick cap of crystalline limestone over igneous rock (Woodring et al., 1924). The range is deeply dissected by the Jean Rabel River and its tributaries, exposing the igneous rock in the valley floors. The crystalline limestone caps of the high elevations have weathered to greater depths than the coralliferous limestone to the west but still contain large amounts of course sands, gravel, and stone.

Below an elevation of approximately 200 m (∿ 656 ft), the crystalline limestone gives way to the soft limestone marls which surround the town of Jean Rabel. The marls of this area are sandy or silty in some areas but generally have a clay texture. They are typically bluish in color, with gray or yellow tints. The soils formed from this material are extremely erosive. Once exposed, the parent material weathers quickly to small blocky fragments which are easily moved by gravity and flowing water.

Soils

Classification of Soils

Soils within the study area are extremely variable, even though most are derived from the same basic limestone parent material. Variation in the physical properties, particularly in depth, can occur within just a few meters. Laboratory analysis of several soils taken throughout the study area show more uniform chemical properties. Additional variation has developed as a result of erosion altering the existing soils, truncating some and depositing great quantities of alluvial and colluvial materials upon others.

A basic classification of the soils was needed as a starting point from which additional refinements could be made. The final classification is not intended to relate to the genesis of the soils but to the physical and chemical properties and local variation which now exist and which reflect site productivity and potential. The soil survey conducted by the OAS (1972) relates many of these factors directly, but due to the large area over which the survey was conducted, many dintinct soil types were grouped. The OAS survey was based on common physiographic characteristics which tended to make each delineated area an agriculture unit. Because the "Seventh Approximation to a Comprehensive Soil Classification" system (Soil Conservation Service, 1975) requires extensive and exact chemical and physical analysis of the soils, time did not permit its use in the OAS study. The OAS survey uses the terminology of the Seventh Approximation whenever possible, and with additional data, it could be linked to the new system. The soil units devised by the OAS survey have definite meaning from both an agricultural and pedological standpoint, but in order to avoid problems of semantics, the term "soil unit" (as opposed to association, type, or series) was adopted.

The OAS survey, as it was conducted, has three major advantages over other soil classifications which have been conducted in Haïti. First, the survey encompasses the entire republic, and its soil units are equivalent to the OAS soil survey of the neighboring Dominican Republic. Thus, comparison between units and extrapolation of data can be made over the entire island of Hispaniola. Second, the survey utilizes the land use classification of the USDA Soil Conservation Service (OAS, 1972). This system has been extensively researched in the U.S., and nearly all agronomists of the Americas are familiar with it. Last, the OAS survey provides a relatively good estimate of the factors which are most limiting to the productivity of the individual soil units. This additional description makes the OAS survey a very practical management-oriented tool which can be easily utilized by foresters and agronomists.

The major drawback of the OAS survey was the large scale at which the study was conducted. Units were delineated from 1956 aerial photographs (scale 1:50,000) and reduced onto topographic sheets of scale 1:250,000. The units were then verified by ground reconnaissance of the country. The units were classified from the 1956 aerial photographs according to their most significant characteristics, but at this scale, several soil types and associations were commonly grouped into a single unit.

The specific units included in the study area are Lascahobas, Auillot, Greenville, Matanza, Jean Rabel, Intermountain valley, Mountain terrain (calcaire), and Recent alluvium. Their distribution within the study area is shown in Figure 6 and overlay Appendix F-1. The last three units have been assigned unit names which are more or less descriptive in themselves. The Lascahobas and Auillot units are

Key to OAS Soil Unit Map

Predominant
Soil Units

47 - 50
4 dr

Land Capability Class

Predominant Limiting Factors

a - aridity
d - depth
r - rocks
t - topography
f - fertility
s - salinity
e - erosion

Soil Units:

2 - Recent alluvium
47 - Greenville
50 - Matanzas
105 - Mountain terrain (calcaire)
110 - Intermountain valley
227 - Jean Rabel
252 - Lascahobas
256 - Abuillot

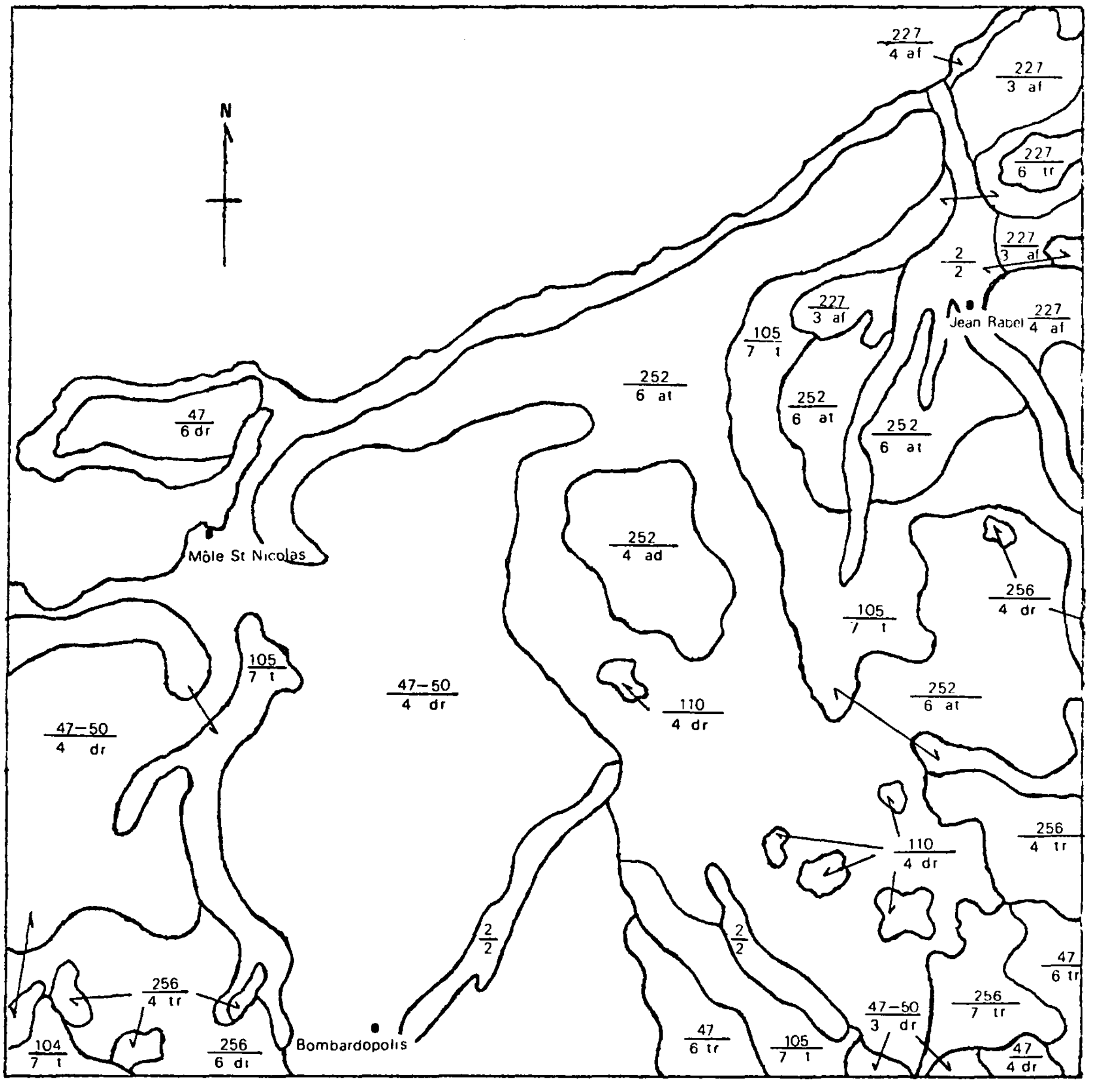

Figure 6: Soil Units of Study Area (OAS, 1972) (see key p. 28)

similar, both being derived from calcaire (a soft, white calcareous parent material containing a large percentage of calcium carbonate) and from alluvial and colluvial calcareous material. The Lascahobas can be distinguished by its older and more distinct profile development (OAS, 1972). The Matanzas and Greenville units are also derived from calcareous parent materials but are in general more productive soils than the Lascahobas and Auillot. The following profile description obtained near Bombardopolis characterizes these soils (OAS, 1972).

depth	
0-30 cm:	reddish brown (5YR 4/4) clay; durable granular structure; very firm.
30-80 cm:	yellowish red (5YR 5/6) clay; subangular blocky structure; stable.
80 cm:	transition into hard calcaire.

The Matanzas and Greenville soils are the most extensive in the study area. They extend from the western border of the study area to the Mare Rouge Plateau. Productivity of these soils is limited by their depth and the arid conditions which prevail in the area.

The Jean Rabel soil unit is also derived from calcareous parent material but has developed to much greater depths than the other soil units within the study area. Profile observations east of the town of Jean Rabel reveal the following characteristics (OAS, 1972).

depth	
0-30 cm:	dark brown (10YR 3/3) clay; granular structure; friable.
30-65 cm:	clay; more clear than underlying horizons; blocky structure; friable; brittle.

depth

65-115 cm: light olive brown (2.5Y 5/4) clay; slightly packed, subangular blocky structure; brittle.
115 cm: strongly altered parent material.

This soil unit, as well as portions of the Recent alluvium and Lascahobas units which surround the town of Jean Rabel, has been subdivided according to the Seventh Approximation (Odell, 1975). This more intensive survey was conducted as part of an irrigation system study on the Jean Rabel River. The type map, as well as physical and chemical description of four soils, is presented in Appendix A. This intensive survey represents the most detailed and descriptive classification of soils in the Northwest but was unfortunately restricted to the Jean Rabel area. Chemical analysis of the soils in this survey revealed the same basic properties as were determined at VPI & SU. These data are provided to supplement the OAS soil classifications and will undoubtedly be of value to future agricultural and forestry programs in the area surrounding Jean Rabel.

Land Capability Classification

The intent of the soil studies made in the area was to delineate areas of uniform characteristics. The edaphic characteristics of greatest interest were those which are most important to the survival and growth of agriculture and forest crops: depth, structure and permeability, fertility, and acidity and alkalinity (FAO, 1974; Goor and Barney, 1976). Soil classification alone can indirectly relate these factors; however, other conditions may exist which limit productivity. Land classification is a much broader term which not only includes the soil characteristics, but other physical attributes such as topography, water movement, existing vegetation, erosion, and present land use. The OAS study has assigned a capability rating, based on a scale of 1-8 (OAS, 1972), to each soil unit, as well as listing the factors most limiting site productivity. The most valuable aspect of the OAS survey is the land capability classification. The scale at which the survey was conducted, again, limits the accuracy and utility of this classification. However, field observations have revealed that the boundaries of the OAS studies are reasonably accurate and are a good basis for additional refinements.

The criteria for classification of each soil unit under the USDA Soil Conservation Service's system was adapted to the conditions of Haïti with close adherence to the criteria used in the Dominican Republic. The classification criteria used are not completely synonymous with those used in the U.S. but have been adapted to tropical forestry and agriculture. Each of the classes assigned represents the predominant classification for the soil unit. Consequently, a single unit may contain several other smaller but distinct capability classes. The classes, as adapted for use in this study, are defined as follows.

Description of Land Capability Classes

(Adapted for use in the Republic of Haïti; Donner, 1976:pp. 50-51)

Class 2 — Cultivable soils, suitable for irrigation; flat to slightly undulated topography with limiting factors of little importance, can easily be overcome through management; high productivity under good management and slight conservation practices.

Class 3 Cultivable soils, suitable for irrigation only with highly profitable crops; topography flat to fairly undulating with noticeably limiting factors; average productivity with intensive management and limitations in the possible crops. Require intensive conservation measures.

Class 4 Soils for limited cultivation, unsuited for irrigation except under special conditions for profitable crops, suitable for pastures and permanent crops; topography flat and undulating, severe limitations demanding very intensive management; productivity poor; adequate conservation work required.

Class 5 Soils not suitable for field crops, good only for rice, but without restrictions good for pasture; severe restrictions, particularly in drainage, high productivity for pasture and rice fields under very intensive management, referring particularly to drainge; soils of low fertility are included and require intensive fertilizer application.

Class 6 Soils not suitable for agriculture, good for hill crops; particularly good for forests and pastures; severe limitations, particularly concerning topography, depth of soil, stones; no restrictions for forest, but limitations for pastures.

Class 7 Soils not suitable for agriculture, suitable only for forestry; severe restrictions for crops; where soil depth and slopes permit, tree cultures may be grown (coffee, fruit), and in certain cases pasture.

Class 8 Soils not suitable for agriculture; no restriction for national parks and conservation zones for fauna and for recreation; the rational use of this soil is imperative for the conservation of the more productive soils described earlier.

Field Observations

Aridity is the major factor limiting productivity of soils of the study area and the remainder of the Northwest. Shallow soils, a large proportion of rock and gravel in the surface horizon, and low organic-matter content of the soils intensify the moisture shortage. The coastal area from Môle St. Nicolas to the mouth of the Jean Rabel River (Jean Rabel Bord Mer) should receive a higher (less productive) rating than is presently assigned by the OAS survey. Soils in this area are very shallow, and evaporation, extremely high. Establishing forest crops would be extremely difficult and expensive. The few areas on this coralliferous bench where agriculture is possible are those located between the Côtes de Fer River and Jean Rabel Bord Mer. Irrigation of this area is possible on an irregular schedule.

The inland area of Greenville-Matanzas soil unit, between Môle St. Nicolas and Bombardopolis, particularly the western portion, is also a high-risk area. Soils are shallow and rocky. Agriculture crops are restricted to the deeper soil pockets, and production is good in years of high rainfall. Closer to Bombardopolis, soil depth, as well as annual rainfall, increases. Outplantings in this area (near sample point #9, Figure 3) have done very well without a great deal of care.

As one moves east, soil depth increases (on the western edge of the Mare Rouge Plateau). The entire plateau and the area north to the headwaters of the Côtes de Fer River are suitable for intensive reforestation and integrated forest agriculture. This section has the highest rainfall in the study area and is very productive in terms of fruit tree crops and coffee.

From the eastern edge of the Mare Rouge Plateau to the Jean Rabel River, soil depth increases, partially because of the transition into a more easily weathered parent material. The limiting factors of aridity and steep terrain present problems; however, plantings have been relatively easy to establish in this area, and growth over the past year has been very good. With respect to the "need for reforestation," this area is designated as first priority. The soils, although of greater depth, are more erosive due to more intense agriculture and steeper topography than any other soils in the study area. This region is part of the Jean Rabel watershed. Deforestation in this area has had a more drastic impact than that in other regions within the study area. Soil conservation and land restoration are critical to improving this water source and protecting the highly productive agricultural land surrounding Jean Rabel and lying north along the river.

The texture, structure, and permeability of the soils of this region are suitable for nearly all agriculture and forest crops. Particle size analysis of eleven soils taken at Mare Rouge, Jean Rabel, and points in between, show that the soils can be generally classed as clays, although silty clays and clay loams also occur (McCart, 1976). Odell (1975) reported clay and clay loam soils in the Jean Rabel area.

The soils observed at all sample points, with the exception of points number 1, 6, and 24 (Figure 3), had fine to coarse granular structure and remained friable even after intensive use. Subsoils generally had subangular blocky structure and were friable, creating good conditions for rapid infiltration and percolation of rainfall.

Soil Analysis

Soil fertility, one of the major edaphic factors controlling site productivity, was indirectly determined by chemical analysis. Soil samples were collected from each sample plot and returned to VPI & SU for analysis. The results of the analyses are presented in Tables 4, 5, and 6. The results are consistent with the findings of Odell (1975) and McCart (1976) for soils of the same general area.

Procedures used for analysis were those recommended for calcareous soils. The pH of a 1:1 slurry (soil:water) was determined with a direct reading calomel electrode. Exchangeable bases (calcium, magnesium, and potassium) were extracted with a 1N ammonium acetate solution and concentrations determined with a Perkin-Elmer, Model 460 atomic absorption spectrophotometer (Chapman, 1965). The sodium bicarbonate extraction outlined by Olsen and Dean (1965) was used to determine phosphorus (P) concentrations of the samples. Percent organic matter (organic carbon) was determined by chromic acid oxidation (Allison, 1965), and percent total nitrogen (N) by micro-Kjeldahl techniques (Bremner, 1965). The results of these last two procedures were positively correlated. Soluble salts were determined to insure that salinity would not be a limiting factor to tree or agricultural crop growth (Bower and Wilcox, 1965).

The most striking feature of the soils revealed by chemical analysis is the extremely high pH values. The high basic reaction is the result of the calcareous parent materials and the slow rate at which organic matter is incorporated into these soils. After analysis, it

Table 4. Results of laboratory analyses of soil samples taken from Subtropical Dry Life Zone within the study area of Northwest Haïti.

Sample Point No.	Soil Depth Sampled	pH	% OM	% N	P	K	Ca	Mg	Electrical Conductivity mm hos/cm
					-----------	ppm	-----------		
1	0-12 cm	8.1	3.5	0.31	101	128	2426	111	2.00
2	0-12	7.2	15.0+	1.28	36	340	9261	254	0.45
3	0-8	7.5	15.0+	1.82	59	340	11025	195	0.53
4	0-12	7.7	3.2	0.21	59	383	7497	275	0.49
5	0-12	7.3	15.0	1.11	22	383	7056	198	0.26
6	0-12	7.8	3.6	0.09	92	85	6615	81	0.51
7	0-12	7.7	15.0+	1.40	95	468	9482	175	0.37
8	0-12	7.5	15.0+	1.45	55	1063	9261	352	0.31
10	0-12	6.9	13.3	0.93	98	383	6174	231	0.35
12	0-12	8.0	5.3	0.38	137	340	5513	93	0.26
	30-46	7.9	----	----	53	128	5954	59	0.26
13	0-12	7.4	15.0+	2.18	98	255	10584	273	0.75
24	0-10	7.8	7.4	0.33	105	340	4410	66	0.35
25	0-12	8.0	1.5	0.12	36	255	6395	246	0.31
26	0-12	8.1	1.4	0.08	42	85	6836	50	0.19
	150-	8.1	----	0.05	5	40	6836	69	0.23
27	0-12	8.3	2.1	0.12	145	340	5513	149	0.26
	122-	8.1	0.2	0.04	14	170	6395	348	0.65
Nan Vincent STP	0-12	7.9	7.2	0.48	113	425	3308	159	0.85

Table 5. Results of laboratory analyses of soil samples taken from Subtropical Moist Forest Life Zone within the study area of Northwest Haïti.

Sample Point No.	Sampled	pH	% OM	% N	P	K	Ca	Mg	Electrical Conductivity mm hos/cm
					ppm				
9	0-12 cm	7.5	10.9	----	38	340	10364	279	0.46
11	0-12	7.1	13.3	----	132	808	8820	250	0.35
14	0-12	7.5	15.0	1.14	20	1190	3749	153	0.49
15	0-12	6.5	13.3	0.68	62	85	5292	185	0.25

Table 6. Results of laboratory analyses of soil samples taken from Subtropical Wet Forest Life Zone within the study area of Northwest Haïti.

