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ENVIRONMENTAL DEGRADATION IN HAITI

An Analysis of Aerial Photography

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"Where there is a forest canopy water reaches the ground, not in unimpeded torrents, but in softened drips and flows. And where there are arboreal root systems, most topsoil remains safely fastened to the subsoil strata from which it emerged. Remove the tree cover and the destructive flow of topsoil begins."

From Murray, 1982

Photo: South slope of Pic Macaya in the proposed Morne Macaya National Park - one of the most remote and inaccessible areas in Haiti.

EXECUTIVE SUMMARY

This research has been designed to fulfill the need for accurate quantitative data on environmental degradation in Haiti in recent years. To determine this, aerial photography from 1956 and 1978 was analyzed for vegetation changes at one study site in the northwest peninsula and two sites in the southwest peninsula. An overflight of one site in the southwest provided data for 1984.

Environmental degradation in Haiti began in the early 1700's when the mountains were first exploited during French colonization. The French cleared forests from entire mountain ranges for export of valuable hardwood timber and to make room for expansion of plantation agriculture from the plains. Soon after the successful slave revolt of the 1790's, degradation was accelerated when a change in population settlement patterns occurred. Small farms were hacked out of the forest as a vast amount of public land was distributed throughout the country. The population began to grow while soil erosion ate away at farm productivity on mountain slopes. In search of new farm land the peasant continued to encroach on the forest. In areas where population pressure was great and the availability of new soils for cultivation were limited, fallow periods were shortened or eliminated from the agricultural cycle so that farming could continue. In many areas productivity eventually became so low that it was no longer economically feasible to produce crops. With no other alternative sources of income, peasants in these areas began to produce charcoal from any available woody material.

The process of environmental degradation continues today. The population is growing, new farm land is becoming scarcer, and charcoal demand is increasing. Once the resources of an area are completely exploited people move elsewhere and the land is left essentially barren.

The results of this analysis reveal a rapidly shrinking forest cover and an increasing amount of exposed soil between 1956 and 1978. At the study site in the arid northwest the only forest cover remaining in 1956 was in a degraded condition, which by 1978 was reduced by 48%. Over this 22 year period the amount of exposed soil at the same site was increased by 149%. Due to a natural resiliency and a lower population pressure per unit of cultivated land, the study sites in the southwest peninsula still contained a substantial amount of old growth forest in 1956. By 1978, the amount of old growth forest at one of these sites was reduced by 60% and replaced by a 127% increase in agricultural crop land and a 99% increase in exposed soil. The other site consisted of 100% old growth forest in 1956 which was reduced to 34% by 1978. In 1984 this was down to 12%.

The rates at which deforestation has occurred at the three study sites between 1956 and 1978 varies from 1.0% in the northwest to 1.3% at one site in the southwest and 1.9% at the other. The data from the overflight of the latter site reveals that the

deforestation rate here, increased to 3.4% between 1978 and 1984. What appears to have occurred is that the pressure on forest resources has moved from areas which have been sufficiently depleted to areas where exploitation is still economically feasible. If this continues, the forests of all three study sites will be eliminated by the year 2000.

This study also investigated the hypothesis that the presence of good transport roads in Haiti have accelerated environmental degradation. It was found that if economic pressures were sufficient and there were still resources left to exploit this did occur. At the study site in the northwest a road constructed in 1968 served to increase the production of charcoal by lowering transportation costs. One study site in the southwest contains a road which was constructed prior to World War II. Not until recently, when agricultural productivity declined and population pressures increased, did the road begin to play a part in accelerated degradation. The third site had degraded more rapidly than the other two sites over the time period of this study, but contains no road access. This reveals that although a road's presence may act as a catalyst to accelerate environmental degradation in Haiti, its existence is not a prerequisite.

Desertification is a term referring to man-caused destruction of the biological productivity of soils in arid and semiarid lands, resulting in the collapse of local agricultural economies. It is initiated when vegetation is removed by deforestation followed by cultivation and/or overgrazing. Plant composition changes occur as water becomes a limiting factor in the ecosystem and original plant species have trouble becoming established. The study site analyses reveals this process at work in Haiti. At all three sites, agricultural productivity is waning, soil erosion is increasing, and water availability is becoming less regular and dependable. In the northwest, plant communities have shifted from degraded forest to cacti and small trees. The shift in the southwest has been from mesophytic forest to open savanna. Although by definition desertification occurs only in arid and semiarid lands, environmental degradation in the humid southwest will eventually cause this region to become arid and desertified if present trends continue.

There has never been a systematic effort to manage Haiti's forests, and land use administration has been fragmented among various governmental departments. Education of the general public about conservation of resources has been ineffective. Peasants have lived so closely to the margin of life and death that they have not been inclined to take risks, resulting in ultimate failure for the majority of conservation projects attempted.

Existing USAID projects can be adapted to bring about positive environmental change. One such project is Secondary Roads Development. Well constructed and maintained transport roads are essential if the benefits of the majority of improvement projects in Haiti are to be realized. Unfortunately, they can also serve

as a vehicle for accelerated exploitation of resources, virtually cancelling the benefits of other projects. This gives road construction a paradoxical characteristic. To alleviate this, the road construction cost-benefit analysis must more realistically reflect potential environmental costs and closely represent the expected benefits if road influenced environmental degradation is to be prevented. The Agroforestry Outreach project must be augmented to reach more farmers. More attention should be given to drainage structures within agroforestry plots. The Establishment of National Parks project should be expanded to include all major upper watersheds. Enforcement mechanisms must be made an integral component of project implementation to ensure park protection.

Changes in land use are the only hope for reversing environmental degradation in Haiti. Upper watersheds must be protected and soil conservation efforts successfully employed on the remaining land under cultivation. A legal survey of state owned land must be undertaken regardless of land tenure sensitivity. Peasants needn't be removed from these lands, but enforcement of soil conservation must be adhered to and written into a comprehensive management plan. Low cost cooking facilities must be developed and distributed, which utilize resources other than charcoal or fuelwood. This will substantially remove the pressure from remaining forest resources. A system to inventory, evaluate, and monitor the environmental situation in Haiti on a regular basis must be installed. Information concerning soil and resource conservation projects from all implementing agencies throughout the country must be stored, coordinated, and disseminated to prevent duplication of efforts. Most important of all, the government of Haiti must be convinced of the need to assess, monitor, and combat erosion or little can realistically be accomplished.

There are no panaceas for the improvement of the environmental situation in Haiti. Past and present improvement projects are not keeping pace with environmental destruction. If drastic changes are not initiated immediately, deforestation in Haiti will level off by the year 2000. The result will be a useless piece of landscape and a population in dire straits. If the projects offered within this paper are executed a reversal in the trend of environmental degradation can begin.

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INTRODUCTION

Haiti is a country whose predominantly mountainous terrain has been severely abused for at least two centuries. Excessive exploitation of forests and mismanagement of land use have nearly destroyed its once abundant supply of natural resources. Soil erosion has become so widespread and advanced that in many regions of the country the self-rejuvenating powers of nature have been stifled. Today, Haiti stands alone as the worst example of environmental degradation in the Western Hemisphere (USAID 1981). For an economy in which agricultural activities provide employment for at least 80% of the people (Anglade 1977) and account for nearly one half the gross national product, this degradation has had severe and profound reverberations (Schultink 1984).

Research Objectives and Design

Recent reports concerning deforestation in Haiti estimate the rate of forest cover losses between 5% and 7% annually (Joint UNDP/WBESAP 1982). It has been stated that 59% of the total forested area was eliminated between 1956 and 1977 and that only 9% of the country's land area was still covered with forests in 1978. As there has never been a systematic inventory of forest resources in Haiti, these statistics are considered unreliable.

This research has been designed to fulfill the need for accurate quantitative data on environmental degradation in Haiti. To accomplish this, land use and associated vegetation changes were studied at three sites in two regions of the country which represent different climatic ecosystems (Figure 1). Aerial photography from 1956 and 1978 was used as the primary data source, with site visits and a review of appropriate literature providing the proper perspective for the interpretive analysis. Another objective of this research was to test a hypothesis that the presence of good transport roads in Haiti have served to accelerate environmental degradation in their areas of influence. In order to test this, study sites were chosen so that each had a different road history.

Report Organization

This report consists of six sections designed to provide a concise presentation of research results. The first section is a synopsis of literature which gives the reader an historical perspective of environmental degradation in Haiti. It provides the socio-economic context of land use evolution and discusses its environmental impact. The second section is a summary of Haiti's ecological features. Climates, soils, and vegetation communities are discussed to provide the reader with an understanding of why environmental degradation is largely site specific. The focus of the third section is to discuss the vegetation changes which have occurred at the study sites from 1956 to 1978. In this section

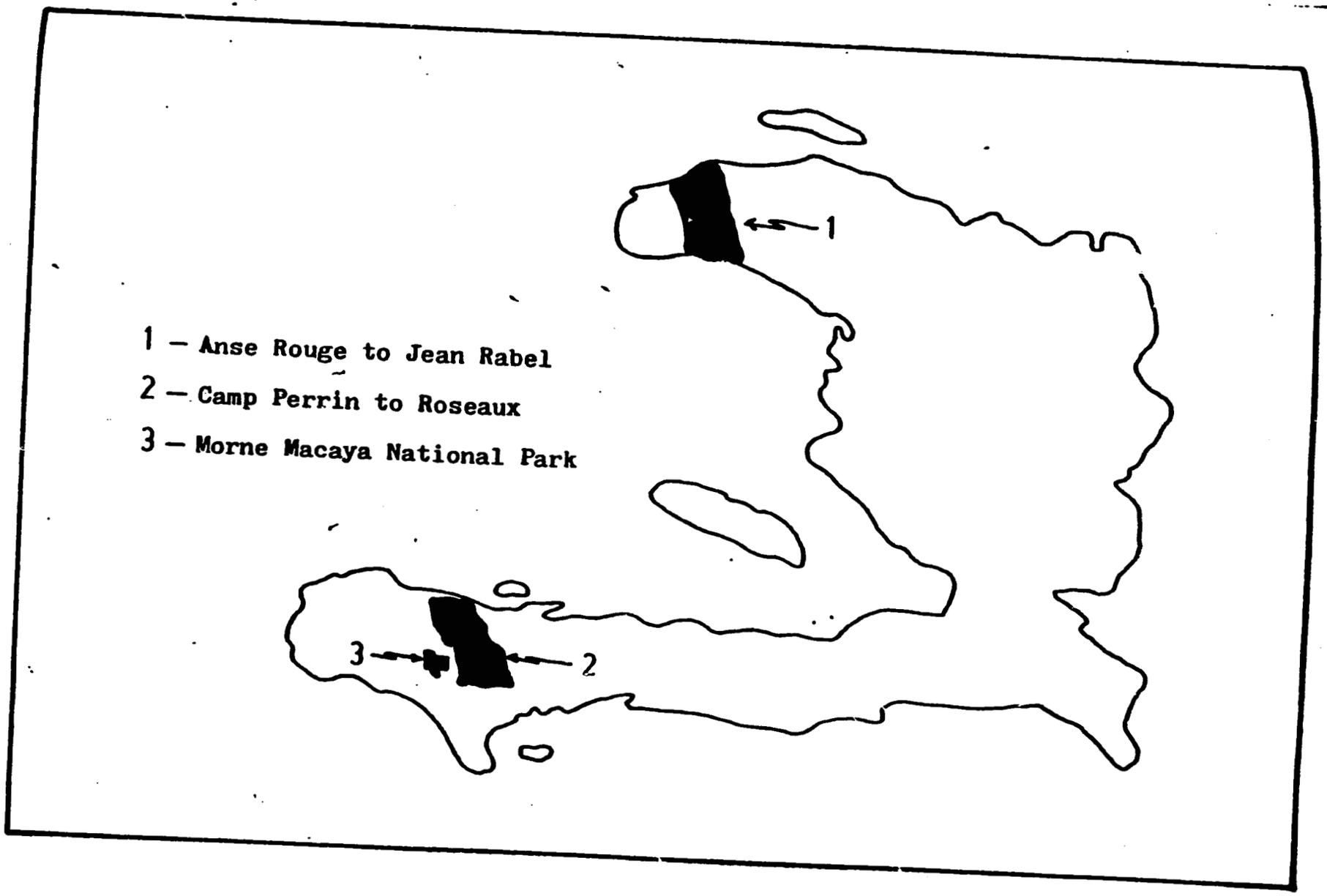


Figure 1. Location of study sites.

the photo interpretation results are presented. The fourth section combines the photo analysis with information from site visits in a discussion of road influences on environmental degradation in Haiti. The man-caused phenomenon of desertification is the topic of section five. It is demonstrated how the quantitative data of the photography analysis reveals this process at work in Haiti.

