A RESOURCE POLICY ANALYSIS FOR THE FORESTRY SECTOR OF THE DOMINICAN REPUBLIC

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ABSTRACT

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There have been several forestry sector models used to analyze forestry policy proposals in the developed countries. However, economic data limitations, lack of institutional coordination, and lack of simulation models to project stand growth have limited the number of forestry applications devoted to developing regions. Furthermore, there are strategic considerations and non-marginal changes that need to be studied in the case of developing countries.

This study analyzes the present forestry policy in the Dominican Republic and an additional policy which includes several programs. To that effect, an institutional analysis and a simulation model were used. The simulation model deals with analyzing forestry policies for the DR for the period 1990 to 2045. Each policy was considered in terms of its effects on the forest resources over time.

Distributed delay techniques were used to simulate forest growth and allowable harvests over time. A population sub-model was developed in order to estimate potential demand of charcoal and firewood. For each program analyzed the model estimated the potential supply and demand of wood material at a given point in time.

Moreover, the decrease in forest land over time due to conversion to other uses was also estimated.

None of the three forestry program considered significantly delayed the depletion process of mature timber within the Dominican forests, when implemented individually. Mature timber within the Dominican dry forest was estimated to be depleted by the year 2002, regardless of the program considered. A combination of the three forestry programs offers better results, especially for broadleaf humid and pine forests. It also delays the depletion of material within the dry forest until the year 2006. However, forest areas were projected to decrease considerably, even under the combination scenario.

A major institutional and financial effort on the part of the Dominican authorities is necessary if the forest resources, specially fuelwood materials, will be available for future generations. A comprehensive solution that addresses various aspects of the problem represents the only avenue that offer a positive outlook for the sector.

To my parents, Beato and Eulalia,
my wife, Sarah, and my newborn
daughter, Gabriela

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INTRODUCTION

1.1 Nature and Extent of the Problem

The history of administrative actions concerning Dominican forests suggests that these resources have been managed primarily for conservation and/or preservation purposes. Thirty-eight percent of Dominican forest land is consigned to the category of "National Parks." The rest of the forests do not have any formal management prescription (Russo et al., 1988). In this study, the Dominican forestry sector is defined as the forest resource base together with the institutions involved in planning, management, and policy making for those resources.

While the Dominican government, through its executive and legislative branches, has been concerned with forest conservation over the years, one has seen a steady degradation of the Dominican forest resource base. Demands for charcoal and household firewood, as well as industrial fuelwood, have increased to critical levels in recent years. Around two-thirds of the Dominican population depend on firewood and charcoal for their energy consumption (Benson, 1984). Contrary to manufactured wood products, firewood and charcoal materials are entirely supplied by native forests. Moreover, levels of removal have passed natural regeneration, especially within the dry forests, creating a deficit which translates to a net loss of forested land over time.

According to The National Commission on Energy (COENER) the total consumption of solid wood for energy in the Dominican Republic was 4,172,700 cubic meters for 1985 (COENER, 1987). Likewise, the United Nations Food and Agriculture Organization (FAO) estimated a total consumption of solid wood for charcoal and firewood of 4,090,00 cubic meters for 1987 (Christiansen, 1987). This level of consumption, together with a very limited reforestation effort, has created some scarcity of forest resources. The continuous destruction of the Dominican forest, specifically of the dry forests, has had an impact on all socio-political and economic groups in the country.

There has been, however, an increase in the number of environmentalist groups in the DR. The number of ecology and environmentalist groups has grown from four to five in 1978, to around 90 by 1985 (Kemph, 1985). This increased level of awareness has facilitated some progress in stopping deforestation in some areas. However, legislation which aims to give incentives for reforestation is thought to be needed at this point (Cicero, 1988). In contrast, the legislators and the government are contributing to the debate by identifying production areas for charcoal and firewood. This decision to design production areas represents a departure from the official national forestry policy which has been characterized by a ban on commercial logging since 1967.

Likewise, the scientific community has expressed its concerns by undertaking several forestry production studies. The objective of these studies was to identify financially profitable forestry production areas (Knudson, el al., 1988; Potter, et al., 1985). The premise behind these studies was to decrease production in critical sites by the introduction of management activities in highly productive areas.

All sectors relevant to the Dominican forestry sector have had varied responses and solutions to the debate on the Dominican forestry sector. The major policy questions regarding natural resources will, however, arise over the intertemporal dimension of resource use (Rees, 1985). A significant question is whether it is economically and environmentally sound to continue with the ban on commercial logging. Answering this question is made more difficult because there is some confusion as to how to evaluate alternative forestry policies and compare them to the present policy scenario from an economic viewpoint.

1.2 Why a Resource Policy Analysis?

This particular study is concerned with forest policies. A *policy* could be defined as a course of action selected from among alternatives to guide present and future decisions. But what are the Dominican government's national forest policies? They are not contained in a single set of documents. Politicians and experts disagree as to what they are. There is no consensus even as to what purpose they should serve. Since policy is related to wise management, there may be confusion as to when a management decision becomes a national policy issue.