Sample Point No.	Soil Depth Sampled	pH	% OM	% N	P	K	Ca	Mg	Electrical Conductivity mm hos/cm
					ppm				
16	0-12 cm	7.2	15.0+	0.92	116	340	8600	295	0.32
17	0-12	6.9	13.3	0.62	95	85	6174	106	0.82
	30-46	6.9	3.0	0.22	42	40	2205	12	0.44
18	0-12	6.9	15.0+	1.08	55	170	6174	203	1.28
	15-30	7.0	----	0.50	22	43	5733	88	0.78
19	0-12	6.4	7.4	0.43	132	128	6615	275	0.55
	51-71	7.0	----	0.17	57	45	2867	154	0.43
22	0-12	7.5	13.3	0.65	20	85	7277	89	0.87
	30-42	8.2	----	----	35	40	4631	10	0.22
23	0-12	7.2	3.6	0.44	101	213	8600	154	0.53
	46-61	7.4	3.1	0.10	112	170	12128	125	0.46
	61-76	7.4	----	0.08	111	128	7938	109	0.32
Mare Rouge STP	0-12	6.5	7.2	0.48	113	425	3308	159	0.85

is apparent that the soils also contain large quantities of active lime.

In nearly all samples, sufficient quantities of potassium (K), calcium (Ca), and magnesium (Mg) were present for normal growth of forest and agricultural crops. However, the large proportion of available Ca may interfere somewhat with uptake of the other nutrient ions. Corn, bean, and sorghum experimental plots in the same region (McCart, 1976) have shown definite responses to P and K fertilization, indicating that deficiencies for these crops may exist. The large amount of calcium carbonate in the soils will undoubtedly reduce the amount of P available for plant uptake by formation of relatively insoluble calcium phosphates.

Available soil N is a major growth limiting factor in the Northwest. Experimental plots of agricultural crops have shown definite response to N-fertilization in the study area. The results of N analyses for several samples (i.e., samples 2, 3, 5, . . .; Table 4) are deceiving. These samples were taken from the dry coastal and dry upland forested sites. Soil depth in these areas rarely exceeds 30 cm ($\sim$ 12 in) and is generally restricted to large fractures in the coralliferous limestone. The soil is composed of over 50 percent organic matter. Once cleared for charcoal production or agriculture, the organic matter content and total N content rapidly decrease.

The results of soluble salt analysis indicate that adverse salinity effects should be negligible.

Soil chemical analyses indicates that sufficient quantities of mineral nutrients measured are present for tree growth. The high levels of available Ca and active lime, and the resultant high pH values, have definite implications for tree planting in the region. Certain species cannot tolerate these conditions (Goor and Barney, 1976). Several species of the genera *Eucalyptus* and *Pinus* become chlorotic when planted on such soils. Growth is significantly reduced, and tree mortality may be high. Trial plantings have demonstrated that certain other species (i.e., *Acacia melanoxylon*, *A. dealbata*, *A. accuminata*) become chlorotic when planted on these soils. It is probable that this reaction was a response to the large amount of active lime in the soil.

Planted citrus trees, particularly introduced varieties, should be closely monitored because of their general low tolerance of high soil pH. Footrot gummosis, a common disease of citrus fruit trees, can do extensive damage to root stock which is not well adapted to high levels of active lime in the soil (Mortensen and Bullard, 1970).

High pH values and high lime content of the soils create favorable conditions for growth of damping-off fungi. These fungi became a severe problem in the tree nurseries which were established in the area. Heat sterilization and acidification of the nursery soil with ammonium sulfate was necessary to reduce damage.

Seed sources should be carefully scrutinized to insure that the species can tolerate the high pH, calcareous soils of the Northwest. The success of outplantings, particularly of introduced species, will depend in part on their ability to withstand these conditions.

Foliar Analysis of Native Vegetation

Foliar analysis of the native vegetation was conducted to determine whether mineral nutrient content varied between sites and to determine whether these data correlated with the results of the soil chemical analysis. Foliage was collected from sample trees in all of the major ecological life zones in the study area. The two species selected were Acacia lutea Mill. and Prosopis juliflora (Sw.) P.DC. These species were selected because of their wide amplitude in the Northwest.

All foliage of the branch approximately 30 cm ($\sim$ 12 in) from the tip was removed. Samples of the same species in an area were taken from several individuals and mixed. However, in some areas, only single individuals could be found and therefore constitute the entire sample. After collection, samples were air dried and transported to VPI & SU, where they were oven dried for twenty-four hours at 75°C. The samples were ground to pass a 40 mm mesh. Total nitrogen was determined by micro-Kjeldahl technique (Bremner, 1965). For determination of P, K, Ca, and Mg, 5 g samples were ashed and extracted with 0.3N nitric acid (Jones and Steyn, 1973). Total phosphorus was determined colorometrically using the procedure of Murphy and Riley (1962). Total K, Ca, and Mg were determined by atomic absorption spectrophotometry. The results are presented in Table 7.

Due to the small sample size and the method of sampling, the figures in Table 7 are presented only as base-line data. Results of soil analyses for the same general area are presented in Tables 4, 5, and 6. Although it appears that the two sets of data are related, no

Table 7. Foliar content of N, P, K, Ca, and Mg of *Prosopis juliflora* and *Acacia lutea*. Samples taken from the three major ecological life zones of Northwest Haïti. Results of laboratory soils analysis from the nearest sample point are presented in Tables 4, 5, and 6.

Sample Location	Ecological Life Zone	Species	N	P	K	Ca	Mg	See Soil Analysis Data
			%					
200 m east of Nan Vincent nursery	Subtropical Dry Forest	Prosopis juliflora	5.37	0.30	2.53	1.01	0.24	Nan Vincent STP Table 4
200 m east of Nan Vincent nursery	Subtropical Dry Forest	Acacia lutea	4.63	0.24	1.30	1.20	0.23	Nan Vincent STP Table 4
1 km west of Môle St. Nicolas near Fort Valeur	Subtropical Dry Forest	Prosopis juliflora	3.38	0.13	1.16	2.50	0.44	Sample points 2 and 3; Table 4
1 km west of Môle St. Nicolas near Fort Valeur	Subtropical Dry Forest	Acacia lutea	4.27	0.17	1.37	1.80	0.22	Sample points 2 and 3; Table 4
2 km southeast of Lavatiere at sample point 13	Subtropical Dry Forest	Prosopis juliflora	3.98	0.07	1.16	1.96	0.31	Sample point 13 Table 4
2 km southeast of Lavatiere at sample point 13	Subtropical Dry Forest	Acacia lutea	3.98	0.11	1.16	1.56	0.19	Sample point 13 Table 4

Table 7. Foliar content of N, P, K, Ca, and Mg of _Prosopis juliflora_ and _Acacia lutea_. Samples taken from the three major ecological life zones of Northwest Haïti. Results of laboratory soils analysis from the nearest sample point are presented in Table 4, 5, and 6. (Continued).

Sample Location	Ecological Life Zone	Species	N	P	K	Ca	Mg	See Soil Analysis Data
			------------		%		------------	
3 km northeast of Grand Sous School, 2 km southwest of Jean Rabel	Subtropical Moist Forest	Prosopis juliflora	4.67	0.24	1.75	1.32	0.30	Sample point 26 Table 5
3 km northeast of Grand Sous School, 2 km southwest of Jean Rabel	Subtropical Moist Forest	Acacia lutea	5.01	0.28	1.55	1.08	0.19	Sample point 26 Table 6
1/2 km southwest of sample point 16	Subtropical Moist Forest	Prosopis juliflora	5.15	0.34	1.19	0.67	0.20	Sample point 16 Table 6
1 km east of Nan Digé nursery near sample point 23	Subtropical Wet Forest	Prosopis juliflora	5.15	0.26	1.63	1.26	0.23	Sample point 23 Table 6
1 km east of Nan Digé nursery near sample point 23	Subtropical Wet Forest	Acacia lutea	4.28	0.21	0.91	1.94	0.26	Sample point 23 Table 6

correlations can be delineated with confidence. Samples taken from mesic environments, on the average, contain greater quantities of all mineral nutrients measured than do samples from dry sites with shallow soils.

The fact that nutrient content in the foliage of these two species differs between individuals and between sites indicates that such a system may be helpful in assigning relative productivity values to the various sites. However, a greater number of samples would be necessary to make statistically sound inferences.

VEGETATION ECOLOGY OF THE NORTHWEST DEPARTMENT

Introduction

The vegetation of a site integrates and reflects the environmental factors of that specific area. Observations and measurements of the undisturbed native vegetation can be used as a direct indication for the potential of native species and indirectly for the potential of introduced species. If the natural vegetation of an area is known, it is relatively simple to set limits on the potential for various forest and agricultural crops. If the existing vegetation represents a lower successional stage (seral vegetation) and not the relatively stable, self-maintaining, and self-reproducing vegetative cover (climax vegetation), it is difficult to make accurate assessments of site potential. The climax vegetation represents the culmination of plant succession. Estimates of relative site productivity should be based upon the climax vegetative cover whenever possible.

A standardized, world-wide, and objective system for classification of environments which relates climax vegetative cover and relative productivity has been sought for several decades by ecologists, as well as by land managers. Several classification schemes have been developed and implemented, but they are generally limited to specific geographical areas (Barbour, 1942). For the entire region within the subtropical and tropical latitudes, no system has proven more accurate and precise than the World Life Zone System of Ecological Classification (Ewel and Whitmore, 1975; Holdridge et al., 1971). The system was proposed over thirty years ago and has been tested, refined, and elaborated throughout the world since that time. The classification scheme, although applicable to the temperate zones, was derived in the tropical latitudes and unlike most ecological classifications, defines in greater detail the less-studied environments of the subtropics and tropics.

The methodology of the classification has been tested in several life zone mapping surveys conducted in Central, South, and North America, and in Southeast Asia and Africa (Holdridge and Tosi, 1972). These studies have confirmed that the life zone classification system has world-wide applicability. This classification system, due to its refinement and extensive use, provides a natural basis for the description, the analysis, and most important, the comparison of sites throughout the tropics and subtropics (Holdridge et al., 1971).

The Republic of Haïti was surveyed and mapped according to this system of ecological classification in 1972 (OAS, 1972). Because of its merits, the system was selected as the basis for site productivity classification for forest tree species within the study area. The preceding sections of this paper should be viewed as supplemental data by which further subdivision of the life zones into meaningful ecological and management units can be made.

The Holdridge Life Zone System of Ecological Classification

The following brief explanation of the methodology used in this ecological life zone classification system will provide the necessary background for the sections which follow.

This genetically ordered system relates all major environmental factors into three hierarchial levels (Holdridge, 1967). The first level is the life zone, which is determined by specific measures of long-term average annual precipitation, mean annual biotemperature, and the potential evapotranspiration ratio. This last parameter is a function of the two preceeding climatic factors and their interaction with the vegetative cover and edaphic characteristics of the site (Holdridge, 1972). Biotemperature is a unique concept of the life zone system of classification. It is a theoretical measure of the heat energy which is assumed effective in plant growth. It differs from mean temperature in that unit-period air temperatures below 0°C and above 30°C are assigned a value of 0 in the sum of all unit-period temperatures (Holdridge, 1967). It is assumed that positive net photosynthesis, consequently the production of vegetative tissue, occurs only within this range of temperatures.

These three parameters are combined into a three-dimensional classificatory model of the life zones (Figure 7). Stated briefly, it is the combination of these major parameters which identifies the specific life zone. Taken collectively, these quantified measures of climate have proven sufficient to delineate "vegetation physiognomy, life forms, growth rates, and presumably the overall environmental potential productivity through their dominating influence on soils, landforms, and vegetationally dependent organisms" (Holdridge and Tosi, 1972:p. 10). The life zones correspond in many respects to the vegetational divisions commonly referred to as "plant formations"; however,

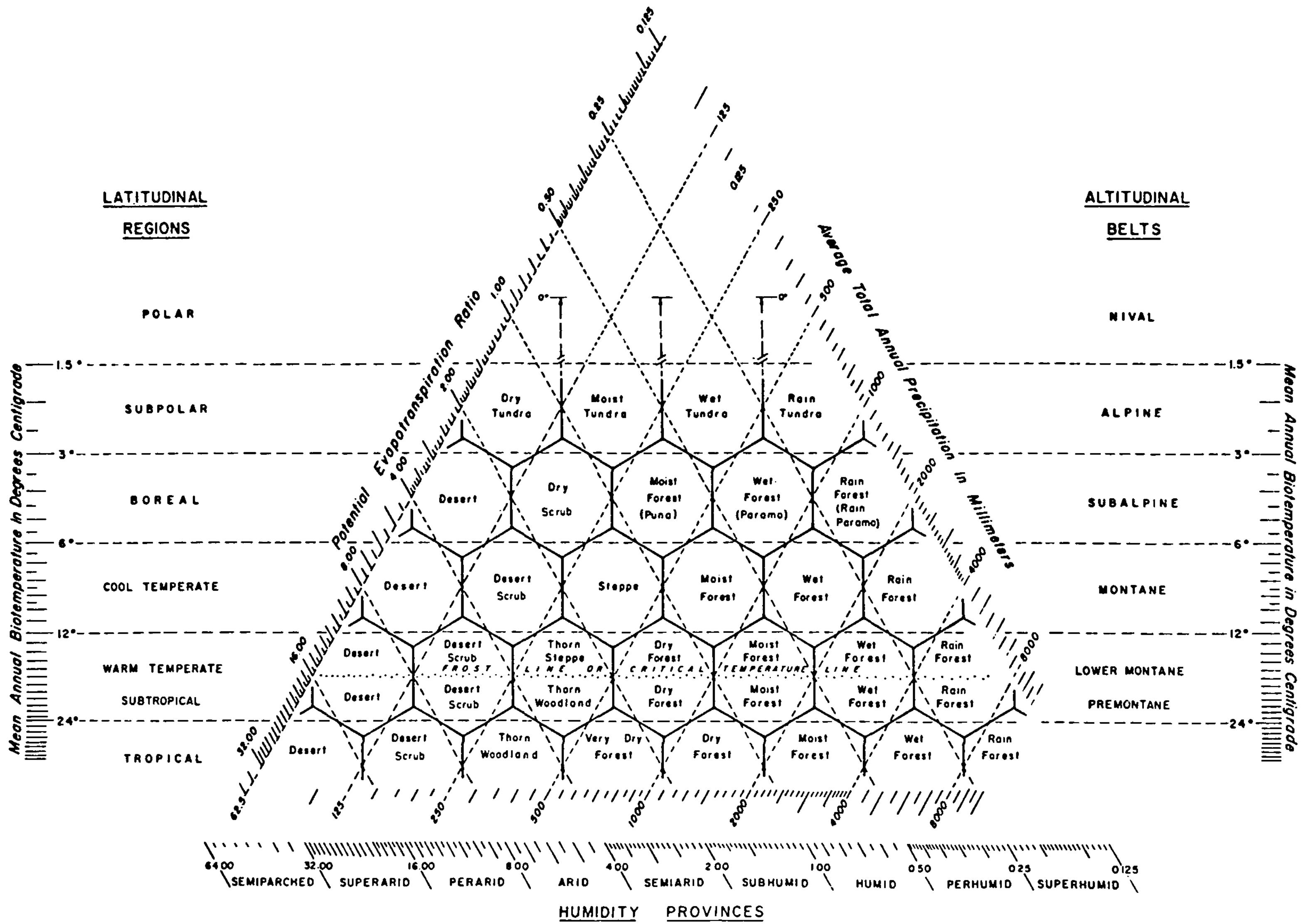

Figure 7. Diagram for the classification of world ecological life zones (Holdridge, 1967).

they are much narrower and much more precise (Holdridge and Tosi, 1972).

With respect to its implementation, the model has additional value in that life zones can be distinguished on the basis of physiognomy and species composition of the climax vegetation. In specific areas where the life zones have been studied for extended periods, the species composition and physiognomy of successional vegetation can also be used to delineate life zones. This capability has been proven in several instances (Holdridge et al., 1971) and "has become more objective by the development of indices relating measured aspects of forest and woodland physiognomy to life zone and association" (Holdridge and Tosi, 1972:p. 12). This aspect of implementing the classification system is particularly valuable in developing regions of the tropics and subtropics which often lack precise continuous climatic data.

Contained within each life zone, there are distinct physical environments known as associations. These are the second level of classification within the system. In undisturbed areas of climax vegetation, the associations roughly correspond to "forest types." The association supports a natural community of organisms which has adapted to a specific narrow range of climatic and edaphic conditions. These conditions are site specific and subordinate to the first level major climatic factors in their influence upon the existing vegetation. Determination of associations is a more subjective procedure than delineation of life zones, but has proven effective (Holdridge and Tosi, 1972).

The number of associations within a life zone is indeterminate. Four general categories of associations are presently recognized: climatic, atmospheric, edaphic, and hydric. The climatic association represents the normal conditions under which no other environmental factors besides gross climatic features significantly affect the development of the climax vegetation. The name of the climatic association is used to denote the life zone. The other associations represent situations in which the evolution of the life zone has been influenced and altered by an additional site factor.

Examples of influences which might produce edaphic associations would be azonal or intrazonal soils, extensive hardpans, unique parent material, salinity, or abnormal soil pH. Tropical and temperate cloud forests and ridges or peaks exposed to constant heavy winds or salty sea breezes are examples of atmospheric associations. The atmospheric associations often appear in areas of unique patterns of precipitation or temperature such as the Mediterranean and monsoonal climates. The extreme of the hydric associations are represented by areas covered with water for extensive periods, such as fresh, brackish, or salt water swamps or marshes. Inland areas with continuous high water tables might also be considered hydric associations.

Successional stage or cover type, the third and final division of the life zone classification system, describes specifically the present vegetative cover of the site. It may represent a natural seral vegetation or a land use to which the area is presently subjected, such as agriculture, pasture, or forest plantation. This final classification is completetely descriptive but is extremely important to effective management of the area. It represents the stage to which the vegetation has digressed from the climax situation and serves as one means by which the productivity of the association can be quantified for a specific use. Because management of the association is primarily concerned with manipulation of the successional stages, it is important to know the present stage plus the direction and rate at which succession will proceed under various treatments.

The stages of succession are distinct for each association, but unfortunately, the successional stages of tropical and subtropical life zones have not been described in great detail. Adaptability and productivity data for specific land uses within the various life zones and associations are needed in order to manage these areas effectively. Proper classification of the land units will result in broader application of agronomic and forest research. Such information can then be extrapolated to similar environments throughout the subtropics and tropics.

Ecological Life Zones and Associations of the Study Area

Within the study area, three ecological life zones have been delineated (OAS, 1972): the subtropical dry forest, the subtropical moist forest, and the subtropical wet forest. Just outside the study area, lies a fourth life zone found in the Northwest Department, the lower montane subtropical wet forest (OAS, 1972). The location of ecological life zones, as mapped by the OAS, is shown in Figure 8 and overlay Appendix F-2.