If wisely managed and conserved, the remaining resources in Haiti can be restored to provide an adequate supply of food, energy, and water for its people. Timber, sugar, coffee, and other processing and export industries can be operated on a sustainable basis giving a needed boost to the country's failing economy. To accomplish these goals will require a proper mixture of various inputs and willing cooperation between implementing agencies. The final section of this report discusses the reasons for past failures of the numerous environmental improvement projects attempted in Haiti and proposes projects, that if implemented, can begin to reverse the destructive trend of environmental degradation. What one should realize after reading this paper is that any implementation of projects aimed at the well-being of Haitian peasants cannot be successful in the long-term if the goal of environmental well-being is not also properly addressed. The reason for this is simple: the livelihood of the peasant in Haiti is inseparably tied to the productivity of the land which supports him.

HISTORICAL PERSPECTIVE

The severity of environmental degradation in Haiti today is the long-term result of an abusive system of land use. An understanding of this provides the proper framework for the implementation of constructive change.*

Early Years

The aboriginal people of the island of Hispaniola at the time of Columbus' arrival in 1492 were the Arawak Indians. Not unlike their "New World" neighbors, they subsisted on hunting, gathering, and farming (Wingfield 1966). Wise use of the timber resource in the mountains assured them of a continuous supply of forest products. Their farming activities were confined to the plains where productivity could be sustained allowing the physical environment on which they depended to remain basically intact (PAF, Inc. 1958). With the advent of colonization by the Spanish this picture began to change.

The Spanish colonials enslaved, massacred, and exposed these indians to diseases for which they had no natural immunities. In less than forty years their population dwindled from an estimated 1.2 million to 60,000. By the early 1600's French buccaneers began settling on the Ile de la Tortue near the northwestern coast of Hispaniola. As Spanish settlers became less interested in the declining productivity of their gold mines, the buccaneers began to outnumber them on the western one third of the island. In 1697 the Spanish ceded that part of Hispaniola to the French under the Treaty of Ryswick.

The Blossom of Degradation

The buccaneers, being of pirate stock, were not interested in farming. However, new French immigrants in the 1720's began to demonstrate steady profits from the cultivation of indigo, sugar, coffee, and cocoa on large plantations using African slave labor. Soon, plantations became so productive that they could no longer be confined to the plains, whereupon virgin forests were cut from entire mountain ranges to make room for what became descriptively known as "open sky plantations" (PAF, Inc. 1958). Other forested areas were harvested to supply a growing world market with highly valued hardwood lumber (de Young 1981). This, and related erosion of the soil were the true beginnings of environmental degradation in Haiti on a large scale.

* Except where otherwise noted the majority of the following information comes from two major sources, Leyburn (1941) and Palmer (1976). The reader should refer to these if a more in-depth perspective of Haitian history is desired.

Population Dispersal

In 1804, after a successful revolution, the slaves declared independence from France and within 20 years a drastic change in land use occurred. Under the rule of Petion a vast amount of public land was parcelled into small plots that were either given away, or sold at low prices non-discriminately. This facilitated a widespread dispersal and settlement of people throughout the mountainous countryside, where a multitude of small farms had to be hacked out of the forest. The effect of this action was largely responsible for the present severity of environmental degradation in Haiti.

From this point on Haiti's natural resources began to deteriorate rapidly. There are various reasons for this, but as depicted in Figure 2, population expansion is primarily responsible. Deforestation, to supply a growing world market with valuable hardwood timber, continued. In 1845 the exports of mahogany alone were 18,600 cubic meters (World Bank 1982). A growing urban population in Haiti began to require large amounts of fuelwood, charcoal, and construction materials (Woodring et al 1924). Rural population growth and a law requiring land holdings to be divided among surviving sons was causing a constant fragmentation of ownership and an intensified land use (Lundahl 1980). A lessening or elimination of the fallow period began to result in losses in soil fertility and site productivity (Smucker 1981). The rural farmer found it necessary to encroach further into the forest by squatting on public land in order to survive. By the 1920's the only remaining forests were confined to the more remote, steeply sloped mountains and areas of sparse population (Woodring et al 1924). In the agriculturally productive plains overcropping, lack of crop rotation, and a clogging of irrigation systems from watershed soil erosion was beginning to affect productivity (Wingfield 1966). Increasing amounts of exposed soil had lessened rainfall penetration rates contributing to a growing aridity in many parts of the country and an irregular water budget in numerous streams and rivers.

This scenario continued into present times where environmental degradation has become an integral element in the fabric of Haitian culture. The population has been increasing at nearly 2% causing it to double almost every 35 years (Wingfield 1966, USAID 1981). The estimated forest resource remaining in the 1950's was already down to 7%, most of which was a mixture of degraded hardwood with small patches of pine (Burns 1954). This was continually cut until 1981 when the government of Haiti terminated existing logging contracts forcing the closing of four operating sawmills (World Bank 1982). In many places farm productivity has become so poor that it can no longer provide a means of subsistance causing much of the rural population to look for another means of livelihood. With nowhere else to turn the forest is again their victim; this time for a greatly increased production of charcoal.

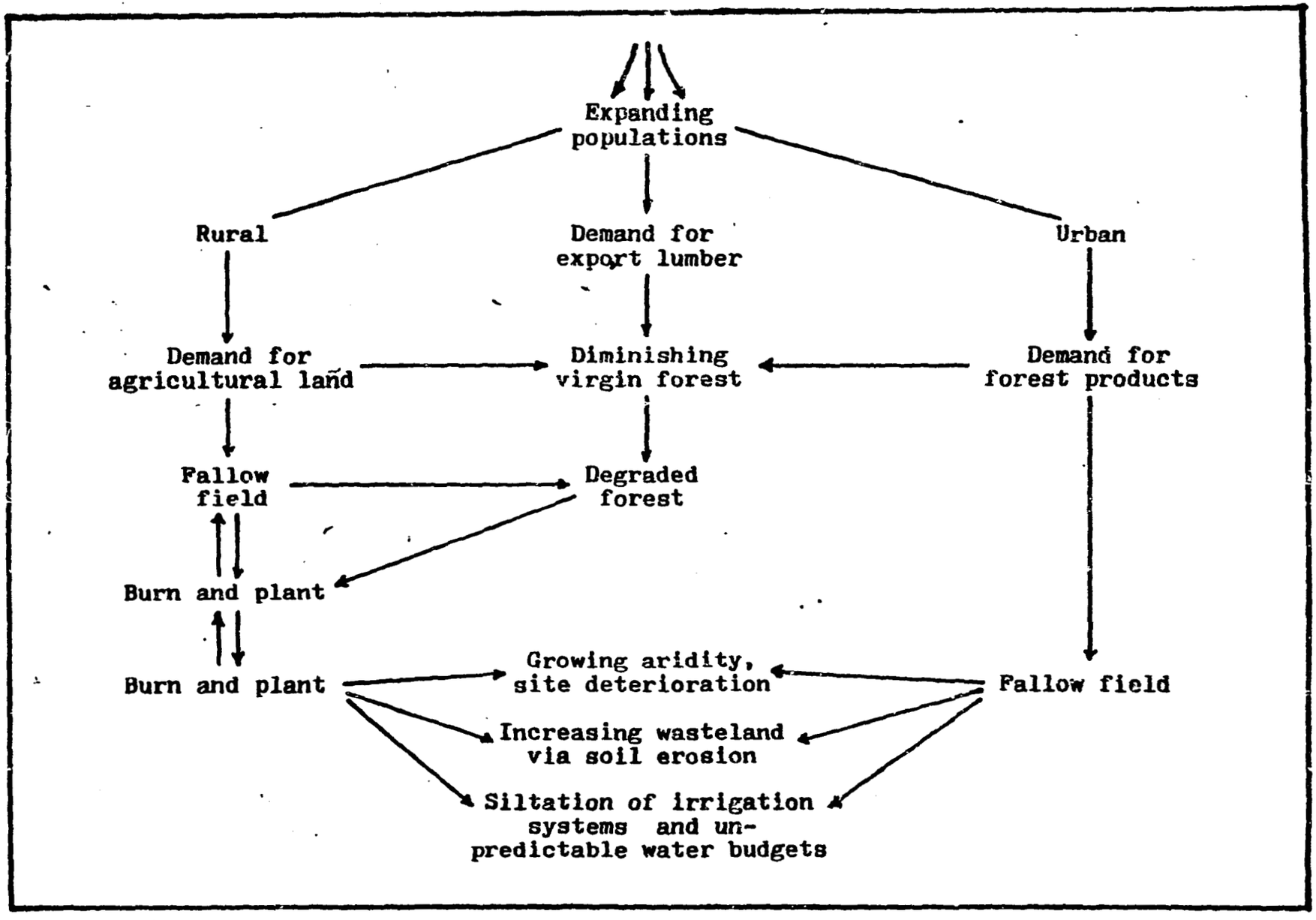


Figure 2. Schematic of historical land use and environmental degradation in Haiti.

Exhaustion for Tired Land

The production of charcoal is primarily a peasant industry (Smucker 1981). The level of production varies from region to region, but normally occurs in substantial quantities in localities where agricultural productivity is nil and there are no other significant economic alternatives (Voltaire 1979). When this occurs the region enters into what is called the charcoal cycle (Figure 3), which is a series of events usually beginning with agricultural crop failure (Ehrlich 1982). Before a community enters this cycle local forest resources supply them with all their fuelwood requirements. During the cycle all available plant material is used in the production of charcoal. Eventually, remaining forest resources are depleted and the community must begin to import charcoal for their own use, leaving them further impoverished. Many people then migrate to urban areas in search of employment.