For instance, environmental groups argue that a problem with promoting private energy farms is that they will be established on agricultural land. Other experts think that energy farms could be planted on land that is presently idle, even if its natural vocation is agriculture, without hampering agricultural production.

One should be concerned only with the question of whether the national government should officially intervene in the decision-making process. Only in such a context do energy farms on private lands become a national policy issue. There is a consensus that reforestation of underutilized deforested land is a desirable aim on general principles. It is quite another matter, though, as to whether or not the government should offer incentives to private owners to encourage them to plant trees, or indeed, whether the government should require that all forest lands be maintained at a certain level of forest cover regardless of the economics of the situation or the wishes of the private owner. Most institutions in the Dominican forestry sector agree that continuous harvesting of wood material from the dry forests will eventually destroy these resources. Further, they seem to agree that opening up sawmills in the *Cordillera Central* region, where most watersheds are formed, will change the water regime and will affect the sediment load of streams in the area. In either case, the policy issue becomes complicated as one attempts to determine at what level of harvesting within the dry forests, or at what point on the water course and what level of sedimentation do these issues become matters of public concern. It does not matter what example one chooses, the answer is the same. A Dominican forest policy must be specific and must deal with those matters of national concern that merit consideration and actions from the legislative and executive branches of the Dominican governments.

There have been several studies in the last decade aimed at identifying efficient wood production regions within the Dominican forests (Knudson, et al., 1988; Potter, et al., 1985; Benson, 1984). Most, if not all, production studies conducted in the DR determined financial profitability of a particular forestry investment project. Production studies are limited to local conditions and interactions which may be different when the country is examined as a whole. Particularly, some economic factors may be left out when policy proposals are analyzed in a piecemeal fashion. A comprehensive exercise would require looking at the country as a whole and assessing real economic benefits or costs of a given policy structure. Furthermore, the importation of wood material plays a decisive role in the Dominican wood-based industry. International trade implications need to be accounted for in such a broader analysis.

A comprehensive resource policy analysis study would consider the forestry sector as an integral part of the global economy. This study could be very useful in the present nationwide debate on whether the DR forests should be used for commercial exploitation. Such a study needs to analyze different policy scenarios and determine welfare impacts of each scenario on the different socio-political and economic groups existing in the DR. This study might help 1) legislators in defining directions for the forestry sector, 2) public and private institutions in defining new priorities for the forestry sector, and 3) the government in taking courses of action aimed at improving the institutional framework surrounding the forestry sector.

The methods developed in this study may be used for guidance in conducting forestry policy analysis in other developing countries. Further, the techniques used in the institutional analysis could be particularly important in assessing the desirability and realism surrounding a given policy proposal.

1.3 Objectives

The central objective of the analysis is compare different forestry policy scenarios rather than to forecast the best forestry policy structure for the DR. The analysis is intended to serve as an active tool to help decision-makers identify economically sound forestry policy structures. Also, the model developed in the study is intended to serve as a general guide in identifying directions for the nationwide debate on forestry policy in the Dominican Republic. Finally, the study aims to serve as a tool in undertaking forestry policy analysis in other Latin American countries. The specific objectives are outlined below.

1. Set the basis for the elaboration of feasible and workable national forestry policies which might prove to be superior to the current policy structure.
2. Evaluate the effectiveness of the current national forestry policy structure from the institutional and forest resources viewpoint.
3. Make an economic comparison of the current forestry policy structure to an alternative policy which evaluate three different scenarios.

1.4 Implications of an Attitude Analysis

An attitude analysis (AA) explores individual institutional positions in order to present them, later, in a summarized and effective manner. The AA is helpful not only in obtaining detailed information about the position of each group regarding key issues of the Dominican forestry sector, but also in increasing institutional awareness within the forestry policy decision making-process.

Moreover, a summary of all group positions on key issues affecting the Dominican forestry sector will be useful in its own right. Such a summary will help both decision makers and the different groups participating in the process. Results from the AA might yield information on the relative power of the different group positions represented, helping each group to either pursue its strategy or change it accordingly. Likewise, the central government and the legislators will have an important tool with which to work. By exploring the range of positions and their relative power, government and legislators could select a strategy that better contributes to the conservation and wise utilization of the forestry resources in the country.

1.5 The Development of a Forestry Simulation Model

Forest resource allocation problems are of great importance in the developing world. Thus, policy questions regarding allocation considerations of resources are critical. There have been several forestry sector models developed, mainly to analyze different aspects of forest products trade for the developed world. Such analyses have produced short-term and long-term forecasts for the sector. However, strategic considerations for resource use are important for some developing countries. In these cases, a model must illustrate possible development paths and outcomes of alternative policy decisions (Lonnstedt, 1983). Hence, the model outcomes represent scenarios rather than forecasts.

This study develops a Forestry Simulation Economic Model (FOSIM) which allows for strategic considerations on intertemporal resource use. FOSIM is comprised of several modules (Fig.1.1). The first component is the demand module, where demand equations for charcoal, and firewood products are specified. The second module of the model is the supply module. Here, the native forests are thought of as capable of producing two kinds of raw material: wood material suitable for the production of charcoal and firewood, and timber material suitable for lumber production (Figure 1.2). The dynamics of forest growth is captured by the use of differential equations which represent the distribution of the time transits from one diameter class to the other. The rate at which the forest grows will be a function of the available volume at time t, the amount of forest land at time t, the forest management prescription used, and the forestry policy structure under consideration.