It is possible to depict the boundaries between the life zones by

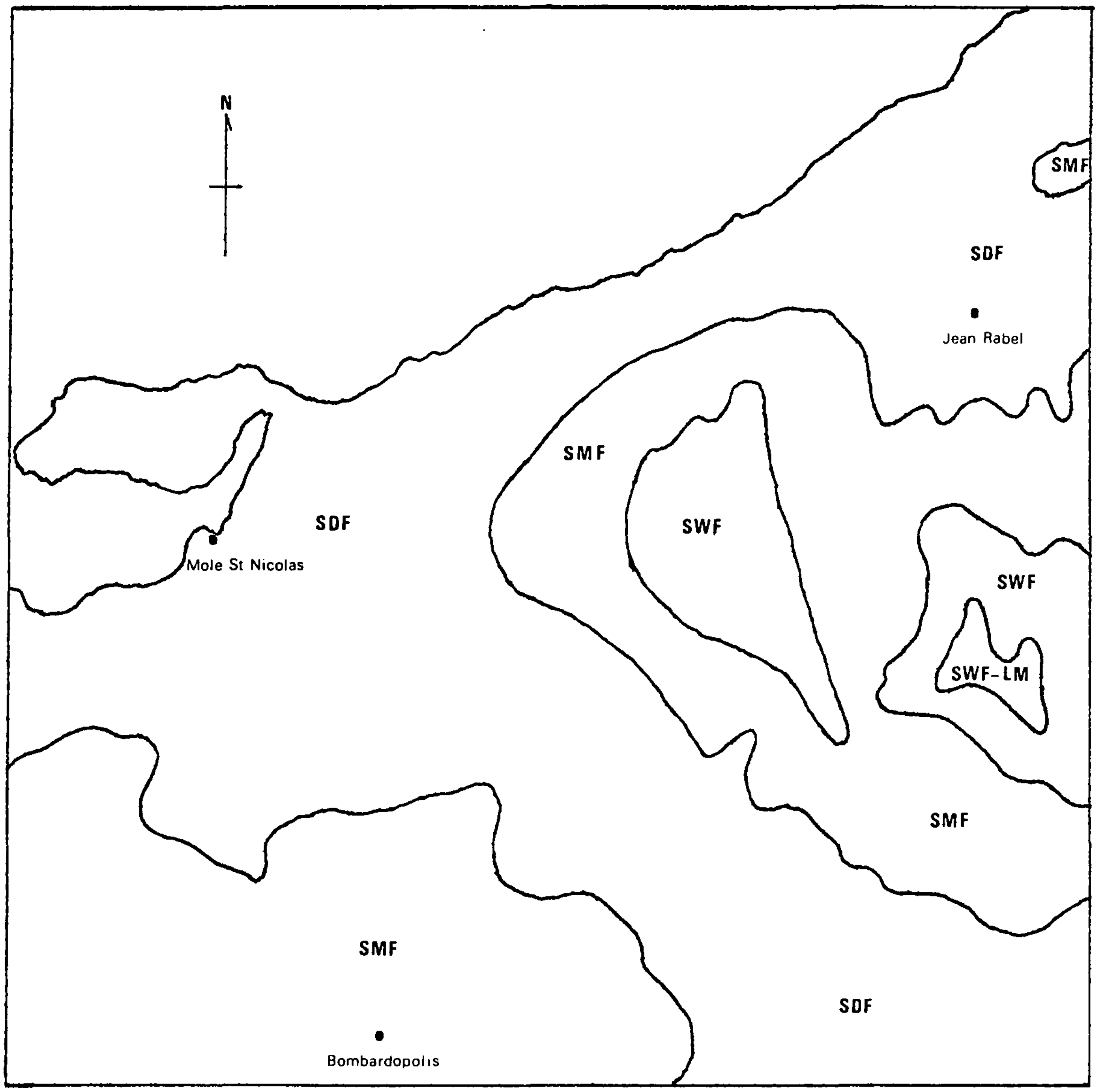

Figure 8: Ecological Life Zones of the Study Area: SDF = subtropical dry forest, SMF = subtropical moist forest, SWF = subtropical wet forest, SWF-LM = subtropical lower montane wet forest (not included in study area).

their characteristic physiognomy and species composition. After nearly a year of observation, it was apparent that the productivity varied considerably between life zones and associations.

The OAS mapping of ecological life zones was based on limited climatic data, particularly for the Northwest. The precise location of the life zone boundaries is questionable. Based on subjective field observations and a review of the climatic data, it appears that the two more mesic life zones (the subtropical moist and subtropical wet forests) have been extended beyond the borders defined by natural vegetation as well as climatic parameters. This over-extension of boundaries is most apparent on the western side of the study area, between the transition from subtropical dry forest to subtropical moist forest, and also between subtropical moist and subtropical wet forest. The boundaries as mapped correspond closely to the distribution of rainfall. Since precipitation in the study area is strongly influenced by orographics, the life zones also correspond to specific elevations. This correlation holds well for the eastern half of the study area, but in the rainshadow west of the Mare Rouge Plateau, the transition between life zones occurs at a higher elevation than that indicated on the OAS map (Figure 8).

Subtropical Dry Forest (SDF)

The subtropical dry forest life zone is the most extensive of the life zones found within the study area. In general, all coastal areas and inland areas below 400 m ($\sim$ 1312 ft) fall within this life zone. The vegetation of this life zone tends to form a complete ground cover.

The canopy rarely exceeds 5 m (∿ 16 ft) and the crowns are usually broad and flattened. The vegetation is generally thorny, and leaves are small and leathery or succulent. Coppicing is a very common phenomenon. When sites are cleared in this life zone, the coppicing species rapidly reclaim the sites, forming dense masses of tangled vegetation.

The apparent range of the SDF has been extended into the subtropical moist forest (SMF) due to continual clearing of the latter. The clearing has resulted in the creation of drier conditions, such as those associated with early successional stages.

Commonly encountered species which could be identified have been listed in Appendix B according to the life zone in which they are observed. The species composition of the SDF, although variable, is very distinct. The presence and abundance of certain species could be used as indicators of this life zone. The list of species compiled for this life zone corresponds at the generic level, and in several instances at the species level, with listings of the SDFs of Puerto Rico, El Salvador, Jamaica, Costa Rica, and southern Haïti (Ewel and Whitmore, 1973; Archer et al., 1978; Holdridge, 1963; Holdridge et al., 1971; OAS, 1972; Asprey and Loveless, 1958; Loveless and Asprey, 1957).

Based on surveys of soil and vegetation made within the study area, two distinct associations have been identified within the SDF. The first of these is the dry edaphic, coralliferous limestone bench association. This association dominates the coastal area from the mouth of the Jean Rabel River to Môle St. Nicolas. It extends inland approximately 1 km (∿ .62 mi) at the midpoint between Môle St. Nicolas and the mouth of the Jean Rabel River. At its endpoints, the association extends inland for greater distances. It occupies a corridor approximately 2 km (∿ 1.24 mi) wide which extends approximately 3 km (∿ 1.86 mi) up the Jean Rabel River. At the western end, this association reaches nearly 5 km (∿ 3.11 mi) inland and includes the entire Presqu'ile du Môle.

Compared to the climatic association, the vegetation physiognomy of this association is marked by a distinct increase in columnar cacti and succulents. Soils, which are largely composed of organic matter, rarely exceed 30 cm (∿ 12 in) and are restricted to cracks within the coralliferous limestone. This soil is completely occupied by plant roots.

The major cover types of this association are Prosopis-thorn woodland and Cactus scrub thorn woodland (United Nations Development Program, 1976). The latter probably represents a lower successional vegetation than the Prosopis-thorn woodland. After clearing within this association, coppicing species such as Prosopis juliflora, Acacia spp., Capparis spp., Cassia spp. and others reoccupy the site; however, their abundance is reduced.

As can be seen from the land use class map (Figure 9) prepared by the United Nations Development Programs (UNDP), Food and Agriculture Organization (United Nations Development Program, 1976), very little of this association is suitable for either permanent or even shifting agriculture. Those areas classified as permanent hill agriculture and shifting agriculture by the UNDP study and which are located near the

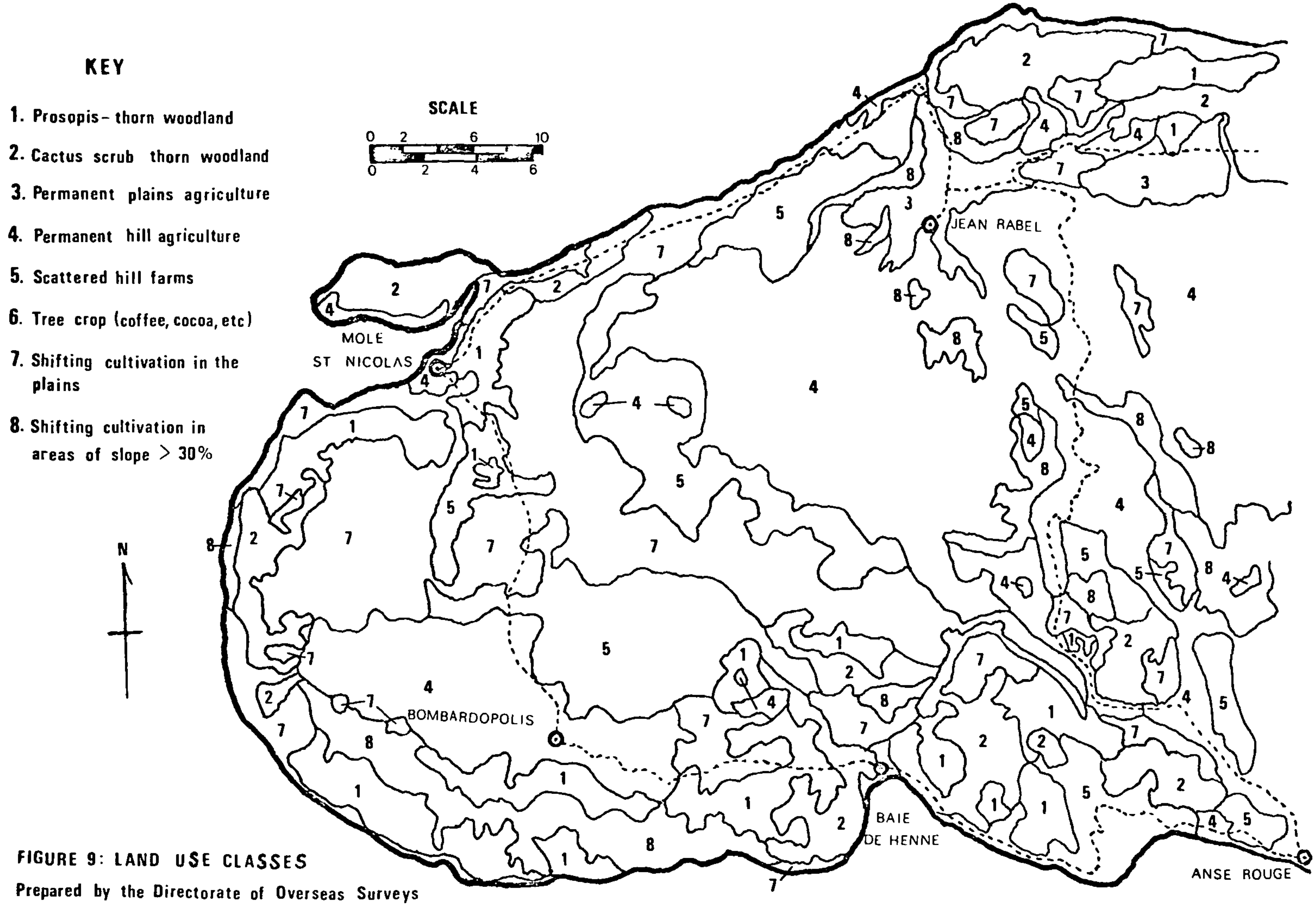

FIGURE 9: LAND USE CLASSES

Prepared by the Directorate of Overseas Surveys 1976, British Government. Ministry of Overseas Development (UNDP project FAO-HAI 72/012) coast and on the Presqu'ile du Môle, are probably not as extensive as they appear on this cover type map.

The potential of this association for forest tree species is low, and establishment is extremely difficult and time-consuming. Productivity is limited by very shallow, high pH soil and a low average annual rainfall.

The most extensive association of this life zone is the climatic association. It is noticeably different from the association previously described in terms of the stature of the vegetation and its successional stages. Species diversity is generally much greater, and the successional vegetation includes several stages of shrub thicket. Succulents, although present, do not appear to dominate any successional stage. Most of the inland area of the SDF life zone should be classed within this association.

Interspersed within this association are several small areas of rock outcropping which might also be included in dry edaphic associations. These generally occur in areas where slope exceeds twenty to thirty percent. Also, in these steep areas, deposits of colluvial and alluvial material have created dry infertile edaphic associations. The soils of all of the SDF life zone are somewhat unique because of their limestone origin. Large amounts of calcium carbonate and the high pH have definite management implications. The qualifying terms "limestone and basic" should be attached to all associations including the climatic association.

Several minor associations were identified within the SDF; however, due to their small area, they will have limited importance to management of this life zone. Although not described in detail, the smaller associations included in the SDF are the coastal mangrove swamp near Môle St. Nicolas; the riparian communities of the Jean Rabel, Môle St. Nicolas, and Côtes de Fer Rivers; and the littoral community which borders the northern shore of the study area.

Reforestation efforts in the SDF life zone are governed by two major factors: soil depth and soil pH. Soil depth can be used as a guide to selection of sites which should yield the greatest returns. As an example, reforestation projects surrounding Jean Rabel, within the SDF life zone, will yield much greater returns and will cost less to establish due to greater soil depth, than will projects in the inland area of the SDF between Môle St. Nicolas, Bombardopolis, and the western edge of the Mare Rouge Plateau. High soil pH will affect all life zones within the study area. This edaphic factor will somewhat limit the species which can be used for reforestation in the study area. A discussion of these limitation is included in the section on soil analysis.

Subtropical Moist Forest (SMF)

The subtropical moist forest (SMF) begins at an elevation of approximately 400 m (∿ 1312 ft) and extends up to an elevation of about 600 m (∿ 1969 ft) where it forms a subtle transition with the subtropical wet forest (SWF). The area occupied by the SMF is more intensively cultivated than the SDF and no less cultivated than the SWF. The land which it occupies is very steep and severely eroded.

Appendix B contains a partial listing of the species commonly encountered in this life zone. On the northern and eastern sides of the study area, the transition between this life zone and the SDF, as already stated, is more abrupt than the transition between the two life zones on the western side of the study area. The boundary of the SMF as mapped by the OAS survey (1972) extends farther to the west than climatic data or vegetation indicate.

The transition between the SDF and the SMF life zones is marked by the scattered appearance of species such as *Sweitenia mahogani*, *Mangifera indica*, *Inga vera*, *Cecropia peltata*, *Catalpa longissima*, *Guazuma ulmifolia*, *Annona muricata*, and *Chrysophyllum* spp. There is also an apparent increase in the number of palm species. The height of the canopy increases rapidly, as does the number of epiphytes.

It is difficult to delineate specific associations due to the great amount of disturbance in this life zone. The western side of the Mare Rouge Plateau and the area north of Bombardopolis are appropriately referred to as dry edaphic associations. These areas lie on the leeward side of the major rain-bearing winds, and this geographical location contributes to the dry arid conditions. Disturbance in these associations has resulted in encroachment of early successional species, such as those of the SDF. However, remnant individuals of the climax or late successional vegetation are still present to serve as indicators of the life zone.

This life zone holds much greater potential returns from reforestation efforts than the SDF. The SMF associations on the eastern edge of the study area are the most productive due to their greater soil depth. This same region is part of the Jean Rabel watershed and therefore should have high priority for land restoration programs such as reforestation. Due to the intensive and relatively productive agriculture practiced in this area, reforestation and revegetation techniques must integrate with agriculture. The reforestation programs must include highly valued species which provide dual uses, such as fruit trees, coffee, or high value timber species. It is in this life zone that silva-agricultural techniques, such as inter-row cropping, will have the greatest utility.

Subtropical Wet Forest (SWF)

The subtropical wet forest life zone (SWF) is difficult to distinguish from the SMF which surrounds it. Species composition does not change significantly, as is evident from comparison of the species lists of the two life zones (Appendix B). The total area of the SWF is much less than that illustrated by the OAS mapping. This error in mapping is indicated not only by the vegetation, but also by the mean annual rainfall which rarely exceeds 2000 mm ($\sim$ 79 in) (FAO, 1966).

The area which extends along the eastern edge of the Mare Rouge Plateau can be considered a dry association of the SWF. It is noticeably richer in terms of epiphytic species and lianas. Tree crops such as coffee and cacao are common and productive. The stature of the trees is much greater than in the surrounding area. Coco, royal, and sabal palms are common components. The area has been cleared of nearly all of the native vegetation and now supports a system of permanent hill agriculture (Figure 9). A few large remnant trees of the species *Spondias mombin*, *Cedrela odorata*, *Ceiba pentandra*, and strangler fig (*Ficus* sp.) remain as indicators of the climax canopy.

This area has reverted to early successional vegetation by continual disturbance. However, its potential for agriculture and forestry remains the best of the entire study area. Tree crops such as coffee, citrus fruits, and cacao should be encouraged in this region. Because the area receives the greatest total rainfall, its protection as a watershed should also have high priority.

SITE POTENTIAL FOR FOREST TREE CROPS IN NORTHWEST HAITI

Introduction

The different environments of Northwest Haïti have a specific potential for the production of forest and agricultural crops. This potential is a function of the factors which have been discussed in the previous sections.

It is difficult to combine and project into a single classification the influence which each factor of the environment has on the growth and productivity of a particular species. The World Ecological Life Zone Classification system (Holdridge, 1963) comes closest to relating these factors and therefore was chosen as the basic classification of the study area. Within the life zone classification system, additional subdivision of the environmental units can be made. Appendices F-1 and F-2 provide overlays of the ecological life zone map and the soil unit map of the study area. By placing each overlay on the base map of the study area (Figure 3), a relatively detailed composite map of the environmental subunits (as they will be referred to in this paper) within the study area can be composed. These subunits, although not completely synonymous with the associations of the life zone classification system, provide a rapid system of relating climate, soil characteristics, vegetative cover, land capability, and major site limiting factors. When the soil unit map is superimposed upon the map of ecological life zones, several of the associations delineated by subjective observation are delineated by the combination of these two surveys.

In order to effectively implement forestry programs, one additional dimension must be mentally projected upon the environmental units of the study area. That final dimension is cover type and present land use (Figure 9). As previously stated, management of the units will depend on manipulation of the successional stage of vegetation and effective integration with the present land use of the area, particularly in the case of land restoration or conservation.