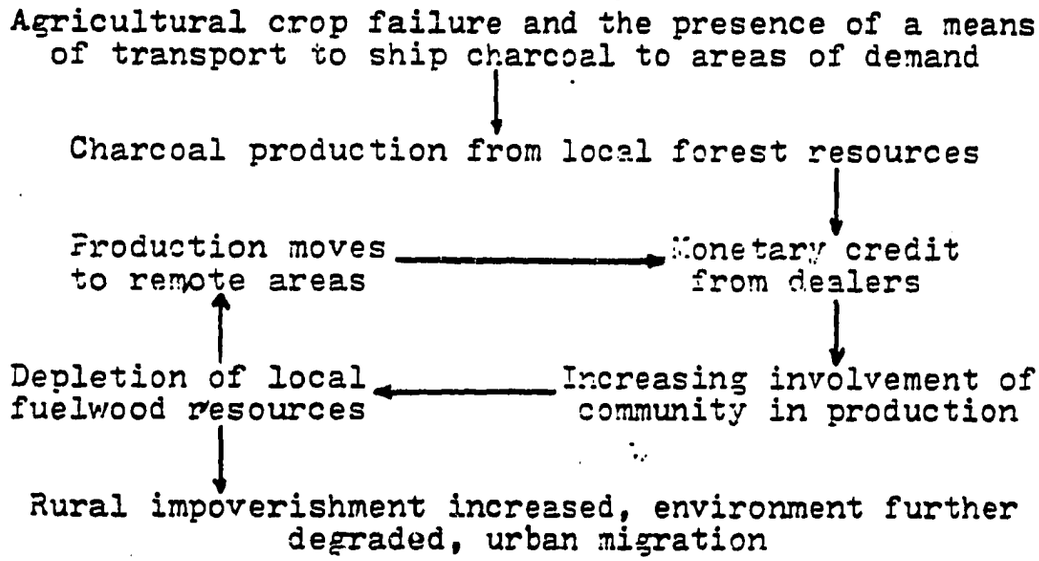


Figure 3. The "charcoal cycle" and its effect on local communities. (Adapted from Ehrlich, 1982).

A recent estimate revealed that wood consumption for energy alone accounts for 85% of all the forest products consumed in Haiti (World Bank 1982). Total annual fuelwood consumption is expected to reach an estimated 4.6 million m^3 in 1985. The current rate of annual regrowth and reforestation is not sufficient to keep pace with consumption, and few sources believe the wood supply will last to the end of this century.

(Editors note: To illustrate the point made above, a simple analysis can be performed. Fuelwood volume of a Leucaena leucocephala tree of 10 cm diameter is estimated at .095 m3 (Timyan, Joel, "Yield Estimates of a Leucaena leucocephala and Azadirachta indica Fuelwood Plantation near Port-au-Prince, Haiti", Agroforestry Outreach Project, Port-au-Prince, 1984). Dividing the conservative consumption estimate of 4.6 million m^3 by the Leucaena volume figure, one obtains a relative annual consumption rate in Haiti of 48 million trees of 10 cm diameter Assuming an estimated natural regrowth of 1.7 million m^3 or approximately 18 million trees (World Bank, 1982), the country still is confronted with a formidable tree deficit yet to be addressed by reforestation projects).

Charcoal production in Haiti effects the fallow period of agricultural systems and exposes vast amounts of soil; as such it is usually quite destructive to the environment.

ECOLOGICAL PERSPECTIVE

Climate

Four fifths of Haiti's terrain has slopes in excess of 8% (Lundahl 1980). These mountains are responsible for a large amount of moisture condensation from weather systems as they move across the country in a generally westerly direction. Consequently, there are higher amounts of rainfall on windward slopes relative to leeward slopes and an average of 50% more rainfall in the mountains than in the plains (Woodring et al 1924). This gives the country gradations in climate from arid to very humid.

Soils

Soils in Haiti consist of three general types: 1) alluvial - the most fertile, covering the plains and valleys; 2) limestone derived red clay near many mountain range summits - fertile but highly erodable; and 3) igneous derived - thin, infertile, and highly erodable, covering the remaining areas. Figure 4 shows the erosion potential for each study site when disturbed by deforestation and cultivation.

Vegetation

In Haiti, differences in rainfall, soil, and altitude have created natural vegetation zones that vary within short distances. The classification and mapping of these zones was first undertaken by L.R. Holdridge in the 1940's as part of a Ph.D. dissertation. Holdridge's system is based on vegetation communities in relation to humidity, precipitation, potential evapotranspiration, altitude, and temperature. Figure 5 displays the zones encompassed by the sites studied in this research.

In general, Haiti's climate is capable of supporting a mesophytic mixture of plant life where rainfall is normal and abundant, as in the southwest peninsula (Woodring et al 1924). This area is the second wettest region in the country (Leyburn 1941) with steep, high mountains and thick, rich soils. In this region rainfall comes regularly much of the year providing a high potential for rainfed agriculture (Hargreaves and Somani 1983).

In contrast, the northwest peninsula is an example of a xerophytic plant community. Rainfall here is less regular and abundant, depending mainly on moisture-laden prevailing winds which first strike the Massif du Nord to the east (Lantange et al 1979). Precipitation is generally variable from year to year, localized, and often extremely intense (Woodring et al 1924). Its dry, drought prone climate and predominantly thin, hilly and eroded soils also make this region the poorest in the country (World Bank 1982).

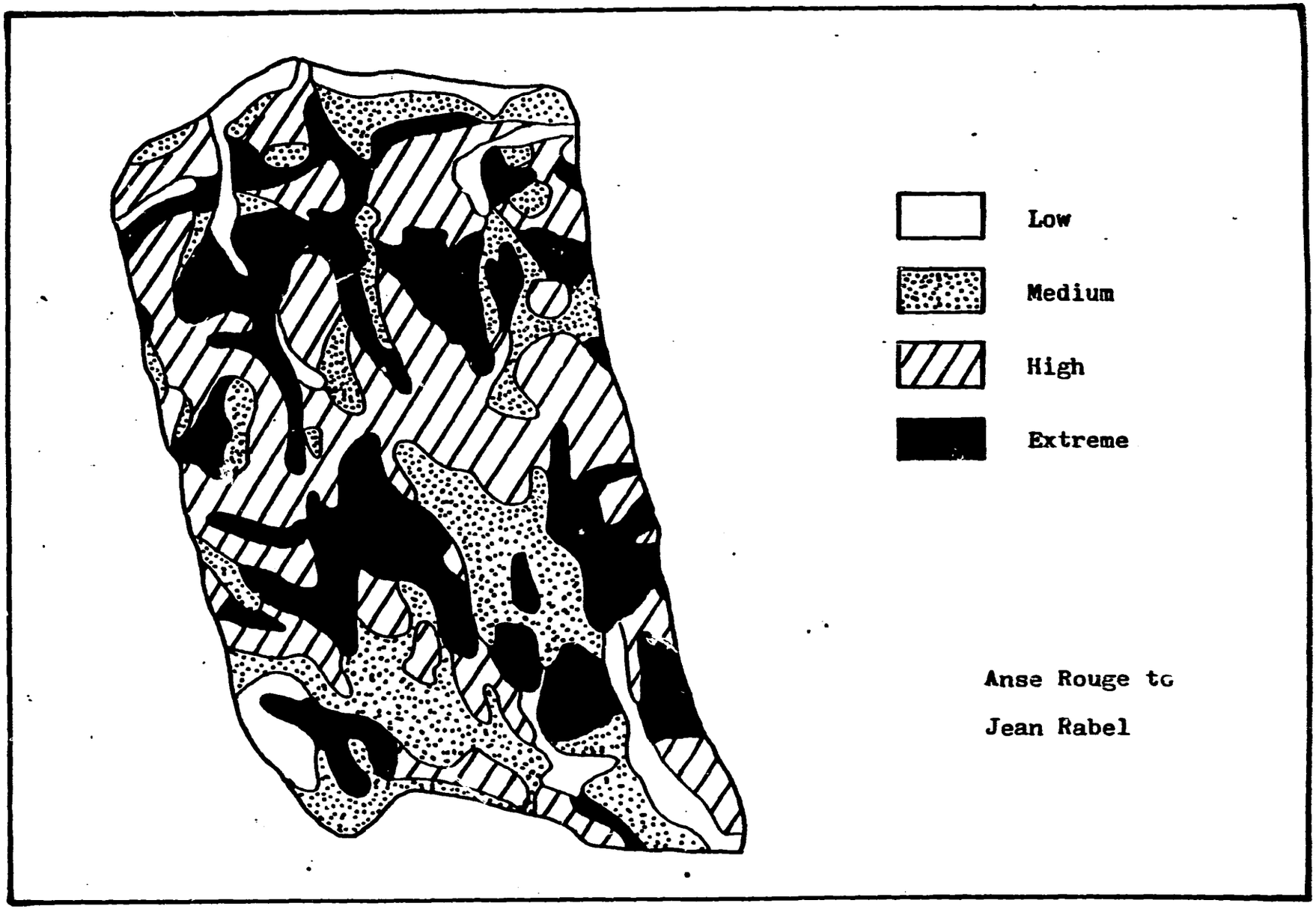


Figure 4. Erosion potential of study sites. (From DATPE, 1982).