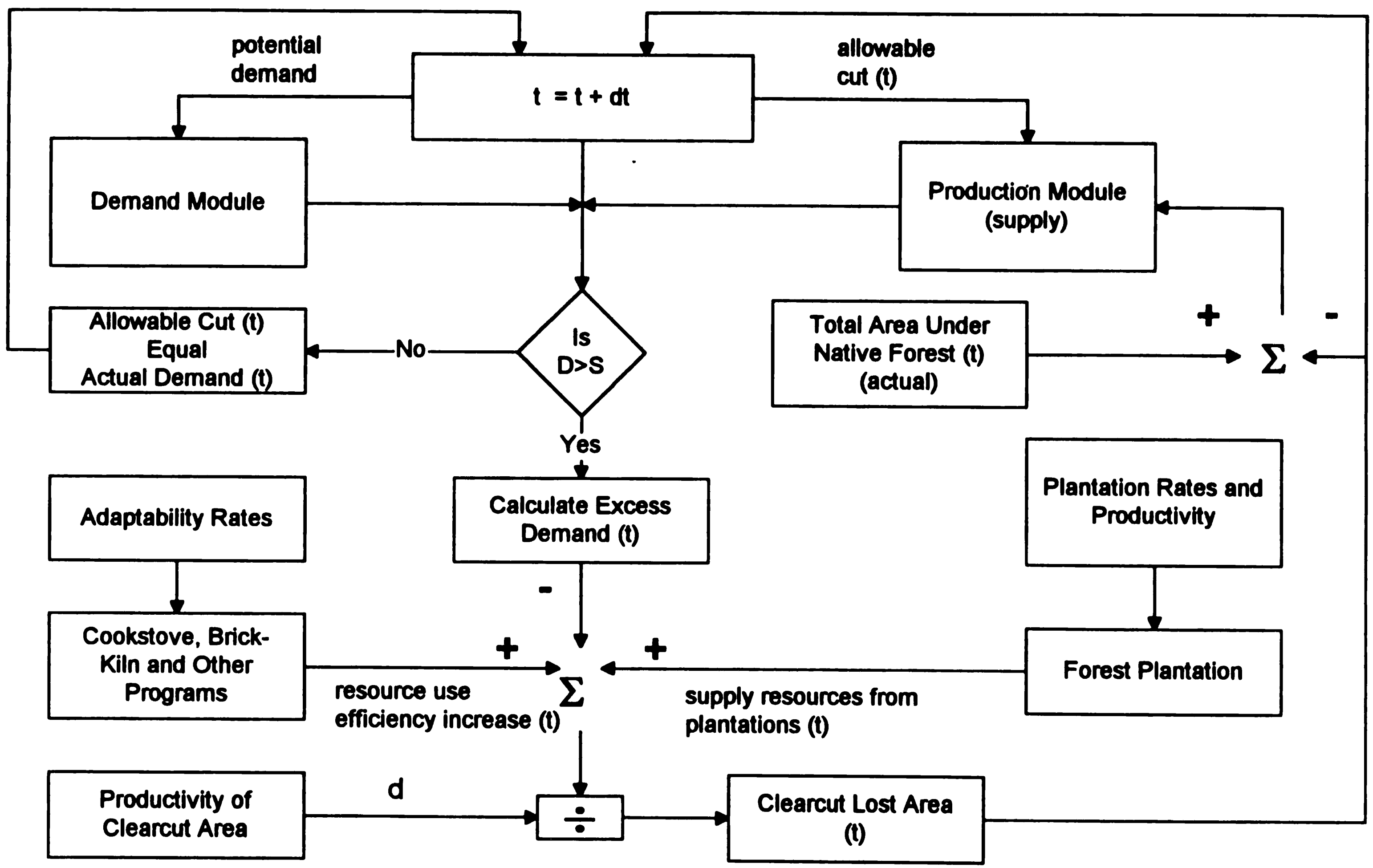

Figure 1.1. FOSIM Iterative Process

Wood demand and supply equations are estimated using time series data on prices, gross domestic product (GDP), and other relevant economic variables. Imports of forest industrial products and roundwood are introduced to the domestic market. The price of the forest product is defined by the potential demand and potential supply in the case of charcoal and firewood markets.

The strength of the model is its ability to answer the "What if?" questions relevant to the situation at hand. FOSIM could be used by ministers, private and public organizations, the scientific community, and any other groups that may influence the future of the forestry sector. A distinct feature of FOSIM is its combination of quantitative and qualitative data.

The results from the Attitude Analysis enter the economic model though linkages with a Forestry Policy Module. This module affects both the land module and the forest management module. The model accounts, to some extent, for trade-offs emerging from the different socio-political and economic groups relevant to the forestry sector under consideration.