The ecological subunits delineated by the combination of ecological life zones and soil units are relatively uniform within themselves. The subunits describe in detail the environments of the study area and for this reason, can be used as a planning base for nearly all future forestry programs. Previous sections of this paper have described in greater detail the climatic and edaphic factors operative within the subunits. The characterization provided by the subunits will assist in making initial selection of forest tree species suitable for an area, provided the site requirements and silvical characteristics of the species in question are known.

An estimate of relative productivity of the individual species can be determined from the information presented thus far. However, it is desirable to know exactly how the individual species will respond in terms of site adaptability and annual yield in the various environmental subunits of the Northwest. Once productivity of a particular species is determined under a specific set of environmental conditions (represented by the ecological subunits), it can be used as a prediction of expected yield in similar environments throughout the study area and the rest of the Northwest.

Species Trial Plots

The true test of species suitability for reforestation in the Northwest Department of Haïti is its ability to grow and compete with the native vegetation. The need for this information was recognized early in the project and was consequently given a high priority. The objective was to establish species trial plots on all major soil types, in all major ecological life zones, and in the various combinations of these two parameters.

Each species trial plot (STP) was designed according to the system outlined by Goor and Barney (1976). The total number of species incorporated into the STP depended on which species were available in the nursery at the time. Native and exotic tree species were planted in the trial plots. The native species provide a relative measure of the adaptability and growth rate of the introduced species.

The trial plots were aligned in rows along the contour, each row containing one randomly located individual of each species. The total number of rows depended on whether other treatments were included in the trial (i.e., cultivation, irrigation). Border rows surrounded all trial plots and separated rows from various treatments. A spacing of 2 m X 2 m was used for the first three STPs completed; however, a 3 m X 3 m spacing was adopted for the third trial plot in order to facilitate inter-row cropping agricultural techniques.

During the first three months, care was taken to insure that all individual trees were established. Trees which died during this period were replaced. It was assumed that individuals lost after this period died as a result of incompatability with the overall environment and not as a result of bias in planting technique, condition of the planting stock, or a specific micro-environment.

Agriculture and grazing by domestic animals are two site components in the Northwest which cannot be ignored in reforestation efforts. To date, both of these disturbance factors have been excluded from the STPs; however, both will undoubtedly encroach upon the plots in the coming year. These two additional variables will complicate the interpretation of measurements taken in the future. Additional research should independently assess the impact of both grazing and agriculture upon the growth and productivity of the various species used for reforestation.

Four trial plots have been completed, one at Mare Rouge, a second at Nan Vincent, a third near the Nan Digé nursery, and the fourth near the Jean Rabel cemetery. Location, planting dates, species used, and other pertinent site information, as well as measurements of the STPs, are included in Appendix C. No additional treatments have been included in the Mare Rouge, Nan Digé, or Jean Rabel STPs. At the Nan Vincent trial plot, cultivation and irrigation are being monitored in a factorial arrangement, each at two levels, treated and non-treated. Three blocks, each containing four rows, are separated by border rows. Either the first and second, or third and fourth rows of each block have been randomly selected for irrigation. Then one row of each irrigated or non-irrigated pair has been randomly selected for cultivation.

Irrigation will be accomplished by running water into a ditch between each pair of rows designated for irrigaton. Unusually heavy rains since establishment of the Nan Vincent STP in September 1977, have precluded the need for irrigation to date (May, 1978). Cultivation is accomplished at two-month intervals by hoeing a 2 m wide strip centered on the designated row. Individual trees of eighteen different species are randomly located within each row.

Both cultivation and irrigation, will be assessed in terms of the relative contribution each makes to tree growth. Cultivation has already proven to be a definite asset to establishment of other plantations in the Northwest region. Irrigation of tree plantations alone will probably never be an acceptable practice in the Northwest, regardless of growth potential; however, the mixing of tree crops with agricultural crops on the same tract of irrigated land is already successfully employed in some areas.

The trial plots have already provided valuable information. Based on periodic observations, production of planting stock within the nurseries is constantly being adjusted. Production of exotic species which outperform native species is being increased in the nurseries. Observations of the STPs also reveal no significant insect or disease damage.

The STPs are presently less than one year old. This growth data is not sufficient to make sound judgments concerning species adaptability and utility. Measurements of the STPs should be made each year, and nursery production adjusted accordingly. Observations to date have

have resulted in increased production of a few species and reduced production of several others. Production of Leucaena leucocephala var. K-8, Eucalyptus gomphocephala, and some ecotypes of Eucalyptus camaldulensis has been increased. Production of the less vigorous species has been held constant as the capacity of the nurseries has expanded.

According to Goor and Barney (1976), observations should continue for at least two years. At the end of that period, the STPs will be converted to seed production orchards in which only the most productive species remain. The Nan Vincent STP is already being utilized as a seed production orchard for Leucaena leucocephela var. K-8.

The trial plots have served as good demonstration sites for extension work and in some respects have made local farmers more aware of reforestation efforts in the area. It has been possible to register the farmers' reaction to specific tree species. This input will ultimately play a major role in reforestation decisions.

Establishment of trial plots should be continued in the area until the entire range of climatic and edaphic conditions is covered. Only then can accurate estimates of site productivity for forest tree species be made over the entire study area.

Production Plantations

Plantations of a single tree species or genus were established in several locations. These plantations were labeled "production plantations". In the Nan Digé area, one plantation of Sweitenia macrophylla and another of two Eucalyptus species were established. Plantations of Bocconia frutescens, Casuarina equisetifolia, and Leucaena leuco-

cephla var. K-8, and one plantation containing eight species of *Eucalyptus* were established at the Nan Vincent experimental farm.

The plantations have the specific purpose of providing seed for the nursery operation, but they can also be utilized to monitor growth of pure stands of these species in specific environments. Growth data have been collected and are presented in Appendix D.

The smaller plantations at the Nan Vincent site, such as the *Bocconia* and *Casuarina*, were established mainly because seed supply of these species was too limited to incorporate them into STPs. The greater risk of mortality and the difficulty of relocating the trees prevented the use of these species in the regular outplanting program. Having small plantations of these species near the Nan Vincent nursery has afforded better supervision of planting and care, a much more convenient system of monitoring growth, and a readily available seed source in the event that demand for the seed increases.

The plantations at the Nan Vincent site have a few secondary benefits. Like the STPs, they are useful for demonstration sites for local farmers and visiting foresters and agronomists. The plantations should be used to test integrated forest-agriculture systems such as inter-row cropping. The plantation of *Leucaena leucocephala* can be utilized to test its additional uses as a green manure for agricultural crops and as a forage for livestock.

In addition to the plantations and trial plots established by the HACHO - VPI & SU project, four trial plantations were established in the Northwest region by the Food and Agriculture Organization of the

United Nations. Very little information could be gathered concerning the design of these plantings and the objective for their establishment. We were able to discover the exact planting dates and the species planted at each site. This information is presented in Appendix E in order that it may benefit future reforestation efforts in the Northwest.

SUMMARY AND RECOMMENDATIONS

The environment of the Northwest is rapidly reaching the point of irreversible damage. Deforestation and soil erosion have reduced the fertility of the soils and disrupted the hydrologic balance of the region. This is neither a recent discovery nor one which need be reemphasized to those who have crossed the Northwest Department of Haïti. Efforts to ameliorate the situation must include programs which will rectify the damage already done and prevent further destruction of the land-based resources of the Northwest.

The HACHO reforestation program is intended to fulfill both functions through active soil conservation and outplanting programs, as well as providing extension services aimed at encouraging land owners to adopt agriculture techniques which are less destructive to the soils of the region.

This study of the environment of the Northwest has brought together and supplemented pertinent ecological information which will assist future reforestation efforts in the area. The survey of ecological life zones combined with the OAS soil unit survey provides a relatively good system of subdividing the Northwest into meaningful management and planning units. The actual implementation of land restoration programs is best initiated on the basis of watersheds or catchment areas (Ewel, 1977; Donner, 1976); however, the classification outlined in this paper provides the necessary description of the various environments within the watershed.

Having been classified according to the Holdridge ecological life zone system and the OAS soil unit survey, the Northwest has been brought up to date in terms of environmental research. With respect to the Holdridge system, the Northwest is now tied to a world-wide classification system which will facilitate comparison and the exchange of related ecological information with other countries which encompass similar environments.

Specific recommendations have been made throughout the body of this paper based on physical features of the Northwest Department. The information presented in this thesis can also be applied in a general manner to all agriculture, horticulture and forestry programs in the Northwest. As pointed out by Donner (1976), land-based programs such as these have a spatial aspect in the sense that in order for them to succeed, certain physical conditions of the environment must be assured. With this description of the environments of the Northwest, specialists can delineate areas of greatest productivity and they can also become more aware of obstacles which must be overcome in order to achieve an acceptable level of productivity. The environmental tolerances and site requirements have been determined for most species and varieties of agriculture and forestry crops. Presented with the detailed description of the environments of the Northwest, agronomists and foresters can make proper selection of both native and exotic species.

The next phase of agronomic and forestry research in the Northwest should be to quantify the various environments in terms of species productivity. Approximate limits can be set on potential productivity based on the data presented in this paper. Adaptability and productivity trials, such as the species trial plots established as part of this study, will eventually provide definite growth data. The trial plots will also assist in the identification of insect or disease problems which may arise. Specific limits on productivity and possible pathogenic problems, as well as social acceptance, are all areas which must be investigated before major investment is made in any one specific forest species or agricultural crop.

Research of cultural techniques is badly needed in the Northwest Department of Haïti. Various techniques of silva-agriculture should be tested. Different mechanical erosion control devices (i.e., terraces, gully dams, contour canals, etc.), combined with reforestation and agricultural cropping, should be evaluated for applicability in the Northwest. Finally, the various uses of certain underexploited species should be fully researched. As an example, Leucaena leucocephala has already proven itself as a productive fuel wood and erosion control species in the Northwest; however, its potential as a livestock forage and as a green manure fertilizer has not been investigated (National Academy of Science, 1977).

The physical environment of Northwest Haïti poses many problems for land restoration; however, none of these problems is insurmountable. Social, cultural, and political problems are more crucial for effective initiation of land restoration programs in the Republic of Haïti. Although these problems are beyond the scope of this paper, it is only fitting that the reader be aware of the dominant role which they play.

The best time for initiation of soil conservation and reforestation programs in the Northwest Department of Haiti has past. However, the information available in this paper provides a sound basis for immediate initiation of large-scale programs in the region. Despite the many obstacles, results are obtainable, provided that the programs are carefully designed, executed with adequate supervision, and monitored to insure that the stated objectives are being achieved.

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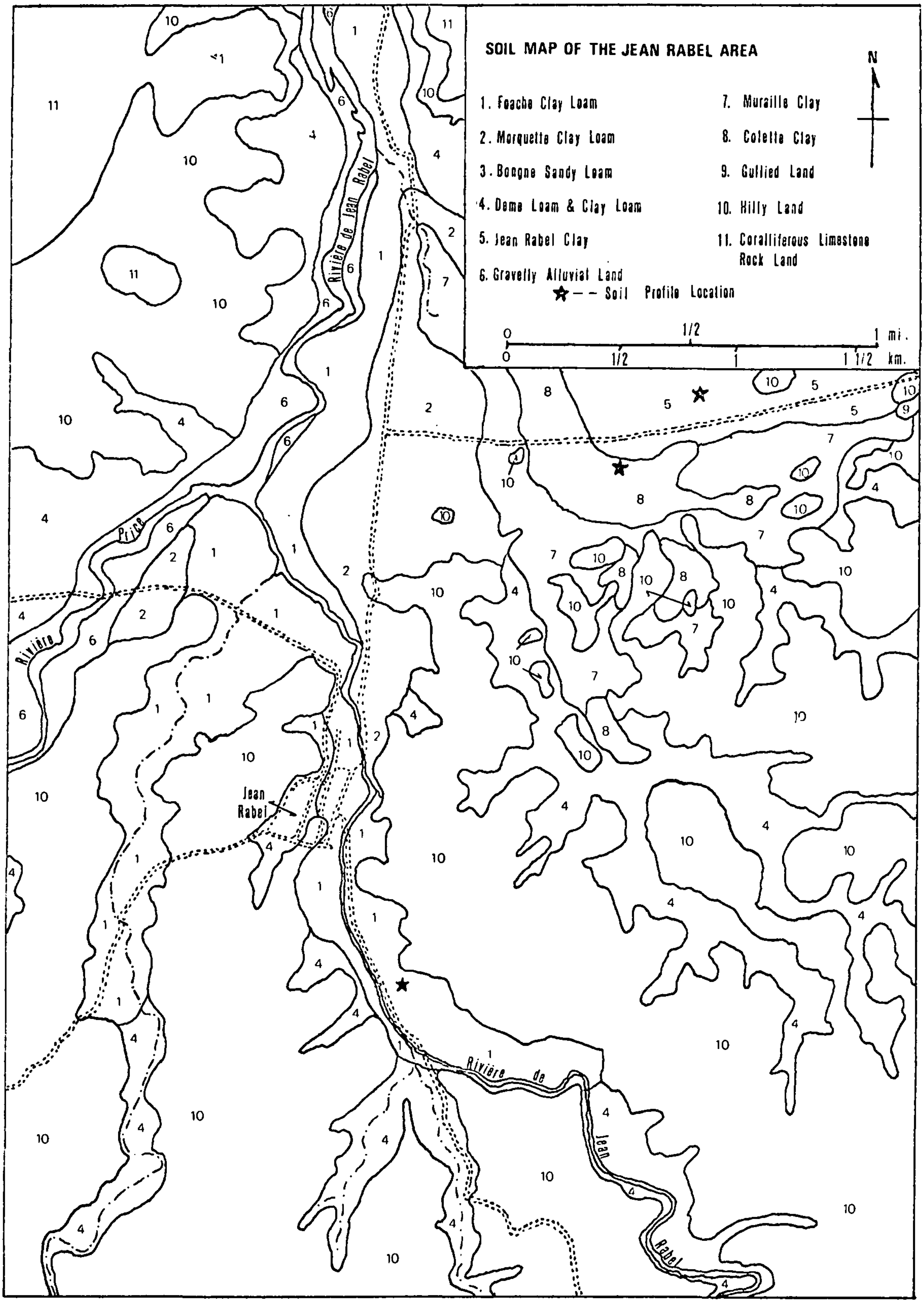
APPENDIX A

Soil map, profile description, and laboratory analysis of four soil types of the Jean Rabel Area of Northwest Haïti (Odell, 1976; from "Task B" Jean Rabel Feasibility Report; used with the permission of Dr. Russel T. Odell, Department of Agronomy, University of Illinois).


SOIL MAP OF THE JEAN RABEL AREA
N
1. Feache Clay Loam
2. Morquette Clay Loam
3. Bongne Sandy Loam
4. Deme Loam & Clay Loam
5. Jean Rabel Clay
6. Gravelly Alluvial Land
7. Muraille Clay
8. Colette Clay
9. Gullied Land
10. Hilly Land
11. Coralliferous Limestone Rock Land
Soil Profile Location
0 1/2 1 mi.
0 1/2 1 1 1/2 km.
Rivière de Jean Rabel
Rivière Price
Jean Rabel

Profile H3, Foáche Clay Loam

Described by R. T. Odell, Miot Jean Francois, and F. Schwencke on December 11, 1975

Location: Topographic map of Haïti, scale 1:50,000, Jean Rabel sheet 5575-I, coordinate 689.7-2195.3; from Jean Rabel market, 1 kilometer south and 46 meters east of road and 91 meters east of Jean Rabel River.

Physiography: Alluvial terrace, 1/4 kilometer wide, of Jean Rabel River.

Relief: Nearly level, < 0.5 percent slope northwest. Altitude 72 meters.

Precipitation: Annual average 95 cm (37 in).

Vegetation: Banana plantation, irrigated.

Drainage: Well drained to moderately well drained. Water table > 125 cm (49 in) below surface.

Parent material: Alluvium from calcareous siltstone (Miocene) and limestone of lower Eocene age.

A_1 0-38 cm (0-15 in)	Dark brown (7.5YR 3/2); clay loam; moderate, fine, granular; friable; calcareous; clear, smooth boundary to horizon below.
A_3 38-74 cm (15-29 in)	Brown to dark brown (7.5YR 4/4); heavy loam; weak, fine, subangular blocky; friable; calcareous; clear, smooth boundary to horizon below.
B 74-102 cm (29-40 in)	Brown (7.5YR 4/4-5/4); heavy loam; weak, medium, subangular blocky; friable; clacareous; clear, smooth boundary to horizon below.
C_1 102-153 cm (40-60 in)	Brown (7.5 YR 5/4); clay loam; nearly massive to weak, medium blocky with a few, fine, white (10YR 8/1) $CaCO_3$ coatings on ped surfaces; friable; calcareous; abrupt, wavy boundary to horizon below.
IIC_2 153-178 cm (60-70 in)	Brown (10YR 5/3); very gravelly loam; single grain; loose; calcareous.
Diagnostic horizons	Mollic epipedon, 0-38 cm (0-15 in). Cambic horizon, 38-102 cm (15-40 in).

Profile H3, Foáche Clay Loam[a]
(Continued)

Classification: Udic Haplustoll, fine-loamy, mixed, isohyperthermic

Horizon Depth of horizon (cm)	A1 0-38	A3 38-74	B 74-102	C_1 102-153	IIC2 153-178
Percent of entire sample > 2.0 mm	0.1	0	0.2	0.1	73.6
Particle-size distribution of < 2 mm (%):					
Very coarse sand - 2.0-1.0 mm	0.1	0.4	1.4	0.5	6.2
Coarse sand - 1.0-.5 mm	1.5	2.4	3.8	2.2	6.1
Medium sand - .5-.25 mm	3.7	5.6	6.5	3.8	7.2
Fine sand - .25-.1 mm	11.4	15.2	14.0	4.3	13.5
Very fine sand - .1-.05 mm	8.7	12.4	9.3	21.1	9.4
Total sand - 2.0-.05 mm	25.4	36.0	35.0	31.9	42.4
Total silt - .05-.002 mm	42.9	38.0	38.3	39.8	35.8
Total clay - < .002 mm	31.7	26.0	26.7	28.3	21.8
Bulk density[b]	1.2	1.3	1.4	1.5	1.7
Moisture: 1/3 atmos. (%)	33.5	28.8	26.2	29.7	22.1
15 atmos. (%)	16.4	15.2	13.6	15.4	10.5
Avail. moist.-hold. capacity[c]	0.20	0.18	0.18	0.21	0.05
Organic carbon (%)	1.47	0.66	0.43	0.73	0.31
Calcium carbonate equiv. (%)	24.8	30.6	24.1	31.0	38.6
Exch. cations (me/100 g soil):					
Ca	37.63	41.25	40.00	42.00	41.50
Mg	3.88	2.75	3.00	4.00	3.25
K	1.97	1.52	0.66	0.56	0.51
Na	0.35	0.36	0.35	0.25	0.33
Exch. sodium percentage	1.4	1.7	1.6	1.1	1.9

Profile H3, Foáche Clay Loam (Continued)

Horizon	A_1	A_3	B	C_1	IIC_2
Depth of horizon (cm)	0-38	38-74	74-102	102-153	153-178
Cation-exch. capacity (me/100 g)	25.01	21.72	22.51	21.94	16.93
pH H_2O	7.8	7.9	7.8	7.9	7.9
Available nutrients:					
NO_3 (ppm)	3	3	3	4	3
P_2O_5 (lbs/acre)	150	20	75	200	200
K_2O (lbs/acre)	100	100	200	100	100
Electrical conductivity (mm hos/cm)	0.28	0.35	0.51	0.40	0.27
Sat. extract sol. cations and anions (me/l):					
Ca + Mg	2.6	0.6	2.6	1.2	1.6
K	2.11	0.32	0.19	0.31	0.16
Na	3.2	5.0	10.8	8.6	10.8
CO_3	0	0	0	0	0
HCO_3	3.4	0.6	0.4	1.4	2.6
SO_4	------	2.0	------	------	1.9
Cl	6.0	8.0	6.0	4.0	8.0
Sodium-adsorption ratio	2.8	9.1	9.5	11.1	12.1

[a] Analyses by J. M. Parker, Champaign, Illinois; except for available nutrients, electrical conductivity, and saturation extract determinations, which were done by the Chemistry and Soils Laboratory, Department of Agriculture, Damiens, Haiti.