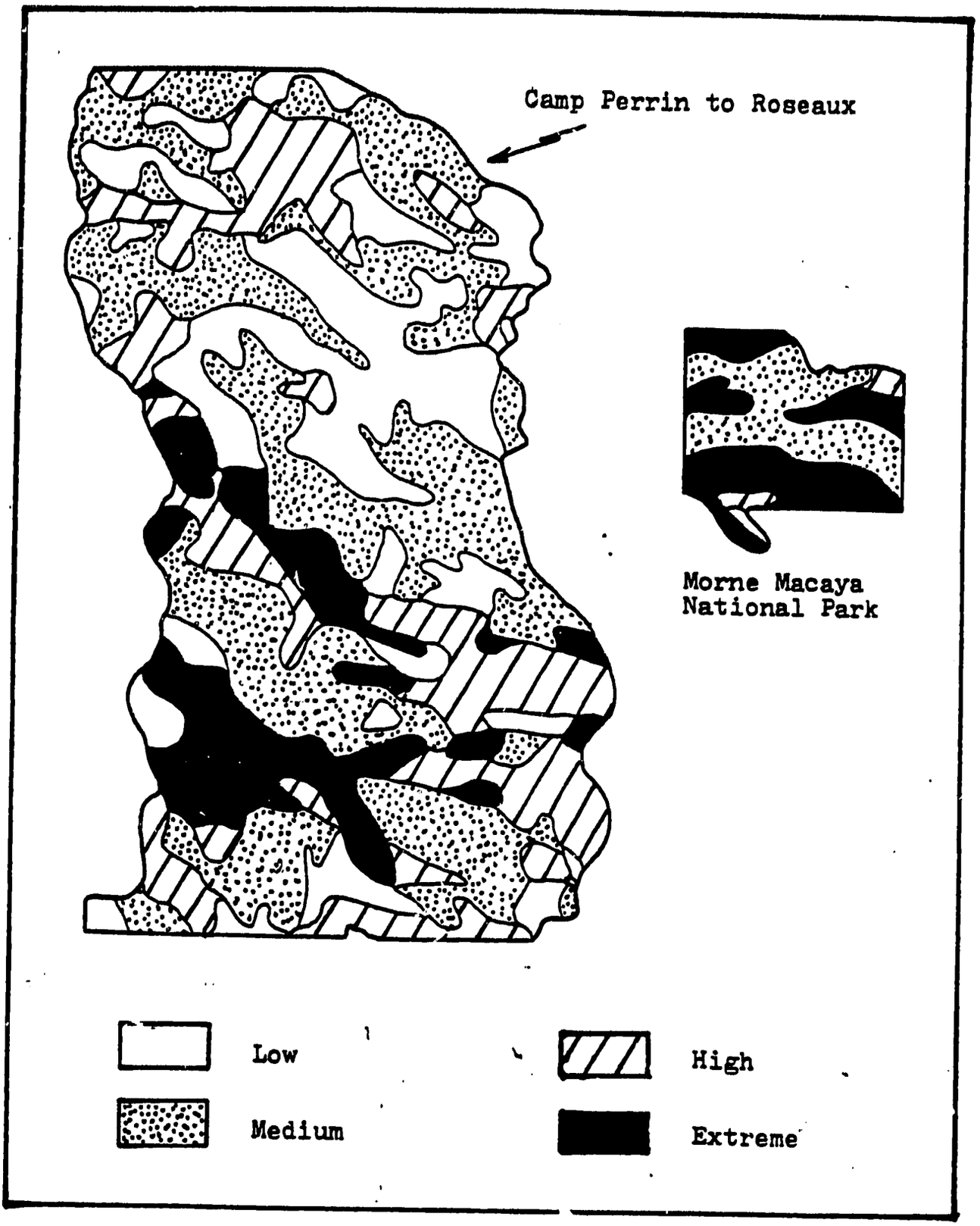
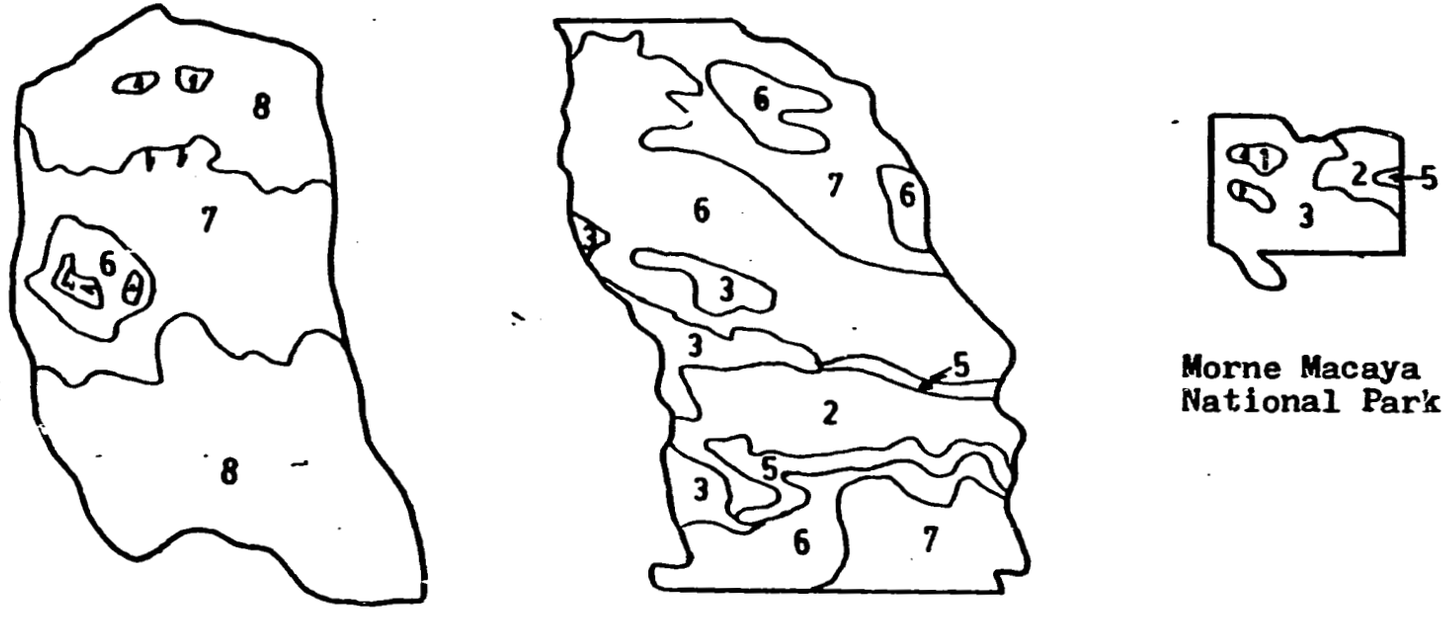


Figure 4 (continued). Erosion potential of study sites. (From DATPE, 1982).



1 Forêt très humide de Montagne

2 Forêt pluvieuse de Montagne de basse altitude

3 Forêt très humide de Montagne de basse altitude

4 Forêt humide de Montagne de basse altitude

5 Forêt pluvieuse de la zone Sous-Tropicale

6 Forêt très humide de la zone Sous-Tropicale

7 Forêt humide de la zone Sous-Tropicale

8 Forêt seche de la zone Sous-Tropicale

Figure 5. Study site vegetation life zones. (From OEA, 1972).

AERIAL PHOTOGRAPHY ANALYSIS

Changes in amount and type of vegetation are indicative of environmental degradation. They reveal land use patterns and allow inferences to be drawn about soil erosion and site productivity. To detect these changes in the research sites aerial photography from 1956 and 1978 was studied and pertinent data extracted and compared. The photos were available for use at Service Géodésie, Cartographie, et Topographie of the government of Haiti.

Vegetation Changes

Interpretive analysis of the aerial photography provided a vegetation type map of each site, representing conditions from 1956 and 1978 (Appendix 1). The Morne Macaya site was supplemented with additional data gathered during an overflight in 1984. These maps show different vegetation types which are separated into stands and given a number. The type designation and size of each stand is given in Appendix 2, where an explanation of stand components is also shown. The maps of each study site were quantitatively analyzed by weighted average computation and then compared to determine changes in vegetative cover.

Anse Rouge to Jean Rabel

As shown in Table 1, the study site in the northwest contained 16.6% exposed soil in 1956. By 1978 the amount of exposed

	1956		1978		
Type Designation	Area (ha)	Percent of Total	Area (ha)	Percent of Total	Percent Change
E	11709.4	16.6	29228.4	41.3	+ 149.6
L	24578.4	34.7	22596.0	32.0	- 8.1
D	32040.4	45.3	16710.8	23.6	- 48.0
Fo	58.0	.1	-	-	- 100.0
N	2344.8	3.3	2195.8	3.1	- 6.4
Total	70731.0	100.0	70731.0	100.0	

Table 1. Changes in vegetative cover from 1956 to 1978 at the Anse Rouge to Jean Rabel study site.

soil was 41.3%, an increase of 149.6% over a 22 year period. The total area under cultivation with an actively growing food crop or in a young fallow condition changed very little, from 34.7% in 1956 to 32.0% in 1978. The increase in amount of exposed soil came at the expense of the remaining area of degraded forest, which decreased from 45.3% in 1956 to 23.6% in 1978, a loss of 48%. The small amount of old growth, open canopied forest still in existence in 1956 had been completely harvested in 1978.

A combination of the categories of exposed soil and actively growing cultivated crop (Table 2) reveals that the percentage of

Relative Soil Protection	Type Designations	1956 Area (ha)	1956 Percent of Total	1978 Area (ha)	1978 Percent of Total	Percent Change
Low	E&L	36287.8	51.3	51824.4	73.3	+ 42.8
High	D&Fo	32098.4	45.4	16710.8	23.6	- 47.9

Table 2. Relative changes in soil protection as provided by forest vegetation at the Anse Rouge to Jean Rabel study site.

total area which provides little or no soil protection had increased from 51.3% in 1956 to 73.3% in 1978. A combination of those categories containing some degree of forest cover shows that the total area of soil with a protective cover decreased from 45.4% in 1956 to 23.6% in 1978, a rate of 1.0% per year.

Camp Perrin to Roseaux

This study site has undergone a similar process of degradation as the site in the northwest (Table 3). The amount of exposed soil nearly doubled from 9.4% in 1956 to 18.6% in 1978 and there was an increase of 126.7% of actively growing cropland. Here, these increases did not result in a substantial loss of degraded forest cover but supplanted the presence of a closed canopy, old growth forest, which decreased by almost 91% in the same 22 year period.

This site also degraded between 1956 and 1978, but Table 4 shows how the degradation process has not progressed as far as at the site in the northwest. At this site 47.3% of the soil had a protective forest cover in 1978 versus a 23.6% cover at the other

Type Designation	1956 Area (ha)	1956 Percent of Total	1978 Area (ha)	1978 Percent of Total	Percent Change
E	6493.0	9.4	12889.0	18.6	+ 98.5
L	10084.8	14.6	22862.2	33.0	+ 126.7
D	21528.2	31.1	20590.0	29.8	- 4.4
Fo	12452.8	18.0	10485.2	15.2	- 15.8
Fc	18107.0	26.2	1649.6	2.4	- 90.9
N	354.2	.5	343.0	.5	- 3.2
M	161.0	.2	362.0	.5	+ 124.9
Total	69181.0	100.0	69181.0	100.0	

Table 3. Changes in vegetative cover from 1956 to 1978 at the Camp Perrin to Roseaux study site.

Relative Soil Protection	Type Designations	1956 Area (ha)	1956 Percent of Total	1978 Area (ha)	1978 Percent of Total	Percent Change
Low	E&L	16577.8	24.0	3571.2	51.7	+ 115.7
High	D&Fo&Fc	52088.0	75.3	32724.8	47.3	- 37.2

Table 4. Relative changes in soil protection as provided by forest vegetation at the Camp Perrin to Roseaux study site.

site. Also, unprotected soil was 51.7%, whereas it was 73.3% at the site in the northwest in the same year. Although this site has not been as severely degraded overall, it has undergone more relative change. The rate at which forest cover was lost, and the rate at which the area with unprotected soil increased was 1.3% per year.

Morne Macaya National Park

Computations of the Morne Macaya site reveal most vividly the severity with which environmental degradation is claiming one of the last remaining thresholds of naturally productive ecology

in Haiti (Table 5). In 1956 this area was 100% covered with an essentially virgin forest. By 1978 only 14.8% of the area was still in this condition, and in 1984 just 3.6%. Only 38.2% of the total area contained in the Morne Macaya National Park site had any protective forest cover in 1984 and a full 61.8% of its soil was inadequately protected from the elements. Furthermore, the rapidity of vegetation changes is greater here than at the other two sites; 1.9% between 1956 and 1978 and 3.4% between 1978 and 1984.

		Type Designation						
	Year	E	L	D	Fo	Fc	E&L	D& Fo&Fc
Area (ha)	1956	-	-	-	-	6280.0	-	6280.0.
	1978	802.8	1816.2	1522.6	1209.6	928.8	2619.0	3661.0
	1984	1408.0	2470.2	1639.2	535.4	227.2	3878.2	2401.8
Percent of Total	1956	-	-	-	-	100.0	-	100.0
	1978	12.8	28.9	24.2	19.3	14.8	41.7	58.3
	1984	22.4	39.4	26.1	8.5	3.6	61.8	38.2
Percent Change	1956-1978	-	-	-	-	-85.2	-	- 41.7
	1978-1984	+ 75.4	+ 36.0	+ 7.7	- 55.7	- 75.5	+ 48.1	- 34.4

Table 5. Changes in vegetation cover from 1956 to 1984 at the Morne Macáya National Park study site.