FOSIM could be expanded to determine the impacts that a given policy structure may have on domestic welfare, domestic wood-based industry, and forest products trade. It could also be extended to show some of the dynamic interactions existing between a given policy structure and the institutional framework. One difference with other forestry sector models is the flexibility that FOSIM has in working at different levels of disaggregation. FOSIM is intended to be used in developing countries which are too small to have a profound effect on the welfare of foreign suppliers or demanders.

1.6 Data Collection on Forest Production in the DR.

There are several studies concerning the Dominican forestry sector which are referred to in this analysis. The present study derives most of its production estimates from *Pre-feasibility Analysis For The Forestry Management Activities in the Dominican Republic* (Potter et al., 1985); *Fuelwood and Charcoal Research in the Dominican Republic* (Knudson et al., 1988); and *Plantaciones Energéticas y Producción de Leña y Carbón* (Per Christiansen, 1987, Energy Farms and Charcoal and Firewood Production). Other production studies were also be taken into account as required. Likewise, the study conducted by the Junta Agroempresarial de Co-inversion y Consultoría (JACC), 1989, *Diagnóstico Subsector Foresta* (Diagnosis Forestry Subsector), is used as a guide for the section institutional framework and the identification of relevant groups surrounding the Dominican forestry sector.

1.7 Scope & Limitation

The present study does not represent forestry production research. It rather draws its production estimates from already existing studies. The study aims to evaluate the performance of a given forestry policy structure under a given institutional framework.

Accordingly, the study is concerned with the issue of forestry resource use over time. The study is also concerned with the role that institutional framework plays on policy outcomes, and simultaneously, with the effects that a given policy structure may have on institutional behavior. Hence, the study will analyze different policy scenarios in a search for an economically sound forestry policy structure, given a particular institutional arrangement.

A limitation of the study is its ability to estimate welfare changes to the foreign sectors. FOSIM is intended to be used under the "small country assumption." Under such an assumption the forestry sector under study is considered to be too small to have any profound effect on foreign sectors. Other limitations are in the different techniques used to estimate parameters. These shortcomings are directly related to the availability and reliability of economic data. Specifically, the lack of time series data on charcoal and firewood quantities (dependent variables) imposes limitations in estimating demand equations for these products.

The results of the Attitude Analysis depended on whether key representatives for each group were interviewed. The questions included in the questionnaire were kept simple in the hope of obtaining better information. The author guaranteed from the outset the anonymity of the responses in order to minimize the bias introduced by a face-to-face interview.

THE DOMINICAN FORESTRY SECTOR

2.1 Resource Base and Land Ownership

2.1.1 Forest Resources in the Dominican Republic

There have been four major studies on forest inventory for the Dominican Forestry Sector: 1) a forest inventory conducted by the Organization of American States (OAS) in 1967; 2) the FAO forest inventory of 1973; 3) an environmental study of the Dominican Republic conducted by Comprehensive Resource Inventory and Evaluation Systems (CRIES) in 1980; and 4) a forest inventory for the Baoruco and Sabana de San Juan regions conducted by MSU (Ramm, 1985).

The OAS study was based on aerial photographs taken in 1958. The area under forest cover was estimated at 557,000 hectares. Specifically, four different forest types were identified: 1) the pine forest which occupied 40 percent of the forest areas; 2) the mixed pine-broadleaf forest at 15 percent; 3) the broadleaf forest with 35 percent of the area; and 4) the dry forest at 10 percent (Table 2.1).

The OAS study considered the pine forest the most important forest type from an economic viewpoint. Hence, the study identified the regions with the highest potential for the development of the pine forest. There were three regions identified: the Cordillera Central with 172,000 hectares;

the Sierra de Neiba with 11,000 hectares; and the Sierra de Baoruco with 32,000 hectares of pine forest.

Table 2.1. Forest types in the Dominican Republic

Forest Types	Area in has	% of total area under forest
Pine forest	215	40
Mixed Pine-broadleaf	83	15
Broadleaf forest	189.5	35
Dry forest	69	10
Total	557	100

Source: OAS, 1967.

Though this study was rather general, it proved to be crucial in setting the basis for later studies. The main contribution of this study was a series of maps at a scale of 1:250,000 and 1:50,000 on climate, geology, soils, land use, distribution of population, and life zones based on the Holdridge classification.

The FAO study may well constitute the biggest effort to date toward inventorying and analyzing the different forest areas in the Dominican Republic. This study, conducted in 1971 and published in 1973, was aimed at identifying the economic potential of the different forest types and

Table 2.2. Forest areas in hectares by region and forest type (in thousand hectares)

	Forest Regions				
Forest Type	Baoruco	Neiba	Central	East	Total
Pine	46.9	13.5	274.3	---	334.7
Broadleaf	201.8	174.8	128.0	155.4	660.0
Other forest areas	56.0	41.0	----	4.9	101.9
Total	304.7	229.3	402.3	160.0	1,096.6

Source: FAO, 1973.

specifically of the pine forest in the Dominican Republic. The study used both aerial photographs and field samples for the most important forests (FAO, 1973).