[b] Estimated values.

[c] Centimeters of available moisture-holding capacity per centimeter of soil, adjusted for the amount of > 2.0 mm material.

Profile H9, Jean Rabel Clay

Described by R. T. Odell on March 12, 1976

Location: Topographic map of Haïti, scale 1:50,000, Jean Rabel sheet 5575-I, coordinate 690.9-2197.9; from Jean Rabel market, 1.5 kilometers north on road, then 1.4 kilometers east on road, then 91 meters north into field.

Physiography: Lower part of colluvial footslope from a hill 300 meters high.

Relief: 2.5 percent slope southwest. Altitude 45 meters.

Precipitation: Annual average 90 cm (35 in).

Vegetation: Corn, not irrigated.

Drainage: Imperfect to moderately well drained. Water table > 200 cm (79 in) below surface.

Parent material: Colluvium from calcareous siltstone (Miocene) and some from coralliferous limestone of Quaternary age.

A_1 0-36 cm (0-14 in)	Black (10YR 2.5/1); clay; moderate, fine, subangular blocky; firm; calcareous; clear, smooth boundary to horizon below.
A_3 36-56 cm (14-22 in)	Dark grayish brown (10YR 4/2); clay; moderate, fine, subangular blocky; slightly firm; calcareous; clear, smooth boundary to horizon below.
B_2 56-84 cm (22-33 in)	Grayish brown (10YR-2/5Y 5/2); clay; moderate, medium, subangular blocky; slightly firm; calcareous, with common, fine, white (10YR 8/1) $CaCO_3$ concretions; clear, smooth boundary to horizon below.
C 84-102 cm (33-40 in)	Brown (10YR-2.5Y 5/3); clay; weak, medium, blocky; friable; calcareous, with few, fine, white (10YR 8/1) $CaCO_3$ concretions; abrupt, smooth boundary to horizon below.
A_{1b} 102-127 cm (40-50 in)	Very dark gray (10YR 3/1); clay; moderate, medium, prismatic, with common, black (10YR 2.5/1) organic and clay coatings; very firm; calcareous, with $CaCO_3$ concretions as in the C horizon and thin $CaCO_3$ coatings on ped surfaces and in channels; clear, smooth boundary to horizon below.

B_b 127-153 cm (50-60 in)	Dark grayish brown (2.5Y 4/2) to grayish brown (10YR 5/2); clay; moderate, medium, subangular blocky, with few dark gray (10YR 4/1) organic and clay coatings; firm; calcareous, with $CaCO_3$ concretions and coatings on ped surfaces and in channels as in the A_{1b} horizon above.
Diagnostic horizons	Mollic epipedon, 0-36 cm (0-14 in). Cambic horizon, 36-84 cm (14-33 in).

Profile H9, Jean Rabel Clay[a]
(Continued)

Classification: Vertic Haplustoll, fine, mixed, isohyperthermic

Horizon	A_1	A_3	B_2	C	A_{1b}	B_b
Depth of horizon (cm)	0-36	36-56	56-84	84-102	102-127	127-153
Particle-size distribution of < 2 mm (%):						
Sand - 2.0-.05 mm	20	24	8	14	16	26
Silt - .05-.002 mm	27	22	39	33	19	20
Clay - < .002 mm	53	54	53	53	65	54
Organic carbon (%)	1.84	0.72	0.26	0.29	0.85	0.31
Calcium carbonate equiv. (%)	20	25	27	25	10	23
Exch. cations (me/100 g soil):						
Ca	47.8	39.8	35.8	-----	39.8	------
Mg	7.9	------	15.9	-----	15.9	15.9
K	1.43	0.48	0.32	0.29	0.48	0.32
Na	0.70	0.58	0.60	0.82	2.28	2.32
Exch. sodium percentage	1.3	1.8	2.5	2.9	7.1	7.2
Cation-exch. capacity (me/100 g)	52.0	32.0	24.0	28.0	32.0	32.0
pH H_2O	7.8	7.6	7.7	7.9	8.0	8.3
Available nutrients:						
NO_3 (ppm)	9	12	5	9	5	14
P_2O_5 (lbs/acre)	200	200	200	75	50	125
K_2O (lbs/acre)	40	40	40	40	40	160
Electrical conductivity (mm hos/cm)	4.00	6.62	0.85	0.75	5.90	4.25

Profile H9, Jean Rabel Clay (Continued)

Horizon	A_1	A_3	B_2	C	A_{1b}	B_b
Depth of horizon (cm)	0-36	36-56	56-84	84-102	102-127	127-153
Sat. extract sol. cations and anions (me/l):						
Ca + Mg	0.6	1.4	1.2	0.8	0.8	0.6
K	0.33	0.12	0.12	0.09	0.07	0.04
Na	0.7	0.6	0.9	2.2	3.0	3.0
CO_3	0	0	0	0	0	0
HCO_3	3.2	2.4	3.7	2.4	3.2	4.0
SO_4	3.4	2.6	2.2	0.2	2.6	4.3
Cl	8.0	8.0	6.0	4.0	4.0	9.0
Sodium-adsorption ratio	1.3	0.7	1.2	3.5	4.7	5.5

[a] Analyses by the Chemistry and Soils Laboratory, Department of Agriculture, Damiens, Haiti.

Profile H10, Colette Clay

Described by R. T. Odell and W. D. Cameron on March 13, 1976

Location: Topographic map of Haïti, scale 1:50,000, Jean Rabel sheet 5575-I, coordinate $6_{90.6}$-$2_{197.6}$; from Jean Rabel market, 1.5 kilometers north on road, then 1.0 kilometer east on road, then 87 meters south into pasture.

Physiography: Near margin of drainageway one-fourth kilometer wide.

Relief: Nearly level, < 0.5 percent slope. Altitude 37 meters.

Precipitation: Annual average 90 cm (35 in).

Vegetation: Grass and scattered Prosopis juliflora (Bayahonde) trees.

Drainage: Poorly drained. No water table to a depth of 142 cm (56 in) on March 13, 1976.

Parent material: Mostly sediments from weakly consolidated, calcareous Lascahobas-Maissade siltstone of Miocene age. The upper three horizons are recent sediment.

A_{11} 0-23 cm (0-9 in)	Mixed dark gray (10YR 4/1) and very dark grayish brown (10YR 3/2); clay to clay loam; moderate, fine, blocky; firm; calcareous; numerous roots; abrupt, smooth boundary to horizon below.
IIA_{31} 23-53 cm (9-21 in)	Grayish brown (10YR 5/2) with common, fine, faint light olive brown (2.5Y 5/4) mottles; loam; weak, fine, subangular blocky; friable; calcareous; many roots; abrupt, smooth boundary to horizon below.
$IIIA_{12}$ 53-81 cm (21-32 in)	Dark gray (1oYR 4/1) with common, fine, faint brown (10YR 4/3) mottles; clay; moderate, fine, subangular blocky; slightly firm; calcareous; common roots; abrupt, smooth boundary to horizon below.
IVA_{1b} 81-112 cm (32-44 in)	Very dark gray (1oYR 3.5/1) with common, fine, faint dark grayish brown (1oYR 4/2) mottles; clay; moderate, fine, subangular blocky; slightly firm; calcareous; few roots; clear, smooth boundary to horizon below.
IVA_{3b} 112-142 cm (44-56 in)	Very dark grayish brown (10YR 3/2) with common, fine, faint dark grayish brown (10YR 4/2) mottles; clay; moderate, fine, subangular blocky; slightly firm; calcareous.

Diagnostic horizons	Ochric epipedon, 0-23 cm (0-9 in). Cambic horizon, 23-81 cm (9-32 in).

Profile H10, Colette Clay[a]
(Continued)

Classification: Thapto Aquollic Fluvaquentic Halaquept, fine, mixed, isohyperthermic

Horizon	A_{11}	IIA_{31}	$IIIA_{12}$	IVA_{1b}	IVA_{3b}
Depth of horizon (cm)	0-23	23-53	53-81	81-112	112-142
Particle-size distribution of < 3 mm (%):					
Sand - 2.0-.05 mm	34	32	20	22	23
Silt - .05-.002 mm	23	42	21	18	16
Clay - < .002 mm	43	26	59	60	61
Organic carbon (%)	2.02	0.91	1.36	1.21	1.01
Calcium carbonate equiv. (%)	28	25	26	28	27
Exch. cations (me/100 g soil):					
Ca	47.8	39.8	51.7	55.7	55.7
Mg	15.9	17.5	15.1	-----	------
K	0.92	0.56	0.47	0.70	0.66
Na	5.80	5.60	4.20	5.40	6.20
Exch. sodium percentage	10.4	17.5	8.8	11.2	15.5
Cation-exch. capacity (me/100 g)	56.0	32.0	48.0	48.0	40.0
pH H_2O	7.8	7.5	7.5	7.2	7.8
Available nutrients:					
NO_3 (ppm)	8	10	8	8	8
P_2O_5 (lbs/acre)	125	75	50	75	125
K_2O (lbs/acre)	40	35	38	35	37
Electrical conductivity (mm hos/cm)	75.00	10.20	12.50	11.80	9.90

Profile H10, Colette Clay (Continued)

Horizon	A_{11}	IIA_{31}	$IIIA_{12}$	IVA_{1b}	IVA_{3b}
Depth of horizon (cm)	0-23	23-53	53-81	81-112	112-142
Sat. extract sol. cations and anions (me/1):					
Ca + Mg	3.6	6.0	3.6	6.8	5.6
K	0.93	0.54	0.85	0.67	0.36
Na	38.4	50.7	50.7	49.3	5.8
CO_3	0	0	0	0	0
HCO_3	3.8	3.3	3.0	3.5	2.6
SO_4	1.7	0.8	4.3	4.3	8.6
Cl	48.0	78.0	104.0	68.0	64.0
Sodium-adsorption ratio	28.6	29.3	37.8	26.7	3.5

[a] Analyses by the Chemistry and Soils Laboratory, Department of Agriculture, Damiens, Haiti.

Profile HL, Hilly Land

Location: Topographic map of Haïti, scale 1:50,000, Chateau sheet 5575-II, coordinate $690_{.6}$-$2193_{.9}$; along the road approximately 3 kilometers southeast of Jean Rabel market, and 0.5 kilometer west of Jean Rabel River.

Relief: The soil profile was described near the crest of a ridgetop (altitude 170 meters) on a 16 percent slope westward.

Precipitation: Annual average 95 cm (38 in).

Drainage: Imperfect to moderately well drained.

A 0-28 cm (0-11 in)	Brown (10YR 4/3-5/3); heavy clay loam; moderate, very fine, subangular blocky; firm; calcareous, with pH 8.1; clear, smooth boundary to horizon below.
B_2 28-48 cm (11-19 in)	Brown (10YR 4/3); clay; moderate, fine, subangular blocky, with few, thin, white (10YR 8/1) $CaCO_3$ coatings on peds; firm; calcareous, with pH 8.2; clear, smooth boundary to horizon below.
B_3 48-81 cm (19-32 in)	Brown (10YR 5/3); clay; weak to moderate, medium, blocky to subangular blocky, with common, thin, white (10YR 8/1) $CaCO_3$ coatings on peds; firm; calcareous, with pH 8.3; gradual, smooth boundary to horizon below.
C_1 81-127 cm (32-50 in)	Brown to light olive brown (10YR-2.5Y 5/3); heavy clay loam; weak, medium, blocky, with common, thin, white (10YR 8/1) $CaCO_3$ coatings on peds; firm; calcareous, with pH 8.3.

APPENDIX B

Species list for the ecological life zones of Northwest Haïti.

Partial Listing of Species Commonly Encountered in the Subtropical Dry Forest of Northwest Haïti (listed by family)
(Little et al., 1974; Pierre-Noel, 1971; Little and Wadsworth, 1964; Barker and Dardeau, 1930)

Acanthaceae

Ruellia tuberosa L.

Amaryllidaceae

Agave sisalana L.

Anacardiaceae

Comocladia glabra Spreng.
Metopium browneii (Jacq) Urb.

Apocynaceae

Plumeria rubia L.
Rauwolfia sp.

Bombacaceae

Ochroma pyramidale (Cav.) Urb.

Borraginaceae

Cordia sp.

Bromeliaceae

Tillandsia usneoides L.

Burseraceae

Bursera simaruba (L.) Sarg.
Tetragastris balsamifera (S.W.) Kuntze

Cactaceae

Cephalocereus sp.
Lemaireocereus hystrix Britt. & Rose
Opuntia moniliformis Haw.
Peireskia portulacifolia (L.) Haw.

Capparaceae

Capparis cynophallophora L.
C. flexuosa L.

Combretaceae

Buchenavia capitata (Vahl.) Eichl.

Euphorbiaceae

Croton spp.
Euphorbia lactea Haw.
Gymnanthese sp.
Ricinus communis L.

Flacourtiaceae

Casearis ilicifolia (Sw.) Vent.
Samyda sp.

Guttiferae

Clusia minor L.
C. rosea Jacq.

Lauraceae

Ocotea sp.

Leguminosae

Acacia lutea (Mill.) Britt.
A. scleroxyla Tuss.
Cassia emarginata L.
C. sp.
Haematoxylon campechianum L.
Leucaena leucocephala (Lam) de Wit
Lonchocarpus sp.
Lysiloma latisiliqua L. Benth
Mimosa sp.
Parkinsonia aculeata L.
Piptadenia sp.
Pithecolobium circinnale (L.) Benth.
Pithecolobium sp.
Prosopis juliflora (Sw.) DC.

Liliaceae

Aloe vera L.
Yucca aloifolia L.

Malvaceae

Gossypium barbadense L.
Hibiscus brasiliensis L.

Meliaceae

Guarea trichilioides L.

Moraceae

Fiscus sp.

Myrtaceae

Eugenia sp.
Pimenta sp.
Myrica deflexa (Poir.) DC.

Ochnaceae

Ouratea ilicifolia (DC.) Baill.

Polygonaceae

Coccoloba sp.

Rhamnaceae

Sarcomphalus sp.

Rubiaceae

Exostema sp.
Randia aculeata L.

Rutaceae

Amyris elemifera L.

Sapotaceae

Chrysophyllum cainito L.

Simarubaceae

Simaruba officinalis P. DC.

Sterculiaceae

Ayenia sp.

Theophastaceae

Jacquinia sp.

Turneraceae

Turnera diffusa Willd.

Ulmaceae

Phyllostylon brasiliense Capan.

Zygophyllaceae

Guajacum officinale L.
Tribulus cistoides L.

Partial Listing of Species Commonly Encountered
in the Subtropical Moist Forest
of Northwest Haïti (listed by family)
(Little et al., 1974; Pierre-Noel, 1971; Little and Wadsworth,
Barker and Dardeau, 1930)

<u>Acanthaceae</u>

Barleria lupulina Lindl.

<u>Anacardiaceae</u>

Comocladia glabra Spreng.
Mangifera indica L.
Spondias mombin L.
S. purpurea L.

<u>Annonaceae</u>

Annona muricata L.
A. reticulata L.
A. squamosa L.
Guatteria blainii (Griseb.) Urb.

<u>Apocynaceae</u>

Cameria latifolia L.
Thevetia neriifolia Juss.

<u>Bignoniaceae</u>

Catalpa longissima (Jacq.) Sims.
Crescentia cujete L.
Doxantha unguiscati (L.) Miers.

<u>Bixaceae</u>

Bixa orellana L.

<u>Borraginaceae</u>

Beureria sp.
Cordia sp.

<u>Bromeliaceae</u>

Bromelia pinguin L.
Tillandsia usneoides L.

<u>Burseraceae</u>

Bursera simaruba (L.) Sarg.
Tetragastris balsamifera (SW.) Kuntze

<u>Capparidaceae</u>

Capparis sp.
Cleome spinose Jacq.

<u>Caricaceae</u>

Carica papaya L.

<u>Celastraceae</u>

Maytenus buxifolia (A. Rich) Griseb.

<u>Combretaceae</u>

Combretum laxum Jacq.
Treminalia catappa L.

Compositae

Eupatorium sp.

Crassulaceae

Bryophyllum pinnatum (Lam) S. Kurz.

Cucurbitaceae

Lagenaria leucantha Rusby

Elaeocarpaceae

Muntingia calabura L.

Euphorbiaceae

Adelia ricinella L.
Euphorbia lactea Haw.
Jatropha sp.
Manihot utilissima Pohl.
Pera sp.
Rincinus communis L.

Flacourtiaceae

Samyda rosea L.

Graminae

Bambusa vulgaris Schrad.

Guttiferae

Clusia minor L.
C. rosea Jacq.

Lauraceae

Persea americana L.

Leguminosae

Acacia lutea (Mill.) Britt.
Albizia lebbek (L.) Benth.
Bauhinia divericata L.
B. sp.
Cajanus indicus Spreng.
Cassia emarginata L.
C. sp.
Delonix regia L.
Haematoxylon campechianum L.
Inga vera Willd.
Leucaena leucocephala (Lam.) de Wit.
Pithecolobium sp.
Prosopis juliflora (Sw.) DC.

Meliaceae

Cedrela odorata L.
Gaurea trichilioides L.
Melia azedarach L.
Swietenia mahogani Jacq.
Trichilia hirta L.

Moraceae

Artocarpus communis J. R. and G. Forst.
Cecropia peltata L.
Fiscus spp.

Moringaceae

Moringa oleifera Lam.

Myrtaceae

Eugenia spp.
Psidium guajava L.

Palmae

Cocos nucifera L.
Roystonea sp.
Sabal causiarum (O. F. Cook.) Becc.

Polygalaceae

Securidaca virgata Sw.