Deforestation Trends

Based on the quantitative information from this study deforestation trends were developed for each site. Having only two data points, the relationship between time and deforestation for two of the sites appears linear. More realistically, deforestation is intensifying per unit of time, as the trend curve using the three data points of the Morne Macaya site represents. The other two curves were adjusted to depict a better approximation. The new shapes are based on the author's knowledge of site histories, and the realization that increases in population, soil erosion, and rural poverty have combined to accelerate the rate of deforestation in recent years and will continue to do so. As depicted in Figure 6, if deforestation trends are not reversed the remaining forest cover will be essentially eliminated at or

before the year 2000 from all sites.

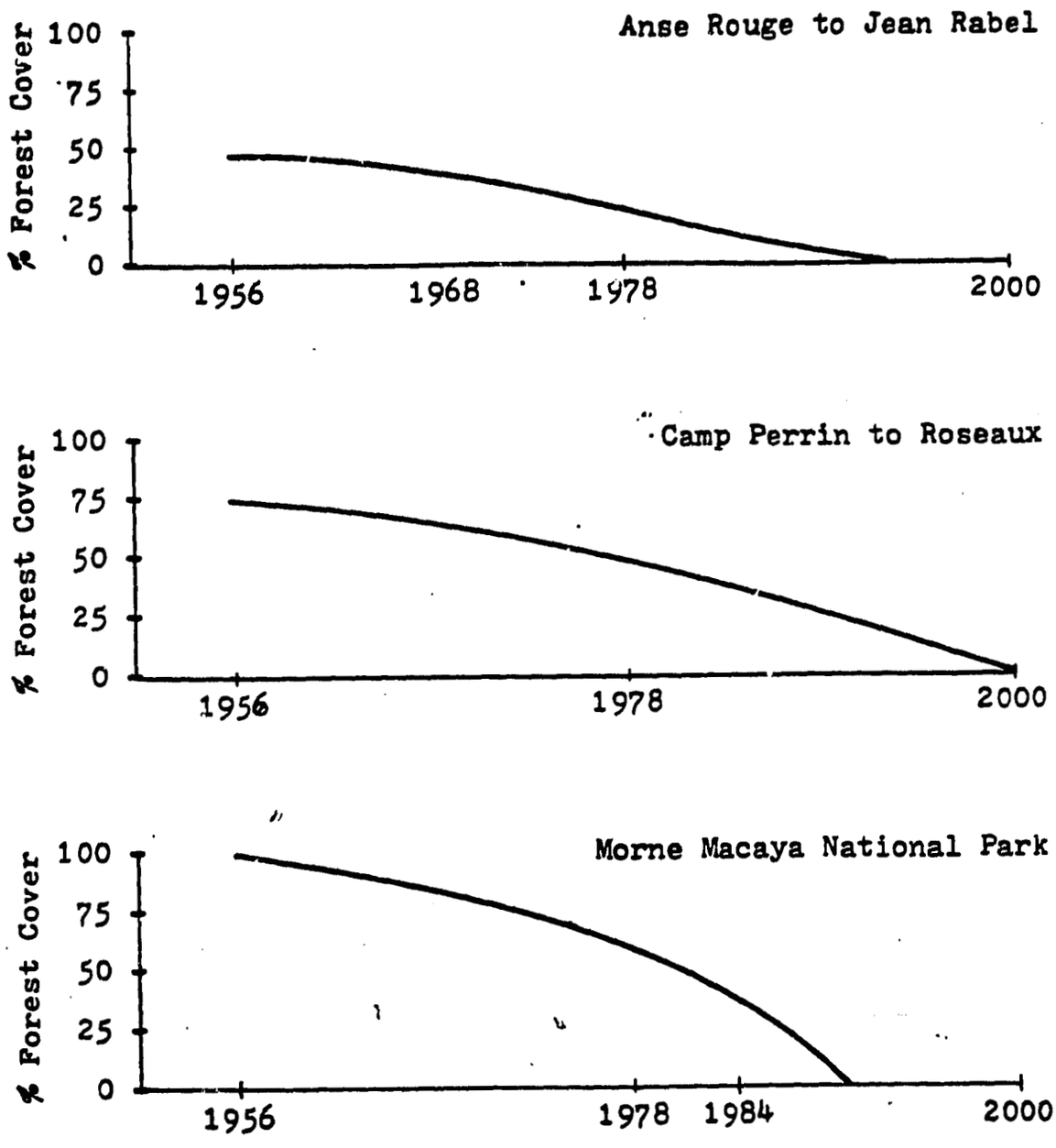


Figure 6. Deforestation trends at the study sites.

ROAD INFLUENCE ON ENVIRONMENTAL DEGRADATION

Transportation routes have been a continuous element in the development of Haiti's resources. The French expended large amounts of capital into developing road systems in the western third of Hispaniola (Lundahl 1980) and by the end of the 18th century a splendid network of roads existed in all the major plains (Leyburn 1941). The Haitian revolution brought about a dispersal of the population into almost every nook and cranny of the mountains. Working from the existing road systems, the peasants hacked out a multitude of foot trails and horse paths (Woodring et al 1924). During the US Marine occupation of Haiti prior to World War II roads were constructed connecting all the major cities. In the recent past, various voluntary organizations have helped construct numerous roads connecting smaller villages and communities. Presently, USAID is improving many of Haiti's roads under the Secondary Roads Development project (No. 521-0149).

Road Justification

The rationale and justification of road rehabilitation and construction in Haiti is indisputable. The presence of dependable transport roads is expected to lead to agricultural production increases by providing rural producers with tools and machines in regular supply, better access to markets, lower transportation costs, and increases in agricultural credit, extension, and applied technology (USAID 1982). Well constructed and maintained roads should increase health and education services and augment small scale housing, construction, and related business industries creating new jobs for rural people. Unfortunately, it is quite possible many of these benefits will never materialize. This is because of potential side effects associated with road construction.

Environmental Impact of Roads

Direct impacts on the environment associated with road improvement are usually modest and temporary, involving erosion and stream siltation (Anderson et al 1982, Devers, Inc. 1980). However, in many countries throughout the world improvement of road systems has acted as a catalyst in the severe acceleration of environmental degradation by providing improved access to previously remote and sparsely populated areas. What has often occurred is an intensification of land use, resulting in a gamut of detrimental effects. Among these are: 1) increased population settlement, 2) accelerated deforestation for lumber, fuelwood, charcoal, and new farm land, 3) more intensive farming and grazing activity resulting in a lessening, or elimination of fallow periods from agricultural systems, 4) increases in soil erosion and siltation of streams, rivers, and irrigation systems, 5) chemical pollution from an overuse of pesticides and fertilizers,

6) a lowering of the water table and leaching of plant nutrients, and 7) destruction of wildlife habitat (Ehrlich 1982, Anderson et al 1982, Vandervoort 1984, Somar International 1984, and Smucker 1981).

To determine the indirect effects road rehabilitation and construction have had in Haiti the three sites studied for environmental changes were chosen so that each had a different road history. The Anse Rouge to Jean Rabel site contains a road which was first constructed in 1968, near the midpoint of the time span covered by this study. The Camp Perrin to Roseaux site contains a road which was constructed by the US Marines prior to World War II. The Morne Macaya National Park site contains no road access.

The results of the vegetation analysis for each site, in combination with their road history, provides some interesting insights into the influence of roads on environmental degradation in Haiti. The following discussion is based on these results and on site visits, which included direct observations and discussions with local peasants.

Anse Rouge to Jean Rabel

Environmental degradation at this site was already in an advanced stage prior to the construction of the road in 1968. In this area of low natural resiliency soil productivity had become so low that farming pressures were responsible for the continual clearing of remaining forests. Seeking an alternative source of income in the 1950's some peasants in the area turned to charcoal production utilizing trees on their fallow fields. As there wasn't a good transport road in the area, most of the charcoal produced was shipped by boat from Mole St. Nicholas to Port-au-Prince, the primary market. The remainder was consumed in local towns and villages, transported via a network of trails. Transportation of charcoal in this manner was inefficient and the profit margin was held at a minimum so that only those in dire straits produced it in great volume. After the road was constructed transportation costs were lowered and for many peasants it became more profitable to produce charcoal than edible food crops. This resulted in a substantial increase in the proportion of producers in the population and the remaining forest cover was reduced at an accelerated rate.

Camp Perrin to Roseaux

This study site contrasts with the site in the northwest in several ways. It is not an arid region, but generally receives adequate rainfall, allowing vegetation to recover quickly after a disturbance. Much of the area is more mountainous, with steeper slopes and higher elevations. The soils are deeper, better developed, and more productive, and population pressure per unit area of cultivated land is among the lowest in the country

economics. As the need for income generation increased this road began to take on an increasing role in the degradation process. This continues today, as evidenced by the stacks of fuelwood which can be seen all along the road, and the common sight of the Haitian peasant carrying lumber on his head along this and other roads in the region.

Morne Macaya National Park

This site contains some of the highest elevations and steepest slopes in the country and has no road access. Consequently, it is also one of the most remote and inaccessible areas in Haiti. Although access to this site is provided by only a few winding and difficult foot paths, environmental degradation has been more severe since 1956 than at either of the other two sites studied. This shows that road access is not necessary for environmental degradation to occur in Haiti, but that other factors, such as land tenure patterns, loss of agricultural activity on other lands, a lack of economic alternatives, and population growth are needed to provide the stimulus.

CAUSE FOR ALARM

A healthy, closed canopy forest, especially in a tropical ecosystem such as Haiti's, is teeming with life. The efficiency of biological productivity under these conditions is extremely high, providing for constant regeneration of component organisms and a building of soil. Misuse of forested land in Haiti has caused much of its productivity to become severely limited. The elements of sun, wind, and rain in association with inappropriate farming practices on mountain slopes following deforestation have acted upon the soil to cause erosion and an increase of infertility and unproductivity. The more arid parts of the country have been most severely effected. In these ecosystems the occurrence of "pseudo-droughts," which are part of a condition called desertification, have become commonplace (Ewel 1977).

Desertification Defined

The term desertification has been defined by Grainger (1982), Sabadell et al (1982), and Dreque as man caused stresses on land resulting in sustained decline and/or destruction of biological productivity of arid and semiarid lands. If continued and unchecked such stresses may lead to ecological degradation and ultimately to desert-like conditions, causing an almost complete loss of soil fertility. In economic terms, land so affected will have a greatly reduced capacity to provide returns under cultivation, grazing, or other uses.

Desertification is not a new phenomenon (Sabadell et al 1982). As early as 500 B.C. a Greek writer referred to erosion and ruin of the once fertile lands along the coast of Turkey. Records indicate that the center of the Thar Desert in India was once a lush jungle. Accounts of Alexander the Great's conquests describe virgin forests where only deserts are found today. Until the 15th century, what is now the biologically unproductive Seistan Desert in Iran and Afghanastan was once known as the "granary of the east." Today, some 200,000 square kilometers (80,000 square miles) of arid and semiarid land deteriorates to the point of zero productivity each year throughout the world (Grainger 1982).