According to the FAO, there were 1,100,000 hectares of forest land in the country. Of this total, 660,000 hectares were broadleaf while 335,000 hectares were pine forest. Likewise, there were 400,000 hectares of dry broadleaf forest and only 250,000 hectares of humid broadleaf forest (Table 2.2). Human intervention was considered to be at alarming levels. Sixty-five percent of the forest areas were found to be affected by logging operations, slash and burn agriculture, or fire and diseases (Table 2.3).

Table 2.3. Forest areas by region and kind of intervention (in thousand hectares)

Region	Hectares affected	Cut	Affected by Agric.	Pasture & Fire	Total
Baoruco	100.4	96.8	29.0	22.5	248.7
Neiba	87.2	58.7	35.4	7.0	188.3
Central	93.0	123.3	102.9	83.1	402.3
East	54.7	100.7	----	----	155.4
Total	335.3	379.5	167.3	112.6	994.7

Source: FAO, 1973.

The volumes of standing industrial softwood and hardwood in the accessible areas of the Dominican forest lands were estimated to be 4,900,000 cubic meters and 7,000,000 cubic meters respectively. Further, there was approximately 10,000,000 cubic meters of wood appropriate for charcoal and firewood production (Table 2.4). The study also gave several management recommendations, among which the most important were: to forbid the practices of pasture and slash and burn agriculture within the Dominican forest; to organize the re-location of small farmers who practice slash and burn practices through a land reform policy; to organize the maintenance cutting of the young pine stands, with a volume of about 30,000 cubic meters per year; and finally, to plan the harvesting schedule in seven wood production areas with a cut of 3,100,000 cubic meters of pine and 1,600,000 cubic meters of broadleaf timber, within the next 20 years.

Table 2.4. Volume of standing industrial wood and charcoal in the accessible areas (in thousand m^3)

Region	Pine	Broadleaf	Total	Broadleaf for Charcoal
Baoruco	1,250	1,500	2,750	2,800
Neiba	10	1,300	1,310	2,100
Central	3,600	2,100	5,700	3,000
East	-----	2,100	2,100	2,400
Total	4,860	7,000	11,860	10,300

Source: FAO, 1973.

Recently, the FAO conducted a re-evaluation of forest in the DR. The study was undertaken in cooperation with the Dominican government and it appears in a preliminary version of the general document *Tropical Forest Action Plan* (FAO, 1987). Accordingly, it was estimated that the areas under forest cover in the country amounted to 871,000 hectares. These areas constitute 18.3 percent of the country's surface. However, it was estimated that 72 percent of the areas under forest cover have been affected by some kind of intervention (Table 2.5). The estimated standing volume was 21 millions cubic meters of wood within the broadleaf stands, and five million cubic meters of wood within the pine forests.

Table 2.5. Total areas under forest cover and status (in thousand)

Forest Type	Hectares Not-Affected	Hectares Affected
Broadleaf	203	444
Pine	39	185
Total	242	629

Source: FAO, 1987.

Comparing the original assessment of the Dominican forest resources by the FAO in 1973 to the FAO revaluation in 1987, the areas under forest cover decreased from 23.04 percent of the national surface in 1971 to 18.3 percent in 1987, which represents a decrease of 20.6 percent during that period. Furthermore, pine areas decreased by 27.7 percent, while broadleaf forest areas decreased by 17.4 percent during the period from 1973 to 1987. Without any management prescription to guarantee sustainable production within the Dominican forests, one can expect a rather drastic deterioration of those areas under forest cover which have been already affected by pasture and/or slash and burn agriculture. Since the affected areas make up almost three-fourths of the remaining forest areas in the country, delaying the quest for possible solutions will only provoke catastrophic results in the near future.

2.1.2 Land Ownership

Resource ownership is a crucial factor for any management program to be operational. Land, as a primary resource, must play an important role in any forest management program. However, determining land ownership in the Dominican Republic is not always a clear and straightforward affair. Though an official classification exists with unique definitions for private and public ownership, an operational system is also in place. Often, state ownership is defined as common property; hence, it is there for anyone to use it. This is particularly the case where public forest land is scattered through a region, making the use of vigilantes (government employees with some police power who protect public forest from cutting) rather expensive. Besides, the Dominican government often gives property title to farmers living and operating in public lands if they can prove that they have been occupying the land for a certain period of time. Hence, there is some confusion between land tenancy and land ownership. This particular land policy has encouraged farmers to cultivate forest land in high elevations of the country.

Pine forests are considered the most important forest type for the Dominican republic in the short and medium-term (FAO, 1973; Potter, et al., 1985). Most pine stands are located in Sierra de Baoruco and the Cordillera Central. Fifty-two percent of the pine area in the Baoruco region is in public ownership. Most land in the Cordillera Central is also in public ownership. These lands are either managed by the forestry authorities of the country or have been classified as national parks and are managed by the parks authorities.

2.2 Policy Tools

Forest policies need a mechanism through which they can be implemented. There are several implementation methods available, such as: a) physical controls; b) technical methods; c) direct investments or investment-influencing policies; d) education and promotion; e) and, pricing, taxes, subsidies, and other financial incentives. Since these tools are interrelated, they should be closely coordinated for maximum effect.