Punicaceae

Punica granatum L.

Rhamnaceae

Gouania lupuloides (L.) Urb.
Columbrina arborescens (Mill.) Sarg.

Rubiaceae

Coffea arabica L.

Rutaceae

Amyris elemifera L.
Citrus aurantifolia (L.) Swingle
C. aurantium L.
C. sinensis Osbeck

Sapindaceae

Dodonaea viscosa (L.) Jacq.
Matayba scrobiculata (H.B.K.) Radlk.
Melicocca bijuga L.

Sapotaceae

Chrysophyllum cainito L.
C. oliviforme L.
Dipholis salicifolia (L.) A. DC.

Simarubaceae

Simaruba officinalis P. DC.

Solanaceae

Solanum torvum Sw.
Solanum spp.

Sterculiaceae

Guazuma ulmifolia Lam.

Ulmaceae

Celtis trinervia Lam.
Phylostylon brasilensis Cap.
Trema lamarckianum (R. & S.) Bl.

Verbenaceae

Lippia sp.

Partial Listing of Species Commonly Encountered in the Subtropical Wet Forest of Northwest Haïti (listed by family) (Little et al., 1974; Pierre-Noel, 1971; Little and Wadsworth, 1964; Barker and Dardeau, 1930)

Amaranthaceae

Chamissoa altissima (Jacq.) H.B.K.

Amaryllidaceae

Amaryllis sp.
Hippeastrum sp.

Anacardiaceae

Anacardium occidentale L.
Comocladia glabra Spreng.
Mangifera indica L.
Spondias mombin L.
S. purpurea L.

Annonaceae

Annona muricata L.
A. reticulata L.
A. squamosa L.
Guatteria blainii (Griseb.) Urb.

Apocynaceae

Thevetia neriifolia Juss.

Bignoniaceae

Catalpa longissima (Jacq.) Sims.
Crescentia cujete L.

Bombacaceae

Ceiba pentandra (L.) Gaertn.

Bromeliaceae

Bromelia pinguin L.
Tillandsia usneoides L.

Caricaceae

Carica papaya L.

Celastraceae

Schaefferia frutescens Jacq.

Compositae

Distreptus spicatus (Juss.) Cass.

Cucurbitaceae

Sycios sp.

Euphorbiaceae

Adelia ricinella L.
Jatropha curcas L.
Jatropha sp.
Ricinus communis L.

Graminae

Bambusa vulgaris Schrad.
Saccharum officinarum L.

Guttiferae

Clusia minor L.
Mammea americana L.

Lauraceae

Persea americana L.

Leguminosae

Acacia lutea (Mill.) Britt.
Albizia lebbek (L.) Benth.
Bauhinia sp.
Cassia occidentalis L.
C. spectabilis P. DC.
Delonix regia L.
Inga vera Willd.
Pithecolobium sp.
Prosopis juliflora (Sw.) DC.

Melastomaceae

Miconia sp.

Meliaceae

Cedrela odorata L.
Guarea trichiliodes L.
Swietenia mahogani Jacq.

Moraceae

Artocarpus communis J. R. & G. Forst.
Cecropia peltata L.
Ficus sp.

Myrtaceae

Eugenia sp.
Psidium guajava L.

Oleaceae

Jasminum sp.

Palmae

Cocos nucifera L.
Roystonea sp.
Sabal causiarum (O. F. Cook.) Becc.

Piperaceae

Piper sp.

Rhamnaceae

Gouania lupuloides (L.) Urb.

Rubiaceae

Coffea arabica L.

Rutaceae

Citrus aurantifolia Sw.
C. aurantium L.
C. maxima Merr.
C. sinensis Osbeck.
Fagara sp.

Sapindaceae

Matayba scrobiculata H.B.K.
Melicocca bijuga L.

Sapotaceae

Chrysophyllum cainito L.

Solanaceae

Solanum spp.

Sterculiaceae

Guazuma ulmifolia Lam.
Theobroma cacao L.

Verbenaceae

Lippia sp.

APPENDIX C

Design and growth measurements of the Nan Vincent, Mare Rouge, Jean Rabel, and Nan Digé species trial plots located in the Northwest Department of Haïti.

Nan Vincent STP

Location: The HACHO demonstration farm, 1 km N. and 1 km E. of the town of Jean Rabel. Plot is adjacent to nursery.

Site Description:

Ecological life zone - Subtropical dry forest

Soil Unit (OAS, 1972) - Recent alluvium (Capability Class 2) (physical and chemical soil analysis - Table 4 and Appendix A)

Slope - 0%

Elevation - 40 m

Treatments: irrigation and cultivation (initiated December 1, 1977)

Planting Date: September 6, 1977

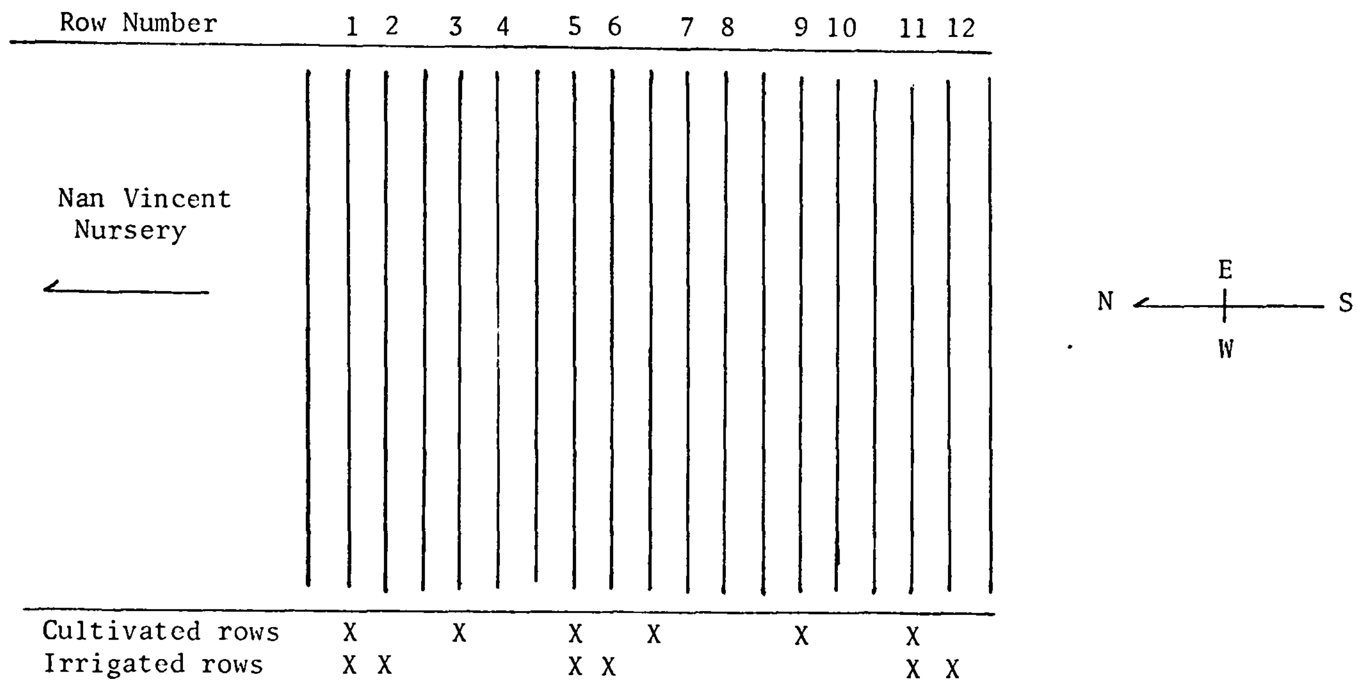
Spacing: 2 m x 2 m

Measurement Dates: November 17, 1977 and March 17, 1978

Nan Vincent STP (Continued)

Species	Seed Source	Species Abbreviation
Acacia accuminata	Tasmania, Australia	AcAc
A. cyanophylla	Brisbane, Australia	AcCy
A. melanoxylon	Brisband, Australia	AcMe
Albizia lebbek	Northwest Department, Haïti	AlLe
Casuarina equisetifolia	California, USA	CaEq
Eucalyptus camaldulensis	Limbé, Haïti	EuCa
E. gomphocephala	Brisbane, Australia	EuGo
E. paniculata	Limbé, Haïti	EuPa
Grevillea robusta	Brisbane, Australia	GrRo
Haematoxylon campechianum	Northwest Department, Haïti	HaCa
Leucaena lecocephala var k-8	Manila, Philippines	LeLe (k8)
L. lecocephala	Brisbane, Australia	LeLe
Melia azedarach	Brisbane, Australia	MeAz
Parkinsonia aculeata	Northwest Department, Haïti	PaAc
Pithecolobium saman	Northwest Department, Haïti	PiSa
Prosopis juliflora	Northwest Department, Haïti	PrJu
Sweitenia macrophylla	Limbé, Haïti	SwMac
S. mahogani	Northwest Department, Haïti	SwMah

Nan Vincent STP Design



Measurements of Nan Vincent STP

a = initial height measurements (cm), taken November 17, 1977
b = second height measurements (cm), taken March 17, 1978
c = initial diameter (at ground level) measurements (cm), taken March 17, 1978

Species	a	b	c	Species	a	b	c
---------- Row 1 ----------				---------- Row 2 ----------			
SwMah	80	168	2.8	PiSa	90	285	4.7
HaCa	80	229	2.8	EuGo	38	172	1.5
EuPa	85	150	1.5	AcCy	28	-- dead --	
PaAc	112	166	2.5	LeLe (k8)	173	340	5.3
LeLe	88	120	2.0	MeAz	50	42	1.8
AcCy	20	95	1.8	CaEq	10	-- dead --	
EuGo	18	97	1.3	LeLe	73	105	1.8
EuCa	125	170	2.9	HaCa	100	277	2.8
AlLe	92	224	3.7	AcMe	60	115	0.8
PrJu	88	163	1.6	GrRo	29	47	0.8
PiSa	40	128	3.3	SwMac	13	20	0.4
SwMac	21	48	1.4	SwMah	74	170	2.4
AcMe	28	-- dead --		AlLe	80	188	3.6
CaEq	24	75	0.6	PrJu	45	216	2.8
MeAz	73	86	2.9	EuPa	95	155	1.3
AcCy	28	58	0.8	EuCa	75	92	0.7
LeLe (k8)	177	315	5.6	PaAc	98	165	2.6
GrRo	37	95	1.3	AcAc	22	-- dead --	
---------- Row 3 ----------				---------- Row 4 ----------			
EuCa	94	136	1.6	AlLe	81	195	3.9
AcAc	20	50	0.4	LeLe	117	35	2.2
AcCy	40	85	1.6	SwMac	20	47	0.7
GrRo	27	50	0.6	EuGo	28	180	1.8
EuGo	35	135	2.3	PiSa	56	228	3.2
AcMe	24	-- dead --		AcCy	43	173	2.2
MeAz	40	46	1.7	AcMe	42	-- dead --	
SwMac	23	46	1.2	SwMah	50	139	1.9
AlLe	75	221	3.9	LeLe	73	90	1.2
CaEq	30	47	0.5	EuCa	103	167	1.8
PiSa	72	200	4.4	PaAc	100	177	2.9
PrJu	64	-- dead --		GrRo	20	52	1.8
SwMah	54	122	2.4	HaCa	48	194	2.3

Measurements of Nan Vincent STP
(Continued)

Species	a	b	c	Species	a	b	c
---------- Row 3 ----------				---------- Row 4 ----------			
LeLe (k8)	95	118	2.0	AcAc	28	-- dead --	
EuCa	110	160	1.9	CaEq	37	91	0.5
PaAc	106	203	2.9	MeAz	56	114	3.4
HaCa	103	247	2.8	PrJu	85	190	2.4
LeLe	88	140	2.0	EuPa	95	168	1.7
---------- Row 5 ----------				---------- Row 6 ----------			
PaAc	92	174	2.7	LeLe	125	160	2.2
PiSa	77	276	4.8	AlLe	37	134	1.4
SwMac	19	-- dead --		LeLe(k8)	164	440	6.0
AcAc	36	-- dead --		EuPa	82	189	1.5
EuGo	30	-- dead --		PiSa	64	191	2.9
LeLe	84	132	1.9	AcCy	34	178	2.3
AcMe	30	45	0.5	MeAz	64	110	2.3
CaEq	10	-- dead*--		EuGo	36	182	1.8
SwMah	56	152	2.4	CaEq	10	-- dead*--	
EuPa	100	157	1.6	EuCa	62	117	1.8
HaCa	47	201	1.7	AcAc	47	-- dead*--	
EuCa	99	107	1.9	AcMe	21	-- dead*--	
AlLe	71	178	2.9	SwMah	57	106	2.0
LeLe (k8)	146	313	4.1	PrJu	62	144	1.1
PrJu	44	133	1.6	SwMac	18	63	1.0
MeAz	45	41	2.0	HaCa	41	183	2.1
GrRo	29	34	0.5	GrRo	15	28	0.5
AcCy	32	145	1.8	PaAc	78	198	2.6
---------- Row 7 ----------				---------- Row 8 ----------			
PaAc	104	144	3.3	LeLe	94	110	2.0
LeLe	85	132	2.3	SwMac	12	-- dead --	
HaCa	82	274	2.6	CaEq	15	-- dead*--	
PiSa	50	230	3.6	AlLe	61	159	2.3
AcAc	19	-- dead --		MeAz	10	75	0.8
LeLe (k8)	130	300	4.8	EuPa	110	125	0.9
SwMac	15	37	0.9	AcAc	50	-- dead*--	
AcMe	43	77	0.7	HaCa	49	178	1.7
PrJu	40	69	1.0	AcMe	35	-- dead*--	
SwMah	49	136	2.5	LeLe	62	71	1.1

Measurements of Nan Vincent STP
(Continued)

Species	a	b	c	Species	a	b	c
---------- Row 7 ----------				---------- Row 8 ----------			
EuPa	94	148	1.3	EuCa	96	127	1.5
MeAz	47	44	1.2	PrJu	45	161	1.5
EuCa	80	132	1.9	PiSa	57	138	3.2
EuGo	31	150	2.2	AcCy	17	33	0.3
AcCy	39	157	3.6	SwMah	49	109	1.7
GrRo	25	43	0.7	PaAc	69	135	1.9
CaEq	17	-- dead*--		GrRo	15	41	0.6
AlLe	56	191	3.1	EuGo	27	156	1.5
---------- Row 9 ----------				--------- Row 10 ----------			
PrJu	45	131	1.2	EuGo	10	-- dead --	
LeLe (k8)	172	355	6.1	AcCy	28	114	1.8
MeAz	10	-- dead*--		LeLe (k8)	160	235	3.8
GrRo	16	45	0.6	MeAz	77	93	2.4
CaEq	10	-- dead*--		CaEq	25	-- dead*--	
SwMac	13	-- dead*--		LeLe	95	123	2.3
EuGo	33	118	2.3	HaCa	55	197	2.1
LeLe	70	117	1.9	AcMe	10	-- dead*--	
EuPa	85	160	1.7	GrRo	15	37	0.5
SwMah	22	106	1.7	SwMac	20	34	0.7
EuCa	77	113	1.6	SwMah	24	87	1.5
HaCa	18	75	0.9	AlLe	42	112	1.3
PaAc	72	117	1.7	PrJu	29	113	1.1
AcCy	12	143	2.8	EuPa	83	141	1.6
PiSa	26	74	1.8	EuCa	82	111	1.2
AlLe	55	219	3.4	PaAc	96	188	2.8
AcAc	33	-- dead --		PiSa	45	135	2.9
AcMe	10	-- dead*--		AcAc	25	-- dead*--	
--------- Row 11 ----------				--------- Row 12 ----------			
SwMah	38	115	2.3	EuGo	38	117	1.6
LeLe	75	133	2.7	SwMah	48	130	2.0
AcMe	27	-- dead*--		LeLe	60	127	2.4
EuPa	93	151	1.8	AcCy	14	56	0.6
AcAc	24	-- dead*--		EuCa	84	128	1.5
PiSa	52	173	3.4	PrJu	50	147	1.2
AcCy	17	62	1.0	AlLe	50	126	1.9
SwMac	17	48	1.2	McAz	23	18	1.0

Measurements of Nan Vincent STP
(Continued)

Species	a	b	c	Species	a	b	c
--------- Row 11 ----------				--------- Row 12 ----------			
EuCa	82	134	1.5	LeLe (k8)	110	325	5.5
HaCa	20	145	1.7	GrRo	14	28	0.4
PrJu	61	153	2.1	EuPa	80	144	1.4
GrRo	17	-- dead*--		AcAc	12	-- dead*--	
CaEq	10	-- dead*--		AcMe	42	99	0.6
EuGo	24	132	2.0	SwMac	20	42	0.8
LeLe (k8)	95	309	4.8	CaEq	10	-- dead*--	
MeAz	43	91	2.3	PiSa	56	184	2.9
AlLe	38	124	1.9	PaAc	75	170	2.0
PaAc	77	144	2.2	HaCa	12	81	0.8

* Dead trees which were not replaced during the first 3 months.