Desertification, by definition, is mainly confined to arid and semiarid lands with 250-575 millimeters (10-23 inches) of rainfall per year. However, it is generally a part of a much larger soil erosion problem and has also been responsible for the transformation of mountain watersheds and rain forests into deserts (Grainger 1982). In all of these environments man has allowed nutrients and organic matter to be stripped from the soil and not replenished. The main cause of this is soil erosion in which individual soil particles become detached from the soil mass (Coffey et al 1984). Remaining subsoil becomes hard and impervious, no longer absorbing rain (Grainger 1982). Plant material then has a hard time becoming established and organic matter

is removed from the system (Dreque).

The process of desertification is initiated when vegetation cover is reduced or destroyed by deforestation and then followed by improper cultivation techniques and/or overgrazing, especially on mountain slopes (Dreque). Overgrazing affects an ecosystem by leading to a decline in the annual production of soil protecting pasture vegetation and a decrease in the percent composition of soil holding perenial species. Removal or shortening of the fallow period from the agricultural system, even on generally level terrain, compounds the problem. It does so by eliminating the potential for soil regeneration from the accumulation of nutrients and humus content in the topsoil (Grainger 1982). Overcropping also causes decreased fertility by reducing the availability of plant nutrients in the soil.

Most scientists agree that changes in climate are not responsible for the vast amount of land going out of production each year (Grainger 1982). Seasonal, annual, and cyclical variations in precipitation are part of the long-term evolutionary process of an ecosystem (Sabadell et al 1982). Plants and animals become adapted to these naturally occurring variations and develop the ability to recover quickly. However, when ecosystem productivity is altered by severe degradation organism resiliency is greatly reduced. This causes a decline or disappearance of species rather than a period of dormancy which occurs during naturally caused stress periods. At this point, cyclically occurring droughts can act to trigger further degradation to the ecosystem. During a drought, degraded patches begin to link up and carry the process of desertification over extended areas. Eventually, a desertified area may join a climatic desert making the final result look as if the desert itself has spread.

A major characteristic of desertification is a lack of water availability for plant growth (Sabadell et al 1982). The scarcity of this commodity in arid and semiarid lands causes these areas to be extremely susceptible. When arid land soils are exposed to the sun they quickly become dried and crusted. A greatly reduced water percolation rate results, preventing moderate to heavy rainfalls from infiltrating (Figure 7). This loss of water seepage into the ground greatly decreases aquifer recharge and causes increased overland flow and gully formation. Streams and rivers become raging torrents after heavy rains and a trickle, or even dry at other times (Ewel 1977). With little water left in the soil, former plant communities have difficulty becoming established. A shift then occurs from mesophytic to xerophytic vegetation, or from partially xerophytic to more xerophytic forms of vegetation. Eventually, plants and microorganisms may cease to exist and the soil will remain bare.

In more humid and well watered ecosystems environmental degradation, if unchecked and sufficiently severe, can also cause an increasing aridity. Although a humid climate allows plant life to become reestablished more quickly, repeated soil exposure can

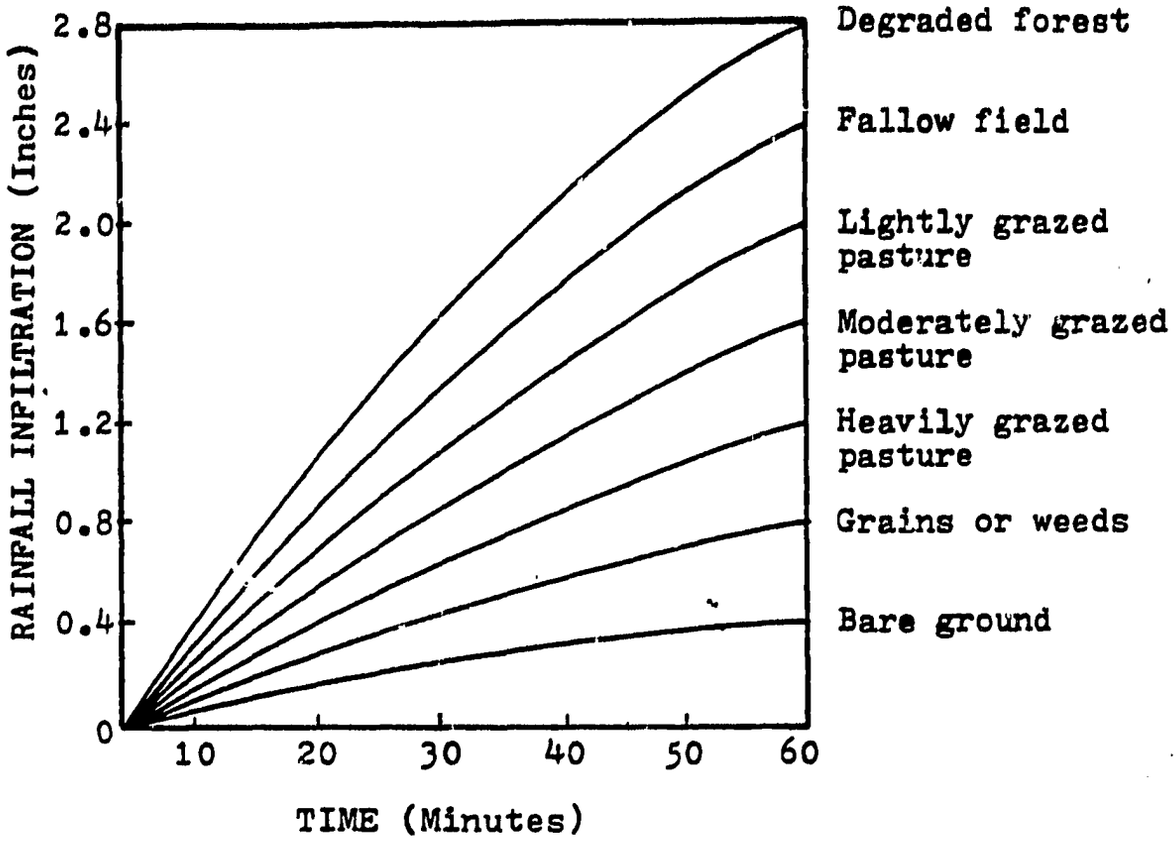


Figure 7. The effect of land use on rainfall penetration rates. (Adapted from Sabadell et al, 1982).

in time cause a loss of water from the system in the same manner as in arid lands but at a slower rate. Another cause of water loss does not involve the exposure of soil to the elements, but simply the removal of trees from the system. Humid areas are often mountainous and in contact to some degree with clouds, or are near coastal regions and frequently inundated with fog. Trees, acting as a "comb," can remove as much as thirty inches per year of water from this moisture-laden air (Vogelmann). When most of the trees are removed the ecosystem becomes more arid and the door is opened for desertification to set in.

Desertification can also result from a poorly designed, or malfunctioning irrigation system if drainage is not adequate and soils are allowed to become waterlogged (Sabadell et al 1982). Continual evaporation from the soil surface can bring up salts from the subsoil, leaving them in the topsoil. This salinization process eventually renders soil unusable.

Desertification in Haiti

A study of available weather data for various parts of Haiti doesn't indicate a trend of decreasing rainfall. Generally, records have been kept for too short a time period or contain too many gaps between entries to reveal trends. Where data is continuous, trends are not obvious because of tremendous variations from year to year. However, there are other indicators revealing the activity and procession of desertification in Haiti. These include severe soil erosion, nutrient loss, a reduction in rainfall penetration, unpredictable water budgets in streams and rivers, and the occurrence of "pseudo-droughts" which have affected agricultural productivity and caused a shift in vegetation communities towards more dry land type species (Coffey et al 1984, Ewel 1977, and Dreque).

The true scope and quantity of soil erosion in Haiti is difficult to determine as it has never been systematically measured (Zevukas 1978). However, it was estimated in the early 1960's by USAID and the Haitian Ministry of Agriculture that 80% of all cultivated land was suffering to some degree from erosion - most of it severely. Since as much as 90% of the total plant nutrient supply in Haiti is found in the top 10 centimeters of soil, this widespread erosion problem has caused greatly reduced agricultural yields (Ewel 1977, Berry and Musgrave 1977). Statistics for total food and agricultural production vary depending on the criteria used for indices (Zevukas 1978), but in recent years it has been shown that production rates have declined by .7 to 2.5 per year (USAID 1981). The severity of the problem may have been averted if the French had not rejected agricultural skills and techniques for farming marginal and mountainous lands available at the time in favor of African gang-line plantation methods (PAF, Inc. 1958). This "flatland" style of cultivation has been the primary method in use by the Haitian peasant since he began settling in the mountains.

Exploitation of forest resources through deforestation, cultivation, and subsequent soil erosion have caused ecological shifts in plant communities (USAID 1981). This has been especially apparent in xerophytic forest areas, such as the northwest. Here, the shift has been from primary climax tree species to secondary trees, shrubs, and cacti resulting in a thick tangle of bayahonde, acacias, yuccas, and agaves (Woodring et al 1924, Berry and Musgrave 1977, and World Bank 1982). In 1842 it was recorded that many of the once productive plantations had been claimed by a lively growth of cacti shortly after being abandoned (Leyburn 1941). Mesophytic regions in Haiti, such as the southwest, have been progressively shifting to less productive savanna plant communities.

Increases in the amount of exposed soil and shifts within the vegetation community of the study sites provides quantitative examples of the process of desertification at work. As shown in Figure 8, shifts from more biologically productive, forest co-