Physical controls are more useful in the short term. In the DR there have been several physical controls within the energy sector, such as rotating power cuts in electricity, controlling the supply of gasoline, controlling the level of wood material harvested for charcoal and fuel wood, and so on. Technical means used to manage the supply of fuelwood include the determination of efficient production technologies (brick kilns for charcoal), research on resource allocation, and choosing the least cost mix of energy sources. Technology may also be used to influence demand, such as introducing more fuel efficient wood cookstoves (i.e., ceramic stoves).

Investment policies have a major effect on both wood energy supply and consumption patterns in the long-run. A successful investment policy for energy farms would increase supply of wood material significantly in the medium and long-run. Investment in other sectors of the economy may also have an effect on forestry, such as the construction of dams and hydroelectric plants. Education and promotion can help to improve the energy supply situation by both making citizens aware of cost-effective ways to reduce consumption and changing the attitudes of small farmers toward forest resources. Plan Sierra, a community development project operating in La Sierra, has devoted a major effort towards changing farmers' attitudes toward forest resources.

Taxation and subsidies are useful policy instruments that can affect supply and demand of forest products too. For example, tax exemption policies such as the "55-88" law, which gives a 100 percent tax exemption for re-investments in or donations to the Dominican forestry sector, can help to improve the deforestation situation in the country. They can also increase investments significantly within the forestry sector. A policy of subsidies to small farmers in exchange for them planting a percent of their farm with wood trees or fruit trees can be effective in slowing down the erosion that results when forest areas are denuded. In sum, controlling the use of wood material through coordinated application of the policy tools is the main goal of fuelwood supply and demand management. FOSIM will be used to analyze the effects that different policy scenarios might have on the DR forest resources. Several policy tools will be utilized in the process, explicitly or implicitly.

2.3 Current National Forestry Policy

Most of the institutions relevant to the Dominican forestry sector argue that the country does not have a clear forestry policy. Rather, they say, one must infer forest policies from among the acts of congress in continuing or eliminating old legislation and posting new laws, and specifically from actions of the president, who often determines, through *decretos*, what is or ought to be the future of the forestry sector. One can only hope that in the long run such acts and actions reflect the will of the Dominican people. The set of laws and rules which govern the formulation and implementation of management programs in the country, however, is thought to fall short of being a national forestry policy.

Law 5856, promulgated in 1962, is still relevant for the sector. This law covers a wide range of activities. Its first article states that, "The present law aims to regulate the conservation, restoration, and foment and commercial exploitation of the forest vegetation, the transportation and commercialization of products thereof, and also the national administration of the forest service and the development and integration of the forest industry" (Consejo de Estado, 1962). One of the paragraph's of this article states that the law is applicable to all forest lands regardless of ownership. Table 2.6 summarizes the different capitulates and articles covered by Law 5856 of 1962 (adapted from Russo, et al., 1989).

The General Directorate of Forestry (FORESTA) was created through this law in 1962. The relationship between FORESTA and the Dominican forestry sector will be made evident in the institutional analysis of Chapter three. One can readily appreciate the degree of complexity of Law 5856-1962 from Table 2.6 above. It would be beyond the scope of this study to analyze the entire text of the law.

Table 2.6. Law 5856-1962: On Forest Conservation and Fruit Trees[1]

Titles	Section	Article No.
General Dispositions	One	1 through 9
Administration of the Forest Fund and Research & Education	I. Administration	10 through 17
	II. Fund	18 through 22
	III. Forest Research & Education	23, 24 & 25
Conservation of Forest Resources	I. Forest Fires	26 through 34
	II. Pasture and Slash and Burn Practices	35 " 40
	III. Diseases and Insects	41, 42 & 43
	IV. Protected Zones	44 through 47
	V. National Reserves & Protected Zones	48 " 53
	[2]VI. National Parks	54 " 63
	VII. Wood Preservation & Extraction & Elaboration of Forest Products	64 " 71
Restoration and Development of Forest Resources	I. Reforestation	72 through 78
	[3]II. Special Provisions for Coffee and Cocoa Plantations and Other Fruit Trees and Palm Trees	79 " 85
Forest commercial Exploitation	I. General Rules	86 through 105
	II. Guidance for Harvesting Wood Trees	106 " 114
	III. Ordinary Harvesting	115 " 122
	IV. Suspension, Cancellations and Renovations	123 " 126
Transportation and Commercialization of Forest Products	I. Transportation and Confiscation of Wood	127 through 135
	II. Commercialization of Forest Products	136, 137 & 138
	III. Commercialization of State Forests	139 through 146
Infractions & Sanctions	One	147 through 159
General Dispositions	One	160 through 164

[1] Adapted from Russo, et al., 1989.

[2] Managed by the Direction of Parks through Law No. 67-74.

[3] Managed by State Secretariat of Agriculture by Law 206-67.