Mare Rouge STP

Location: Approximately 1.5 km southwest of Mare Rouge; the plots is approximately 30 m off the south side of the Mare Rouge-Bombardopolis road

Site Description:

Ecological life zone - transition between subtropical moist and subtropical wet forest

Soil Unit (Oas, 1972) - Lascahobas (Capability Class 4) (chemical analysis - Table 6)

Slope - 0%

Elevation - 580 m

Treatments: none

Planting Date: September 7, 1977

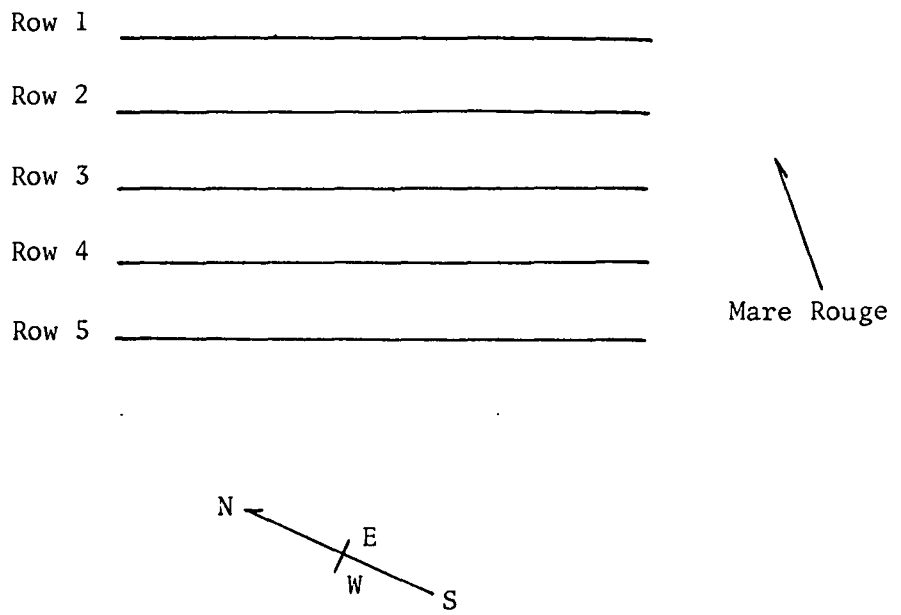
Spacing: 2 m x 2 m

Measurement Dates: November 23, 1977 and March 18, 1978

Mare Rouge STP (Continued)

Species	Seed Source	Species Abbreviation
Acacia accuminata	Tasmania, Australia	AcAc
A. cyanophylla	Brisbane, Australia	AcCy
A. melanoxylon	Brisbane, Australia	AcMe
Albizia lebbek	Northwest Department, Haïti	AlLe
Eucalyptus camaldulensis	Canberra Australia	EuCa
E. gomphocephala	Brisbane, Australia	EuGo
Haematoxylon campechianum	Northwest Department, Haïti	HaCa
Leucaena leucocephala var. k8	Manila, Philippines	LeLe (k8)
L. leucocephala	Brisbane, Australia	LeLe
Melia azedarach	Brisbane, Australia	MeAz
Parkinsonia aculeata	Northwest Department, Haïti	PaAc
Pithecolobium saman	Northwest Department, Haïti	PiSa
Prosopis juliflora	Northwest Department, Haïti	PrJu
Sweitenia macrophylla	Limbé, Haïti	SwMac
S. mahogani	Northwest Department, Haïti	SwMah

Mare Rouge STP Design



Measurements of Mare Rouge STP

a = initial height measurements (cm), taken November 23, 1977
b = second height measurements (cm), taken March 18, 1978
c = initial diameter (at ground level) measurements (cm), taken March 18, 1978

Species	a	b	c	Species	a	b	c
---------- Row 1 ----------				---------- Row 2 ----------			
PaAc	85	143	1.7	AcCy	45	108	2.7
PrJu	52	96	1.0	EuGo	46	92	1.5
LeLe (k8)	75	103	1.6	LeLe	115	160	2.9
HaCa	39	99	1.3	PaAc	70	89	1.1
MeAz	20	22	1.0	AcAc	7	25	0.3
EuGo	33	71	1.2	AlLe	45	38	0.7
SwMah	20	38	0.8	PiSa	65	78	2.3
PiSa	69	79	2.1	SwMac	10	-- dead --	
LeLe (k8)	53	101	2.0	EuCa	35	97	1.1
SwMac	21	37	1.0	SwMah	22	42	1.0
AcCy	42	140	3.1	AcMe	30	33	0.6
EuCa	43	140	3.1	HaCa	34	97	1.3
AcAc	68	161	1.4	LeLe (k8)	115	172	3.0
LeLe	65	96	1.7	MeAz	33	33	0.9
AcMe	47	84	1.0	PrJu	40	54	0.5
---------- Row 3 ----------				---------- Row 4 ----------			
SwMac	29	37	1.1	EuCa	65	127	1.7
LeLe	105	149	2.6	EuGo	35	75	1.2
EuCa	50	107	1.5	AcMe	25	56	0.6
AcCy	27	74	1.5	PrJu	45	52	0.7
AcMe	53	81	1.0	LeLe (k8)	130	214	3.0
PaAc	76	117	1.4	AlLe	60	67	1.9
MeAz	30	55	1.9	LeLe	80	103	1.9
SwMah	10	26	0.7	PaAc	86	120	1.7
LeLe (k8)	78	120	2.1	MeAz	37	31	1.0
EuGo	45	107	1.6	PiSa	75	89	2.1
HaCa	25	67	1.1	AcAc	12	31	0.3
AlLe	40	74	1.3	SwMac	20	35	1.0
PrJu	38	51	0.9	HaCa	45	43	1.2
AcAc	20	-- dead --		SwMah	15	27	0.6
PiSa	40	44	1.5	AcCy	34	62	1.5

Measurements of Mare Rouge STP
(Continued)

Species	a	b	c
------------- Row 5 -------------			
PiSa	80	98	2.3
MeAz	36	37	1.1
PaAc	25	72	1.0
EuCa	63	140	1.8
HaCa	10	41	0.7
SwMac	10	28	0.5
AcAc	25	70	0.9
LeLe	87	117	2.2
EuGo	35	67	1.1
AcCy	20	69	1.3
SwMah	70	84	2.3
LeLe (k8)	72	114	1.7
AcMe	12	-- dead --	
PrJu	33	32	0.5
AlLe	34	42	1.8

Jean Rabel Cemetery STP

Location: Approximately 250 m south west of the southern end of the Jean Rabel Cemetery.

Site Description:

Ecological life zone - Subtropical dry forest

Soil Unit (OAS, 1972) - Lascahobas (Capability Class 6) (physical and chemical soil analysis - Appendix A)

Slope - 30%

Aspect - S 40° E

Elevation - 80 m

Treatments: none

Planting Date: December 13, 1977

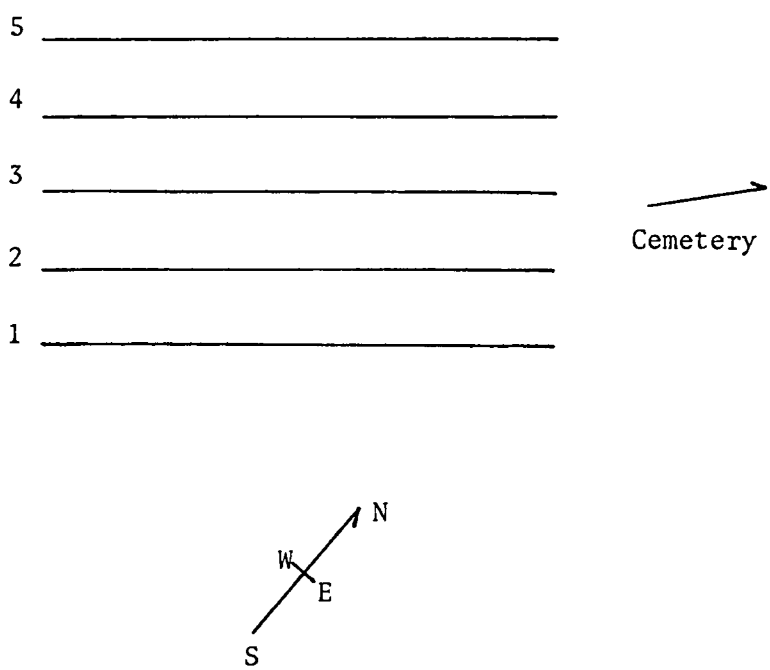
Spacing: 3 m x 3 m

Measurement Date: January 18, 1978

Jean Rabel Cemetery STP (Continued)

Species	Seed Source	Species Abbreviation
Acacia accuminata	Tasmania, Australia	AcAc
Casuarina equisetifolia	California, USA	CaEq
Cedrela odorata	Northwest Department, Haïti	CeOd
Eucalyptus camaldulensis	Canberra, Australia	EuCa
E. gomphocephala	Brisbane, Australia	EuGo
Haematoxylon campechianum	Northwest Department, Haïti	HaCa
Leucaena lecocephala var. k-8	Manila, Philippines	LeLe (k8)
Melia azedarach	Damien School Ag., Haïti	MeAz
Parkinsonia aculeata	Northwest Department, Haïti	PaAc
Pithecolobium saman	Northwest Department, Haïti	PiSa
Sweitenia macrophylla	Limbé, Haïti	SwMac
S. mahogani	Northwest Department, Haïti	SwMah

Jean Rabel Cemetery STP Design



Measurements of Jean Rabel Cemetery STP

a = initial height measurements (cm), taken January 18, 1978

Species	a	Species	a	Species	a	Species	a	Species	a
---- Row 1 ----		---- Row 2 ----		---- Row 3 ----		---- Row 4 ----		---- Row 5 ---	
LeLe (k8)	73	HaCa	30	PaAc	14	LeLe (k8)	95	PaAc	11
CaEq	13	EuGo	50	EuCa	63	HaCa	25	MeAz	20
AcAc	29	MeAz	30	PiSa	37	EuCa	60	PiSa	20
SwMah	22	LeLe (k8)	60	SwMac	20	AcAc	25	EuGo	33
MeAz	25	CeOd	10	CaEq	15	SwMah	17	SwMac	19
HaCa	28	SwMac	27	EuGo	40	PaAc	15	CeOd	6
EuGo	35	CaEq	12	CeOd	10	PiSa	25	HaCa	18
CeOd	20	SwMah	30	AcAc	10	SwMac	20	SwMah	32
SwMac	23	AcAc	8	MeAz	25	CaEq	15	AcAc	10
PaAc	13	EuCa	50	SwMah	28	EuGo	35	LeLe (k8)	75
PiSa	24	PaAc	15	HaCa	23	CeOd	12	CaEq	19
EuCa	53	PiSa	10	LeLe (k8)	57	MeAz	24	EuCa	63

Nan Digé STP

Location: Approximately .5 km south of Nan Digé nursery.

Site Description:

Ecological life zone - Subtropical wet forest

Soil Unit (OAS, 1972) - Mountain terrain (calcaire) (Capability Class 7)

Slope - 45%

Aspect - S 60° E

Elevation - 480 m

Treatments: none

Planting Date: August 9, 1977

Spacing: 2 m x 2 m

Measurement Date: no measurements made due to improper design of the plot

Species	Seed Source
Acacia accuminata	Tasmania, Australia
A. cyanophylla	Brisbane, Australia
A. melanoxylon	Brisbane, Australia
Albizia lebbek	Northwest Department, Haïti
Annona muricata	Northwest Department, Haïti
Delonix regia	Northwest Department, Haïti
Haematoxylon campechianum	Northwest Department, Haïti
Leucaena leucocephala	Brisbane, Australia
Melia azedarach	Brisbane, Australia
Parkinsonia aculeata	Northwest Department, Haïti
Persea americana	Northwest Department, Haïti
Pithecolobium saman	Northwest Department, Haïti
Prosopis juliflora	Northwest Department, Haïti
Robinia pseudoacacia	Virginia, USA
Sweitenia mahogani	Northwest Department, Haïti

APPENDIX D

Design and growth measurements of production plantations located in the Northwest Department of Haïti.

Leucaena leucocephala var. k8 Plantation

Location: The HACHO Nan Vincent Demonstration Farm, adjacent to the Nan Vincent nursery.

Site Description:

Ecological life zone - Subtropical dry forest

Soil Unit (OAS, 1972) - Recent alluvium (Capability Class 2) (physical and chemical soil analysis - Table 4 and Appendix A)

Slope - 0%

Elevation - 40 m

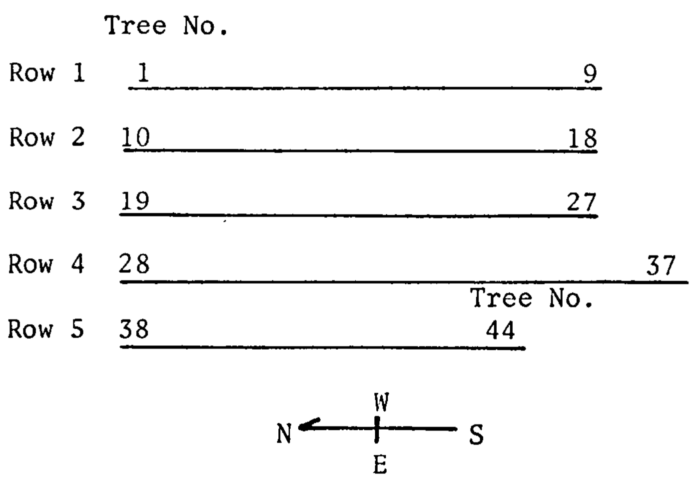
Planting Date: November 8, 1977

Spacing: 2 m x 2 m

Seed Source: Manila, Philippines

Measurement Dates: December 7, 1977 and March 18, 1978

Plantation Design



Measurements of <u>Leucaena leucocephala</u> var. k8
Plantation (Nan Vincent)

a = initial height measurements (cm), taken December 7, 1977
b = second height measurements (cm), taken March 18, 1978
c = initial diameter (at ground level) measurements (cm), taken March 18, 1978

Tree Number	a	b	c
Row 1			
1	74	187	2.7
2	33	192	3.0
3	48	196	3.1
4	43	253	3.0
5	89	199	2.8
6	46	100	2.0
7	23	204	2.5
8	81	135	1.6
9	64	147	1.9
Row 2			
10	69	195	3.2
11	51	172	2.7
12	61	229	4.1
13	48	126	1.9
14	69	182	2.9
15	69	215	3.0
16	69	207	3.1
17	43	167	3.3
18	71	185	2.2
Row 3			
19	81	210	3.2
20	61	197	2.5
21	71	183	2.3
22	53	189	1.9
23	64	202	2.6
24	51	207	3.0
25	58	201	2.5
26	76	187	2.5
27	91	191	2.0

Measurements of *Leucaena leucocephala* var. k8
Plantation (Nan Vincent)
(Continued)

Tree Number	a	b	c
Row 4			
28	64	169	2.3
29	56	179	2.7
30	74	99	1.1
31	58	195	2.7
32	61	196	2.4
33	64	188	2.2
34	61	192	2.7
35	53	159	2.7
36	71	181	2.5
37	64	171	2.5
Row 5			
38	36	173	1.8
39	53	187	2.6
40	41	167	2.4
41	61	143	1.5
42	34	144	1.4
43	71	214	3.7
44	43	171	2.8

Eucalyptus spp. Plantation (Nan Vincent)

Location: The HACHO Nan Vincent demonstration farm, adjacent to the Nan Vincent nursery.

Site Description:

Ecological life zone - Subtropical dry forest

Soil Unit (OAS, 1972) - Recent alluvium (Capability Class 2) (physical and chemical soil analysis - Table 4 and Appendix A)

Slope - 0%

Elevation - 40 m

Planting Date: November 22, 1977

Spacing: 3 m x 3 m

Seed Sources:

Canberra, Australia:
- E. camaldulensis (seed lots S7912, S10885, S11340, S11571)
- E. cladocalyx (seed lot S11180)
- E. gomphocephala (seed lot S11557)
- E. occidentalis (seed lot S9903)
- E. oleosa (seed lot S3698)
- E. rudis (seed lot S8952)
- E. sideroxylon (seed lot S12017)

Brisbane, Australia
- E. gomphocephala
- E. rudis

Limbé, Haïti (Hôspital Le Bon Samaritain)
- E. camaldulensis
- E. paniculata

Measurements of Eucalyptus spp. Plantation (Nan Vincent)

(Individual trees are staked and numbered in the plantation)

a = initial height measurements (cm), taken December 7, 1977
b = second height measurements (cm), taken March 18, 1978
c = initial diameter (at ground level) measurements (cm), taken March 18, 1978

Tree Number	a	b	c
E. camaldulensis (Canberra, Australia; seed lot S7912)			
1	56	86	1.0
2	48	107	1.2
3	61	84	1.1
4	61	89	1.3
5	69	117	1.3
6	51	83	0.9
7	71	115	1.3
8	43	92	1.2
9	38	95	1.6
10	53	128	1.5
11	89	168	2.2
12	66	126	1.4
13	53	92	1.3
14	43	103	1.4
15	53	83	1.1
53	46	78	0.6
54	38	101	1.3
55	36	133	1.3
56	36	76	1.2
57	41	110	1.1
58	38	89	1.1
E. camaldulensis (Canberra, Australia; seed lot S10885)			
76	23	28	0.3
77	23	55	0.8
E. camaldulensis (Canberra, Australia; seed lot S11340)			
89	53	96	1.4
93	23	57	0.8
94	23	59	0.7

Measurements of Eucalyptus spp. Plantation (Nan Vincent)
(Continued)

Tree Number	a	b	c
E. camaldulensis (Canberra, Australia; seed lot S11571)			
78	30	58	0.9
79	25	64	0.9
80	25	44	0.6
81	23	58	0.8
82	28	88	1.0
83	36	79	1.0
84	30	52	0.7
85	30	64	1.0
86	23	47	0.6
88	18	130	1.3
91	28	11	0.2
96	23	38	0.2
E. camaldulensis (Limbé, Haïti)			
71	76	105	1.0
72	94	91	1.0
E. camaldulensis (seed source unknown)			
92	22	39	0.5
102	25	76	0.9
103	18	68	0.7
E. cladocalyx (Canberra, Australia; seed lot S11180)			
95	36	40	0.5
98	26	17	0.3
E. gomphocephala (Canberra, Australia; seed lot S11577)			
63	43	68	0.8
64	46	66	0.9
65	25	70	0.9
66	41	54	0.8
67	38	115	1.2

Measurements of Eucalyptus spp. Plantation (Nan Vincent)
(Continued)

Tree Number	a	b	c
E. gomphocephala (Brisbane, Australia)			
21	30	70	1.1
22	33	91	1.3
23	28	62	1.0
25	36	63	1.0
26	41	77	1.2
27	48	70	1.0
28	33	62	0.8
29	33	46	0.5
30	25	77	1.1
31	33	48	0.7
32	33	82	1.2
33	45	75	0.9
34	38	81	1.4
35	41	104	1.5
36	33	94	1.3
39	36	61	1.1
40	41	74	2.1
42	38	71	1.2
43	39	55	0.6
44	38	75	1.3
45	30	73	1.0
46	41	79	1.2
47	43	90	1.6
48	41	93	1.5
50	30	57	0.7
51	33	53	0.7
E. occidentalis (Canberra, Australia; seed lot S9903)			
19	23	40	0.3
60	18	22	0.3
61	24	48	0.5
90	18	26	0.5
E. oleosa var. oleosa (Canberra, Australia; seed lot S3698)			
100	15	68	1.1

Measurements of *Eucalyptus* spp. Plantation (Nan Vincent)
(Continued)

Tree Number	a	b	c
E. paniculata (Limbé, Haïti)			
17	107	118	1.3
18	86	110	1.2
70	84	86	0.9
E. rudis (Brisbane, Australia)			
37	18	45	0.7
E. rudis (Canberra, Australia; seed lot S8952)			
74	48	41	0.5
79	13	66	0.8
E. sideroxylon (Canberra, Australia; seed lot S12017)			
49	23	93	1.5

<u>Sweitenia macrophylla Plantation</u>

Location: Approximately .5 km northeast of the Nan Digê nursery along the road to Jean Rabel. The plantation is approximately .25 km north from the *Eucalyptus* plantation which also lies northeast of the nursery.