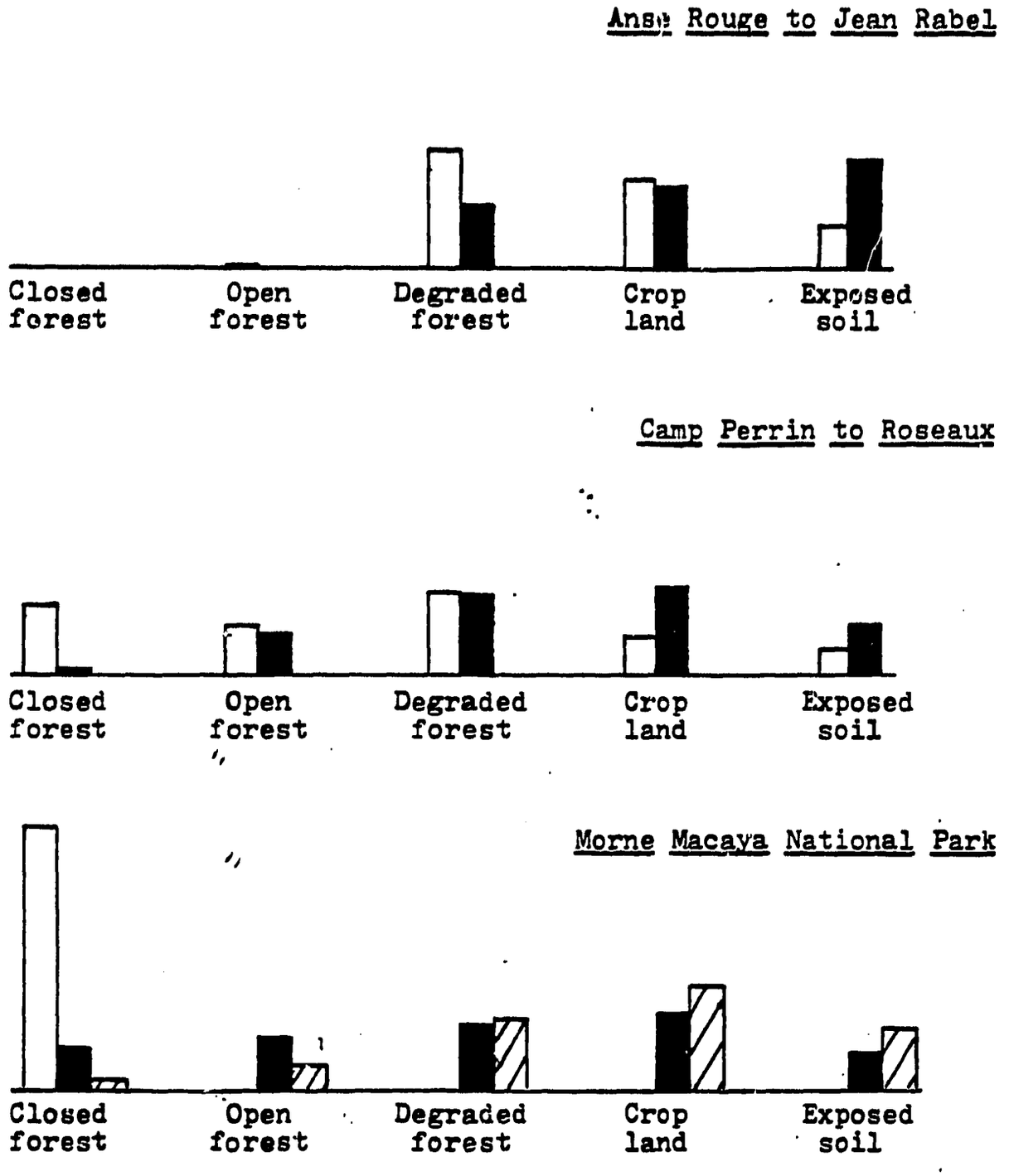


Figure 8. Vegetation changes over the time period of this study at each site. 1956 data is white, 1978 is black, and 1984 is hatched.

vered soils to less productive, often sterile bare soil have occurred.

The Anse Rouge to Jean Rabel study site is a naturally arid to semiarid region. As agricultural productivity declined and population increased from 1956 to 1978, more forest covered land was cleared to replace worn-out cropland. The low natural resiliency of this arid environment in combination with an excessive amount of charcoal production since the mid-1950's, has left it with a large amount of exposed, unproductive soil. The remaining forest vegetation is mostly of low density and is in a severely degraded condition, consisting largely of slow growing species with limited economic value.

The two sites in the southwest are not yet desertified. However, the soils of much of the region are on karst topography, and quite porous. This edaphic characteristic is responsible for a natural moisture availability shortage for much of the year. As environmental degradation increases, moisture is becoming a limiting factor in plant growth here. The shift in vegetation at the Camp Perrin to Roseaux study site has been one of reducing most of the remaining old growth forest to replace agricultural lands. A doubling in the amount of exposed soil over the 22 years covered by this study indicates this area is also headed for a desertified fate. The Morne Macaya National Park site is possibly undergoing the process of environmental degradation more rapidly than any other area in Haiti. Unlike Morne La Visite, another relatively remote area of the country, Macaya is presently not provided institutional protection. If the current changes in land use and vegetation cover continue they will eventually render this area biologically dead.

REVERSAL OF DEGRADATION

Negligence and Past Failures

There has never been a systematic effort to manage Haiti's forest resources on a sustainable basis (USAID 1981). In the early 20th century the government of Haiti was advised of the consequences of uncontrolled deforestation, but they did virtually nothing to prevent it (Otto and Sugrue 1980). The chronology of Haitian laws, decrees, and administrative decisions on forest protection is impressive, containing about 50 in number (USAID 1981, World Bank 1982), but a lack of funds, personnel, and institutional weakness have rendered all of these ineffective. One example is the establishment of the St. Raphael National Forest in 1926. As the boundaries of this reserve were never legally defined, they were unknown to those delegated responsibility for its protection (Burns 1954). Furthermore, if this forest was protected it would have eliminated a source of income for the government's General Revenue Service. As a result, no effort was ever made to protect the area and it was eventually released for agricultural uses.

The ultimate responsibility for forest resources has rested with the Ministry of Agriculture, Natural Resources, and Rural Development (USAID 1981). However, jurisdiction of land management has been somewhat fragmented. The National Council on Environment and Erosion Control has been responsible to the President for overall policy and protection of the environment and natural resources, control of erosion, and development of inexpensive energy supplies. The Division of Land Management and Environmental Protection within the Ministry of Plan has been responsible for land use and environmental planning. Much of the state owned land has been administered by the Land Division of the General Revenue Service, responsible for tax collection.

In the recent past the forestry personnel within the Ministry of Agriculture consisted of three people, only two of which had forestry training (World Bank 1982). The official field personnel list contained 37 forestry agents, 96 forest rangers, 25 timber control agents, and 5 reforestation agents. These government employees have been poorly trained, underpaid, and primarily concerned with fiscal and police functions. The Ministry's agricultural college has provided no effective training in soil conservation, forest management, or water resources (Otto and Sugrue 1980), and has conducted essentially no research in these areas.

Education of the general public in the way of conservation of resources has been limited (Leyburn 1941) and long-term effects virtually unsuccessful (Otto and Sugrue 1980). Most of the conservation efforts have been in the form of international assistance and private voluntary organizations from which financial and technical expenditures have often been inadequate and/or misappropriated. Nonetheless, it is with this assistance where the

hopes for trend reversal and environmental recovery lie. A listing of source agencies and organizations operating within the study sites is given in Appendix 3.

The USAID mission in Haiti funded a study to determine the reasons for the dismal failure of almost all attempted environmental improvement projects in the country. It was found that farmers live so close to the margin of life and death that they aren't inclined to risk their livelihood on technologies such as terracing, which have not been proven to them as successful (Otto and Sugrue 1980). Erosion control has not provided sufficient incentive for tree planting (Smucker 1981), as trees make grazing more difficult and take up space usable for other crops (Murray 1978). Farmers have been paid to plant trees, but not to maintain them (Otto and Sugrue 1980). Site and species have not always been compatible in reforestation efforts (World Bank 1982). "Ekips," or work gangs, which disappear once the work is completed have often been utilized, rather than local community groups. The end result has been a general lack of protection for seedlings, which are either grazed by livestock or cut down. In arid areas the survival of seedlings is further affected by a high variable rainfall (Lantagne et al. 1979).

Future Hopes

Environmental degradation is a manmade phenomenon and as such its control requires modifications in the ways man uses land. Foremost among these is the need to halt soil erosion. Rainfed farming production on better lands needs to be increased so that cultivation on more marginal lands is halted (Grainger 1982). There must be a restoration of forest cover in upper watersheds so that water resources are protected. Increased productivity and higher monetary yields on remaining agricultural lands must be realized via the construction of terraces and through the control of grazing and agroforestry intercropping techniques (Zevukas 1978). There must be an intensive effort to establish the formation of local community groups and involve them intimately in conservation efforts; not just in the initial stages, but in a way that assures continual maintenance (Murray 1978, Zevukas 1978). Peasants need to be educated as to the merits of soil conservation (Wingfield 1966). In upper watersheds the conservation of soil can make the development of hydroelectric power more feasible by reducing siltation of reservoirs (Voltaire 1979). This, in combination with the development of low cost cooking facilities, can alleviate much of the pressures for fuelwood from remaining forest resources. Perhaps the most important aspect of all is in helping the government of Haiti to establish the means and desires to assess, monitor, and combat soil erosion.

To overcome and reverse environmental degradation, a long-term time frame and commitment of financial, human, and technical resources is necessary for credibility and social acceptance

(Otto and Sugrue 1980). Areas of greatest need, and where rehabilitation is feasible, should be given highest priority (Ewel 1977).

Existing USAID Projects

Secondary Roads Development

Most existing USAID projects indirectly address the soil erosion problem in Haiti by attempting to improve the peasant farmer's economy. All successes in these projects, no matter how small, somewhat alleviate the stresses that farmers place on the environment. Of all these projects, Secondary Roads Development (Project No. 521-0149) has the greatest potential to bring about positive environmental change. This is because almost all other improvement projects depend to some degree on an effective road network. At the same time this project has the potential of acting as a vehicle for further abuse of the land, placing it in a precarious and paradoxical situation.

The direct effects of road construction on the environment are easily dealt with and will not be discussed here. It is with the prevention of indirect negative effects where the real concern lies. Due to the great dependence present and future improvement projects have on roads, they must be constructed. The challange is to be extremely discriminating in the placement of these roads, which unfortunately was not adequately addressed in the Secondary Roads Development project paper. Rather, it was assumed that the combination of benefits from all the other projects would act to sufficiently suppress substantial degradation increases. This is not so. At the very least, there is a fairly long lag-time between road rehabilitation and improvement of the peasant economy via other projects.

To eliminate, or at least substantially reduce road effects, the cost-benefit analysis for each road must be changed to realistically represent environmental costs (Vandervoort 1983 and 1984, Anderson et al 1982 and Devers, Inc. 1980). It must be realized that the different circumstances of each area will cause different reactions. Data needed for each road includes area population, wood energy use, industrial timber and pole requirements, soil erosion qualities, forest regeneration capabilities, traditional practices regarding access to forest products, community level authority for controlling access, trends in exploitation, length of fallow periods, crop yields, etc. More attention should be placed on a realistic appraisal of expected benefits. Only if these considerations are put in their proper perspective and cautiously weighed should a road be rehabilitated or constructed.

Agroforestry Outreach

Reforestation is a race against time; a struggle to overcome obstacles that are social, political, and physical in nature. Nonetheless, it is a sound overall approach that is basic to solving the degradation problem. Agroforestry Outreach (Project No. 521-0122) is the most successful and well financed seedling distribution and forestry extension undertaking ever attempted in Haiti. Its purpose is to motivate Haitian peasants to plant and maintain trees, and to obtain reliable information on the technical and socio-economic variables of reforestation in Haiti. This project could be improved by placing more attention on drainage structures within the individual cultivation plot, by more appropriate species selection on a micro-site level, and by reaching more farmers.

Establishment of National Parks

The Establishment of National Parks (Project No. 521-0169 (6)) is in concept an excellent general approach for protecting the Morne Macaya and Morne La Visite watersheds. If not protected, destruction of these ecosystems will cause a great deal of suffering, in spite of the combined benefits of all foreign aid projects. These two areas should also be conserved to protect the unique gene pools which they contain. Numerous species of flora and fauna in these environments are found nowhere else in the world (Judd 1984).

The real difficulty facing this project is not the establishment, but the protection of these parks. Additional funds should be allocated for the purpose of surveying their boundaries so that this protection can be realized. Cultivation of the soil should never be permitted, although in the future other economic possibilities such as timber production can be considered.