There has been little change in the official perception of how to manage the Dominican forestry sector since Law 5856 was passed in 1962. Some of the relevant features of the set of rules governing forestry policy and management program implementation in the country are: a) the most important institution relevant to the Dominican forestry sector is FORESTA, which is run by the State Secretariat of the Armed Forces; b) it is forbidden to cut any wood or fruit tree without a cutting certificate from FORESTA (Article 87); c) it is necessary to prove land ownership before a cutting certificate can be issued (Article 91); and d) after 1985 there have been several laws, including incentive packages, to develop the forestry sector, such as the 290-85 and the 55-88. Though these incentive laws are aimed at attracting private capital for forest investment, the specific guidance for implementation is still unclear.

The results obtained after nearly thirty years of implementing a strictly policed forestry policy are far from positive. The Dominican forest resource base has steadily deteriorated. A steadily increasing population in the urban regions of the country has increased the demand for non-industrial forest products, such as charcoal, which increases the harvesting pressures on the native forests. Furthermore, a rapid deterioration of affected forest lands, due to erosion, is forcing small farmers to continue to move further into the unaffected sites. The situation is particularly dangerous in sites such as watershed surroundings, which are crucial for the production of water and electricity for the country.

The difficulty of implementing the present policy, as represented by the complex set of rules and articles, has brought concerns for the future of the forestry sector in particular and the country in general. Most groups seem to be blaming each other for the lack of good alternative policy proposals, rather than drawing strength from one another. However, they all seem to agree that the direct influence that the president of the country has regarding the Dominican forestry sector, limits the study and implementation of any proposed policy scenario. A further limitation of the Dominican case arises from the lack of understanding existing among the relevant institutions regarding each others' roles in formulating forestry policy alternatives for the country.

2.4 Forest Products: Markets and Industry

As a result of a rapid deforestation process during the 1950s and 1960s, the Dominican government, through a presidential mandate, closed down all sawmill operations in the country in 1966. The mandate No. 3777-69 states that no cutting permit will be given unless under a special situation and with the consent of the executive power

(Consejo de Estado, 1966). After this mandate, the country started to import all industrial forest products, especially softwood lumber products, plywood, and particle board.

In 1979 after hurricanes David and Frederick, it was necessary to utilize the fallen wood material. Hence, FORESTA started to manage some sawmill operations in the *Cordillera Central* region. However, this process provoked a rebirth of sawmill operation in the country which was once again controlled by Law 705 in 1982.

In sum, the Dominican Republic imports most of the industrial wood material and forest products it consumes. Natural forests, especially dry forests, supply all wood material for charcoal, household firewood, and industrial firewood consumed in the country. Further, it is estimated that nearly thirty percent of the wood material utilized in the furniture industry comes from broadleaf and pine forests located in the sub-humid regions, about 6000 cubic meters per year (FAO, 1987). All marketing operations are done exclusively by the private sector. Though a main marketing path can be identified for all products, there are several alternative channels, primarily for charcoal and firewood.

2.4.1 Fuelwood

Wood is one of the most important sources of fuel in the Dominican Republic. Two-thirds of the population depend on wood for heating and cooking (Benson, 1984). Firewood is particularly important in the rural areas where nearly 325,500 families consume firewood for cooking. However, urban populations use both charcoal and firewood, with a total of 226,900 families using charcoal and 142,600 families using firewood as the main fuel source (Table 2.7). FAO estimates that the demand for wood material for fuelwood surpassed 4 million cubic meters of solid wood for 1887 (FAO, 1987). The same study concluded that even by incorporating all dry forests into management programs, it would be very difficult to meet future demand.

The degree of illegality involved in the commercialization of forest products within the country makes it difficult to obtain reliable estimates on the quantities produced and consumed during a particular time period. The Development and Population Study Institute (IEPD) estimated that 100,000 hectares of forest are cut annually in the country. Further, the study suggests that only 20 percent of those areas regenerate naturally (IEPD, 1987). All firewood consumed in the country comes from the domestic natural forests, especially from dry forests. According to the FAO in 1987 the area with production potential for fuelwood material varies between 200,000 and 300,000 hectares.

2.4.2 Fuelwood Market.

The degree of humidity of the wood determines its quality for firewood. The length of the *palos* (sticks) is more or less uniform and the diameter required is decreasing as better material is no longer available (Russo, et al., 1989). Hardwood charcoal is considered to be superior to softwood charcoal.

However, there are few limitations regarding the quality of the wood. Charcoal quality depends on both the species utilized and the production process followed. The degree of dependency on fuel sources and an increasing scarcity in resource availability are responsible for a relatively inelastic demand curve for charcoal and firewood products. This particular characteristic of the demand may suggest that the market can tolerate, to some extent, an input substitution of softwood (pine) material for the traditional hardwood material. The implication of such a substitution will be examined in Chapter Five where the results for the different scenarios are presented.

Table 2.7. Number of Households that Use Firewood and Charcoal for Cooking in the Dominican Republic in 1986.

Region/Type	Firewood	Charcoal	Total
Whole country	358,900	369,500	728,400
Urban	33,400	226,900	260,300
Rural	325,500	142,600	468,100
Santo Domingo	14,400	94,900	109,300
Urban	3,000	71,300	74,300
Rural	11,400	23,600	35,000
Cibao Region	189,400	129,800	319,200
Urban	13,400	73,400	86,800
Rural	176,000	56,400	232,400
SouthWest	71,000	45,800	116,800
Urban	12,900	31,700	44,600
Rural	58,100	14,100	72,200
SouthEast	84,100	99,000	183,100
Urban	4,100	50,500	54,600
Rural	80,000	48,500	128,500

Source: COENER, 1987.