Site Description:

Ecological life zone - Subtropical wet forest

Soil Unit (OAS, 1972) - Mountain terrain (calcaire) (Capability Class 7)

Slope - 5%

Aspect - N 50° W

Elevation - 460 m

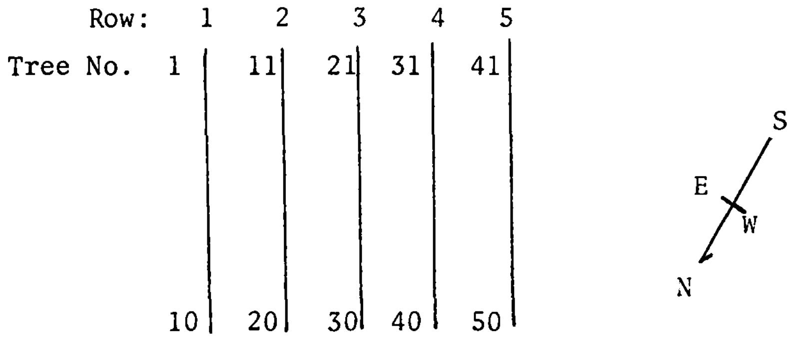
Planting Date: November 28, 1977

Spacing: 3 m x 3 m

Seed Source: Limbé, Haïti (Hôspital Le Bon Samaritain)

Measurement Date: January 4, 1978

Plantation Design



Measurements of Sweitenia macrophylla Plantation

a = initial height measurements (cm), taken January 4, 1978

Tree Number	a	Tree Number	a
Row 1		Row 3 (continued)	
1	20	26	21
2	28	27	25
3	30	28	17
4	25	29	13
5	.20	30	27
6	20		
7	23	Row 4	
8	25		
9	25	31	16
10	37	32	26
		33	28
Row 2		34	29
		35	29
11	21	36	27
12	20	37	28
13	26	38	19
14	16	39	42
15	23	40	20
16	24		
17	16	Row 5	
18	29		
19	20	41	13
20	20	42	18
		43	31
Row 3		44	25
		45	24
21	30	46	18
22	14	47	27
23	15	48	26
24	27	49	25
25	13	50	26

Bocconia frutescens Plantation

Location: The HACHO Nan Vincent Demonstration Farm, adjacent to the Nan Vincent nursery

Site Description:

Ecological life zone - Subtropical dry forest

Soil Unit (OAS, 1972) - Recent alluvium (Capability Class 2) (physical and chemical soil analysis - Table 4 and Appendix A)

Slope - 0%

Elevation - 40 m

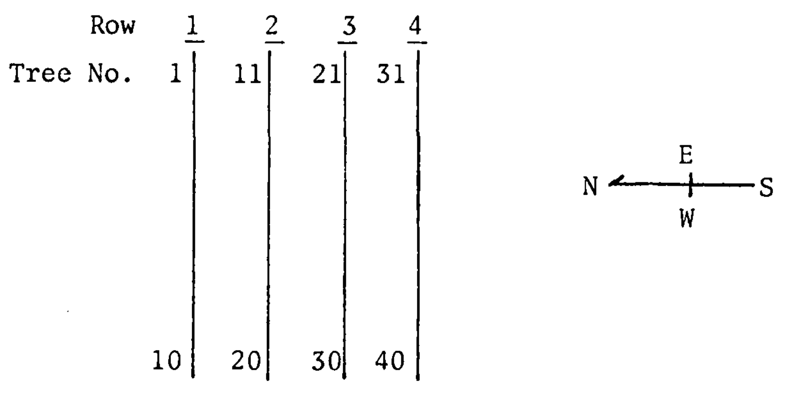
Planting Date: January 19, 1978

Spacing: 3 m x 3 m

Seed Source: Damiens Agricultural School, Haïti

Measurement Date: January 26, 1978

Plantation Design .



Measurements of Bocconia frutescens Plantation

a = initial height measurements (cm), taken January 26, 1978

Tree Number	a	Tree Number	a
Row 1		Row 3	
1	15	21	14
2	28	22	13
3	17	23	21
4	15	24	14
5	19	25	9
6	23	26	9
7	15	27	12
8	28	28	8
9	13	29	5
10	18	30	10
Row 2		Row 4	
11	9	31	9
12	9	32	12
13	23	33	16
14	24	34	10
15	31	35	12
16	17	36	12
17	9	37	18
18	11	38	19
19	12	39	18
20	11	40	14

Eucalyptus spp. Plantation (Nan Digé)

Location: Approximately .5 km east of Nan Digé nursery along the road to Jean Rabel. The plantation is on the west side of the road.

Site Description:

Ecological life zone - Subtropical wet forest

Soil Unit (OAS, 1972) - Mountain terrain (calcaire) (Productivity Class 7)

Slope - 0%

Elevation - 450 m

Planting Date: January 27, 1978

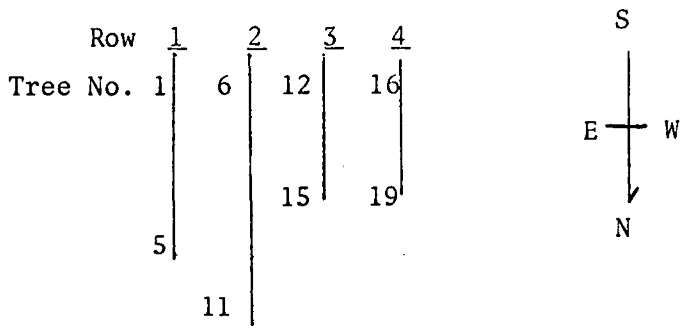
Spacing: 3 m x 3 m

Seed Source: Brisbane, Australia

Measurement Date: January 27, 1978

Species and Species Abbreviation: Eucalyptus camaldulensis - EuCa
E. rudis - EuRu

Plantation Design



Measurements of *Eucalyptus* spp. Plantation (Nan Digé)

a = initial height measurements (cm), taken January 27, 1978

Tree Number	Species	a
Row 1		
1	EuRu	47
2	EuRu	53
3	EuRu	50
4	EuRu	40
5	EuRu	21
Row 2		
6	EuRu	60
7	EuRu	52
8	EuRu	13
9	EuRu	25
10	EuRu	42
11	EuRu	16
Row 3		
12	EuCa	31
13	EuCa	30
14	EuCa	15
15	EuCa	18
Row 4		
16	EuCa	24
17	EuCa	27
18	EuCa	35
19	EuCa	24

Casuarina equisetifolia Plantation

Location: The HACHO Nan Vincent Demonstration Farm, adjacent to the Nan Vincent nursery

Site Description:

Ecological life zone - Subtropical dry forest

Soil Unit (OAS, 1972) - Recent alluvium (Capability Class 2) (physical and chemical soil analysis - Table 4 and Appendix A)

Slope - 0%

Elevation - 40 m

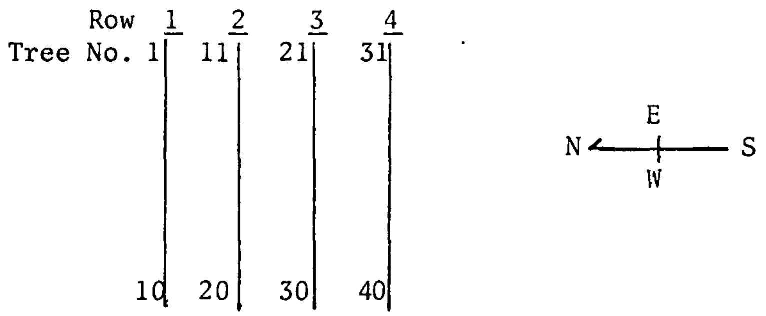
Planting Date: February 2, 1978

Spacing: 3 m x 3 m

Seed Source: Southern California, USA (Carter Seed Co., Inc.)

Measurement Date: February 3, 1978

Design of Plantation



Measurements of *Casuarina equisetifolia* Plantation

a = initial height measurements (cm), taken February 3, 1978

Tree Number	a	Tree Number	a
Row 1		Row 3	
1	18	21	15
2	21	22	18
3	14	23	18
4	18	24	14
5	22	25	18
6	18	26	20
7	17	27	8
8	16	28	18
9	9	29	13
10	21	30	14
Row 2		Row 4	
11	23	31	15
12	18	32	15
13	15	33	20
14	20	34	13
15	18	35	20
16	15	36	16
17	25	37	17
18	17	38	16
19	22	39	17
20	16	40	15

APPENDIX E

Trial Plantings of the Food and Agriculture Organization (UN)
Jean Rabel Area of Northwest Haïti

Location: Cateron, on west side of road built to Jean Rabel city water source, approximately 2 km southwest of the town of Jean Rabel

Planting Date: December 16, 1976

Species	Number Planted
Acacia farnesiana	10
A. tchad	10
Eucalyptus glauca	10
E. paniculata	75
E. salifonia	75
E. tchad	10
E. wandoo	36
	226

Location: Morne Deme-La Montagne, west side of the proposed barrage site, approximately 2 km south of the town of Jean Rabel

Planting Date: December 17, 1976

Species	Number Planted
Acacia farnesiana	25
A. tchad	20
Casuarina sp.	40
Eucalyptus glauca	6
E. paniculata	178
E. salifonia	172
E. tchad	17
E. wandoo	6
	464

Location: Ka Philippe, on main road between Anse Rouge and Jean Rabel, south of Ka Philippe school house

Planting Date: November 9, 1976

Species	Number Planted
Acacia farnesiana	54
A. tchad	32
Casuarina sp.	85
Eucalyptus glauca	30
E. paniculata	194
E. salifonia	100
E. wandoo	5
	500

Location: Morne Bourrique-Jean Rabel Communal Forest, at intersection of Port-de-Paix, Anse Rouge, and Jean Rabel roads, approximately 5 km east of the town of Jean Rabel

Planting Date: December 16, 1976

Species	Number Planted
Acacia farnesiana	432
A. tchad	148
Casuarina sp.	351
Eucalyptus glauca	124
E. paniculata	364
E. salifonia	186
E. tchad	346
E. wandoo	18
	1969

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EVALUATION OF FOREST SITE POTENTIAL IN THE NORTHWEST DEPARTMENT OF THE REPUBLIC OF HAITI

by

John Robert Johnson

(ABSTRACT)

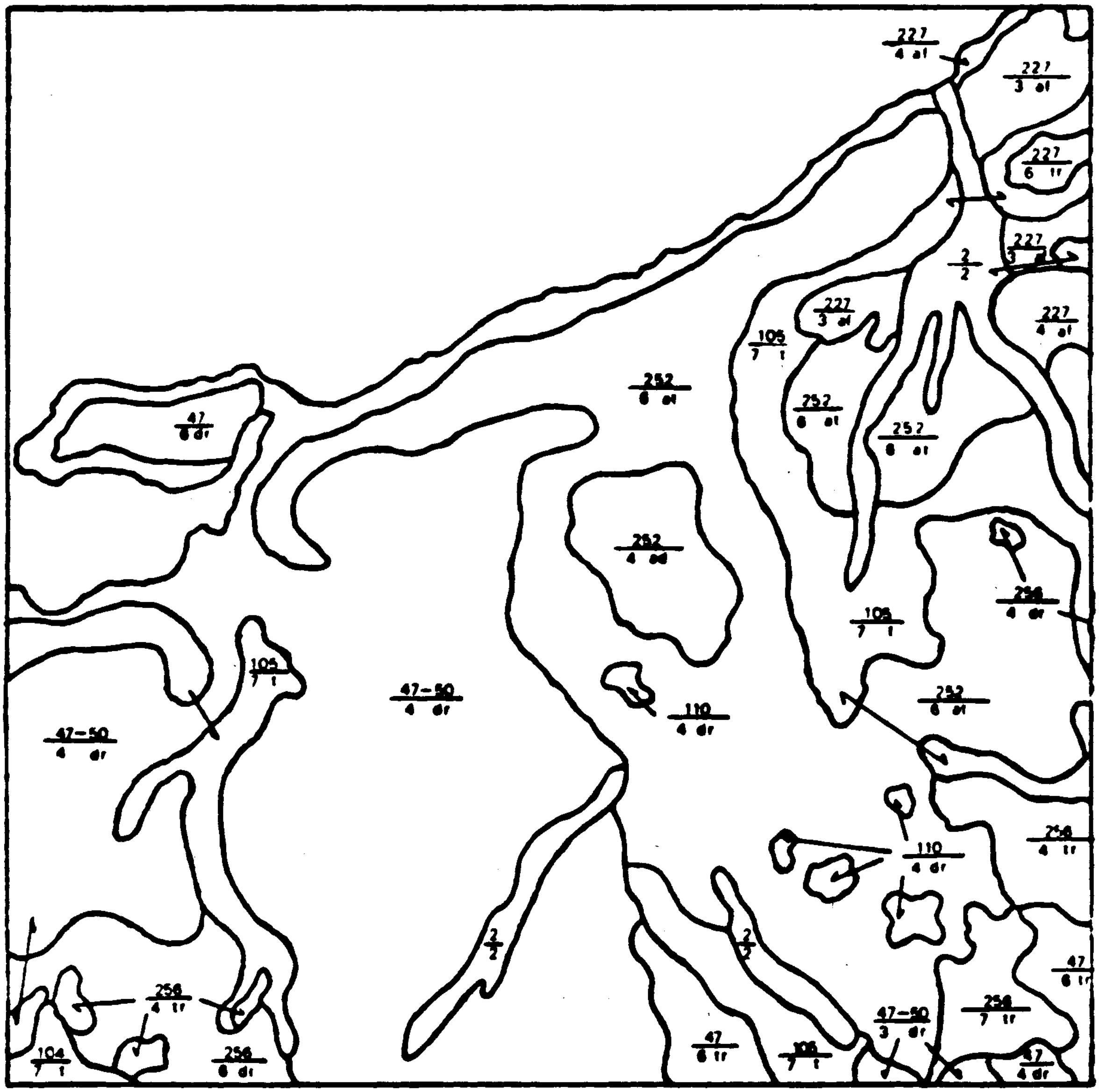
In August, 1976 a cooperative reforestation program between Virginia Polytechnic Institute and State University and the Haïtian-American Community Help Organization was initiated in the Northwest Department of the Republic of Haïti. A network of forest tree nurseries was established in the Northwest to provide planting stock for soil conservation and reforestation projects in the region.

The long-term objectives are to integrate the programs with the existing agriculture system and also provide raw material for the active charcoal industry of the Northwest. In order to achieve these objectives, the nursery program utilizes a wide variety of native and exotic tree species.

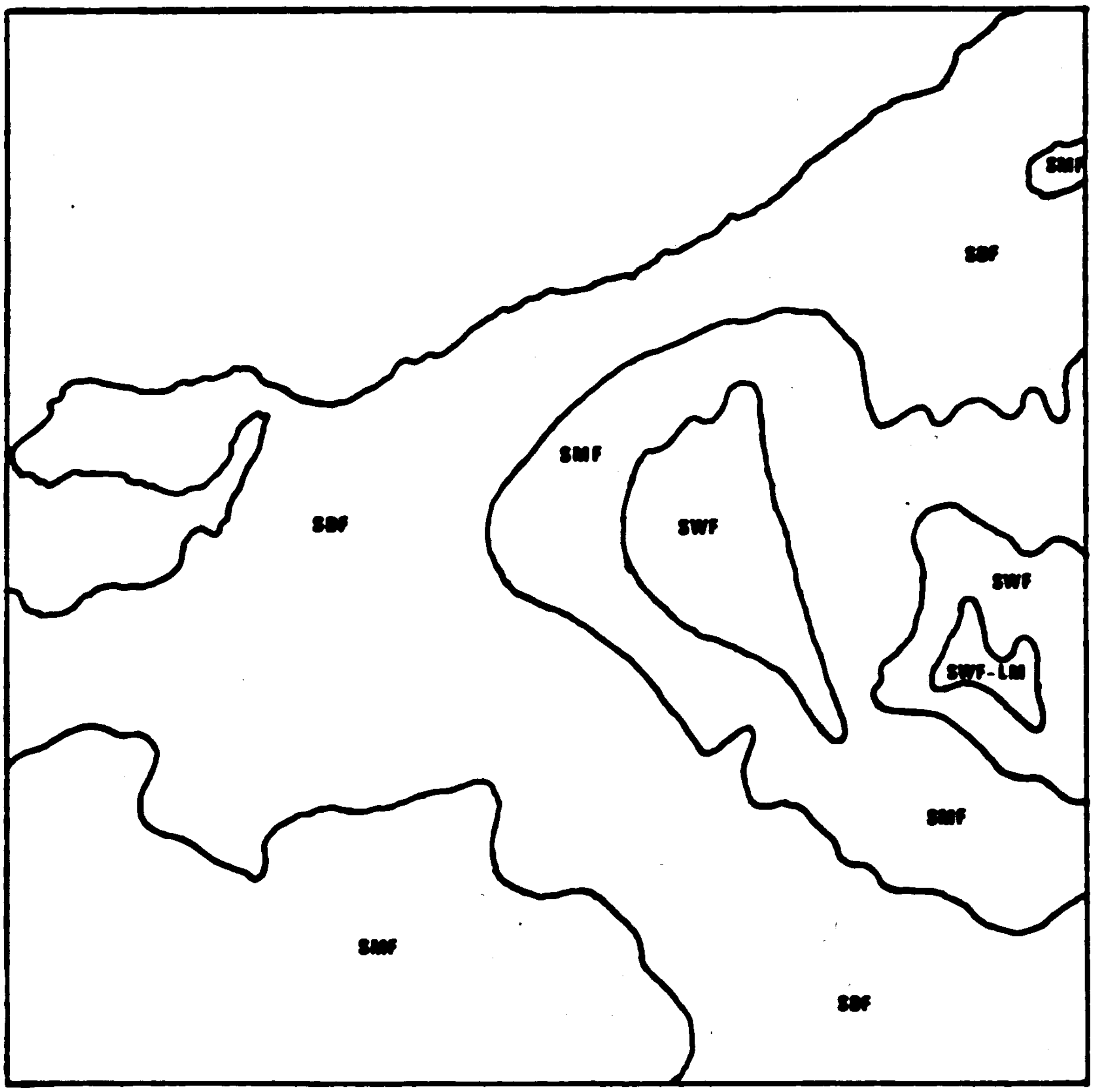
During the initial phase of the program, selection of species, selection of suitable planting sites, and determination of necessary cultural techniques after planting were based upon subjective observations of the environment. Determination of potential productivity of the different tree species was also difficult due to the shortage of environmental information.

This study has brought together and supplemented environmental studies of the Northwest. The study area was divided into descriptive ecological units based on several parameters. The Holdridge ecological life zone model was used to make the initial classification of sites within the study area. Soil and vegetation surveys were used to varify, subdivide, and provide additional description of the life zones. Trial plantations were established in the various life zones to determine adaptability, quantify productivity, and monitor possible pathogenic problems of the different tree species.

The information provided in this study will help guide current land-use decisions and suggest goals for future research. The classification used in the study has also tied the Northwest to a world-wide system of classification. Consequently, the results of applied forestry and agricultural research in similar environments can now be related to development of Northwest Haïti.



Soil Units of Study Area (OAS, 1972)(see key p. 28)



Ecological Life Zones of the Study Area: SDF = subtropical dry forest, SMF = subtropical moist forest, SWF = subtropical wet forest, SWF-LM = subtropical lower montane wet forest (not included in study area).