Major upper watersheds throughout the country should be included in the park system. In areas which have already lost virtually all their productivity through desertification, protection and wise management can bring them back to life. This has been accomplished in China, Russia, Israel, and other countries with great success. As the rewards of proper land treatment become evident, these reclaimed deserts should begin to cause a change in peasant attitude. The protection of major watersheds which are still productive is also essential. It must be realized that the loss of productivity on the majority of cultivated land in Haiti is not far off. Where it has not already occurred, most peasants will soon reach a point where their environment has been destroyed and will no longer support agriculture. The removal of upper watersheds from abuse will only take a small percentage of the total land mass out of agricultural production and will provide for a continuous and dependable source of water for downstream farming, irrigation, and hydroelectric projects.

Project Proposals

To improve the productivity of Haiti's soils several new projects should be initiated. Some of what are listed here will be difficult to attain; nevertheless they are essential to reversing degradation and restoring the well-being of Haiti's environment and improving its economy so a sustainable livelihood for its people can be realized.

1) Solar energy is an abundant resource in Haiti. By developing and distributing a cook stove which utilizes this energy the dependence on charcoal and fuelwood can be alleviated and a great deal of pressure on the forest eliminated.

2) Although by definition human populations are the cause of environmental degradation and desertification, it is not the population density or growth rates of an area which are singly responsible. Rather it is these in relation to an area's carrying capacity, or the population density the natural environment can support under a given land use system (National Academy Press 1982). As degradation increases an area's natural carrying capacity decreases. In Haiti, the capacity of a large percentage of the land to support farming is approaching zero, while population densities are steadily increasing. It is therefore essential that a massive public education program through all available media which infiltrates every corner of the country be undertaken. This program should profess two distinct ideas: population control and the wise use of natural resources. It is through the control of population growth that all potential hopes for improving peasant economies begins. For without such controls, other improvement projects simply postpone rather than eliminate a pending doom. The peasant must equally be shown the merits of soil conservation and the improved economy awaiting him if he internalizes these practices and puts them into action.

3) A terracing system which allows soil cultivation on mountain slopes without adverse environmental reactions must be developed in Haiti to deal with the unique circumstances here. In many countries throughout the world proper drainage structures have meant the difference between agricultural successes and failures.

4) State land ownership should be firmly established by legal survey. It is not necessary to remove the peasant from these lands, but restrictions should be imposed on land use practices. A requirement of any person remaining on the land must be to adhere to soil conservation practices. A management plan providing for sustained yields in the future must be written and strictly enforced.

5) The management, planning, collection of revenues, and enforcement of natural resource utilization must be consolidated under one main governmental authority. Trained foresters, soil conservationists, and hydrologists must be an integral component

of this governing body. The agricultural college should be provided with the means to conduct research in these disciplines and to provide improved training to students.

6) A project is needed which has the capability to systematically inventory, evaluate, and monitor the condition of Haiti's natural resources on a repetitive basis. It should also include the storage and coordination of past and ongoing resource management project information. This can eliminate a duplication of efforts when information requirements are common to more than one activity and provide for the dissemination of up to date and accurate maps, statistics, and general information. As feasibility studies for AID projects usually must contain detailed information about population, urban patterns, economic activity, land use, forest cover, soils, farm size, cropping patterns, water availability, etc., this information base can be used for planning and policy decisions. Essential components of such a system are adequate computer facilities which are capable of handling spatial and temporal data from state of the art remote sensing technology.

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APPENDIX 2

Vegetation Classification System and Examples

Type Symbol	Definition
E	Exposed soil.
L	Farm crop vegetation <10 feet in height. Predominantly agricultural crops which are cultivated at some time during the year (includes young fallow fields and pasture land).
D	Degraded forest cover >10 feet and <25 feet in height. Includes old fallow fields, fruit and yard trees, and forests in which all merchantable lumber has been removed.
Fo	Open canopy forest cover >25 feet in height. Indicates disturbance by man and/or nature.
Fc	Closed canopy forest cover >25 feet in height. Includes old growth and virgin forests.
N	Nonproductive soils. Includes beach, urban, and standing water.
M	Mangrove, and associated vegetation.

Each type may occur by itself, as in:

Fc = 100% Fc
Lc = 100% Lc

or in combination with 20% denominations, as in:

E6L4 = 60% E and 40% L
D2Fo4Fc4 = 20% D, 40% Fo, and 40% Fc

Stand Designation for Vegetation Type Maps

Site - Anse Rouge to Jean Rabel

Stand Number	1956 Type	1956 Size (ha)	1978 Type	1978 Size (ha)
1	N	1941	L8D2	1020
2	E6D4	3825	E4L6	4946
3	L2D8	3556	E2L4D4	2861
4	E6L2D2	1711	L4D6	4702
5	E8D2	1211	E8L2	13861
6	E4D6	1365	E6L4	3238
7	E4L4D2	5708	L2D8	156
8	L2D8	154	N4L4D2	310
9	E	77	E2L6D2	10312
10	E4L2D4	192	E4L2D4	2285
11	D	11705	D	1487
12	L	2998	E4L4D2	4015
13	Fo	58	E6L2D2	2329
14	E2L4D4	10398	E2L2D6	2107
15	E2D8	2729	E4D6	976
16	E2L6D2	4305	N2D8	111
17	E2L2D6	1057	E2D8	710
18	N6L4	673	E8D2	998
19	E6L4	519	L	533
20	L6D4	9283	L6D4	177
21	L4D6	1442	E2L8	1597
22	E2L8	1518	E	23
23	L8D2	3998	E6D4	9094
24	E4D6	308	N2L6D2	466
25			N	1841
26			N2E2L4D2	577
Total		70731		70731

Site - Camp Perrin to Roseaux

Stand Number	1956 Type	1956 Size (ha)	1978 Type	1978 Size (ha)
1	E4L4D2	3219	L4D6	5965
2	E4L6	161	E4L4D2	5947
3	D	3747	E2L6D2	3545
4	E2L4D4	3058	E2L4D4	4784
5	E2L2D6	1425	L6D4	4651
6	E4L2D4	391	L4D4Fo2	7890
7	E2L6D2	529	E8L2	1907
8	L8D2	115	D	114
9	L2D8	2529	L	400
10	E2L8	828	L8D2	705
11	E2D8	667	E6L4	2592

Camp Perrin to Roseaux (continued)

Stand Number	1956 Type	1956 Size (ha)	1978 Type	1978 Size (ha)
12	L4D6	2230	E2L8	1125
13	L6D4	299	E2L2D6	285
14	M	161	L2D8	285
15	N4L2D4	138	E4L6	1849
16	D2Fo4Fc4	2598	E2L2D2Fo4	1144
17	Fo	2460	L4D2Fo4	648
18	D6Fo4	1081	E4L2D4	991
19	L2D4Fc4	7610	M	305
20	L2D6Fo2	1287	L4M6	95
21	D4Fc6	1471	D4Fo6	2040
22	L4D4Fc2	253	E4D2Fo4	1582
23	Fc	9219	D6Fo4	1678
24	L4D2Fo2Fc2	1195	E2D4Fo4	572
25	L2Fc8	1563	L2D4Fo4	3011
26	L4D4Fo2	437	E6L2Fo2	1296
27	L2Fo4Fc4	989	E2L4D2Fo2	1543
28	L4Fc6	391	E2D2Fo6	667
29	L6Fo4	391	L2Fo2Fc6	514
30	L4Fo4Fc2	759	E	534
31	E2L4Fo4	575	D2Fc8	229
32	L2Fo8	299	E2L2Fo6	762
33	L2D2Fo2Fc4	437	D2Fo4Fc4	1639
34	E6D4	736	E4L4Fo2	1505
35	D4Fo4Fc2	1586	L2D2Fo6	724
36	E2L2D4Fo2	1104	E2D2Fo4Fc2	628
37	E4D4Fc2	506	Fo4Fc6	76
38	L2D4Fc4	322	E6D4	58
39	Fo6Fc4	1058	L6D2Fo2	171
40	Fo4Fc6	1563	E4D6	267
41	D2Fc8	713	E4D4Fo2	114
42	D4Fo6	437	E2L2D4Fo2	705
43	D2Fo6Fc2	276	E2L4Fc4	76
44	L2D2Fo6	184	D4Fo4Fc2	762
45	E4D2Fo4	575	D8Fo2	1220
46	E4D6	1770	D4Fo2Fc4	133
47	E2Fo4Fc4	437	E2D4Fo2Fc2	476
48	E4D2Fc4	1172	E4L2Fo4	400
49	E4D4Fo2	1609	E6L2D2	229
50	E2D2Fc6	1816	N	343
51	E4Fo2Fc4	506		
52	N	299		
Total		69181		69181

Site - Morne Macaya National Park *

Stand Number	1978 Type	1978 Size (ha)	1984 Type	1984 Size (ha)
1	D2Fo4Fc4	780	E2L6D2	1104
2	E6L2Fo2	381	D	290
3	L4D4Fo2	533	E	350
4	E2L6D2	1199	E2L2D4Fc2	320
5	E8L2	209	Fo	233
6	E6L4	133	E2L4D2Fo2	814
7	L4D6	457	E2L8	464
8	L4Fo6	76	E2L2D6	436
9	Fo	304	E2L4D4	640
10	L8D2	153	D2Fc8	204
11	E4D6	19	E6L4	58
12	D6Fo4	19	L4D4Fo2	698
13	E4Fo6	38	E4L6	669
14	L6D4	533		
15	D4Fc6	38		
16	E6L2D2	38		
17	D2Fo2Fc6	990		
18	E2L2D4Fo2	171		
19	D4Fo6	171		
20	E2L4D4	38		
Total		6280		6280

* In 1956 this study site contained only one stand, consisting of 6280 hectares of classification type Fc - virgin forest.

APPENDIX 3

Foreign Aid Natural Resource Projects Other than USAID at the Study Sites*

Source of Assistance	Duration of Project	Cost of Project	Nature of Assistance
CA/EMH/EPER	1965-Present	$ 40,000	Organization of peasants in the Grande-Anse region into 120 groups for development of agriculture, art, education, health, rural engineering and appropriate technology, reforestation, and livestock.
FAC	1983-1984	743,000	Experiment with irrigation by drilling on 120 to 150 hectares in the Plaine de l'Arbre.
IDA/BIRD	1982-1987	4,000,000	Program to counter the depletion of forest resources in Haiti. Reenforcement and restructuring of the Forestry Bureau, formation of forest technology, fuelwood plantations, and management of 20,000 ha of the Forêts de Pins.
RFA/ODNO	1976-1984	5,231,000	Agricultural and sylvicultural program in the Northwest to increase production, augment the revenues of peasants, guarantee long-term charcoal production, and food for work.

* From Rapport Sur L'Assistance External en Haiti, 1984. Programme des Nations Unies Pour le Développement.

Acronym	Definitions
BIRD	Banque Internationale de Reconstruction et de Développement (Banque Mondiale).
EMH	Église Méthodiste d'Haiti.
EPER	Entr'aide Protestante d'Aide aux Réfugies.
FAC	Fonds d'Aide et de Coopération (France).
IDA	International Development Association
ODNO	Organisme de Développement du Nord-Ouest.
UMCOR	United Methodist Church of America.

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