Charcoal is commercialized in 70 to 75 pounds sacks (35 kilograms). At a lower level of the commercialization chain, it is sold in three pound bags and oil containers of 15 to 30 pounds capacity. The firewood is sold by *cargas* (bundles) of 100 pieces at the farm, and bunches of 1000 pieces at the major markets. The main process of commercialization can be summarized as follow. The state gives a permit to the truckers who transport the charcoal from the production centers to the major markets. Retailers get the product from the market and sell it to the consumers (COENER, 1986). There are, however, other routes of commercialization in the country (Fig. 2.1). FORESTA controls the volume transported by a truck registration system within the production regions. The total number of vehicles authorized to transport charcoal in 1985 was 460. FORESTA gives from two to three permits per month to each vehicle. There is DR$0.05 tax per sack of charcoal plus a 12 percent ad valorem tax, regardless of volume. Also, there is a fixed charge per permit depending on the capacity of the vehicle. Firewood comes mostly from the same production centers as does charcoal. Here, however, truckers have already secured sales with bakeries and small industries. There are also some sales to retailers and consumers (COENER, 1987).

2.4.3 Prices

Charcoal and firewood prices do not follow any established path. Since the market is characterized by a relatively inelastic demand curve (Sedjo, 1986), an increase in product prices has little effect on the total quantity demanded. Indeed, prices are usually influenced by production and transportation costs and some institutional factors. In this sense, scarcity in the supply of the product, either from a decreasing physical supply or from an increase in policing operations by FORESTA, has a direct effect on market prices.

2.4.4 Non-Fuel Wood Sector

Most wood utilized in the construction sector and furniture industry is imported. However, native species account for up to 6000 cubic meters of the wood material utilized in these sectors (Russo, et al., 1989). Industrial wood is imported in the form of roundwood, logs, sawtimber, particle board, pulpwood, and paper and paper manufactures. The average foreign exchange expended on wood product imports for the period of 1975 to 1986 was US$55 million (Table 2.8).

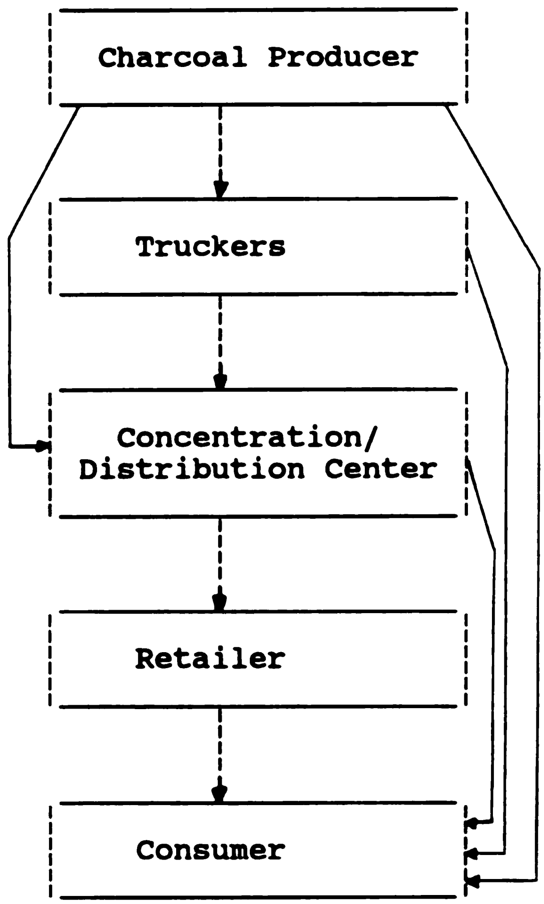

Fig. 2.1. Charcoal Commercialization Process in the Dominican Republic

Source: Jiménez and Ceballos, 1986. (Presented in Knudson, et al., 1989, p.149).

Table 2.8. Total Value of Imports of Wood, Wood Products, and Paper (in thousand US$, nominal)

Year	Paper & Carton	Wood & Manufacture	Total
1975	19,151	15,470	34,621
1976	21,311	18,997	40,308
1977	23,567	16,321	39,888
1978	27,289	16,424	43,713
1979	33,340	22,301	55,641
1980	43,276	29,780	73,056
1981	40,139	22,749	62,888
1982	42,102	24,323	66,425
1983	40,371	26,669	67,040
1984	40,735	19,494	60,229
1985	35,762	19,260	55,022
1986	37,398	23,739	61,137

Source: Anuario de Comercio Exterior, ONE, 1988.

2.5 Investment Opportunity within the Dominican Forestry Sector

Due to all the interactions and non-market forces that shape the Dominican forestry sector, decision makers have realized the need for treating investment planning, pricing, and management in an integral way. To that effect new incentive laws are being put into action to attract private capital into the Dominican forestry sector. The new legislation (Consejo de Estado, 1989) also specifies a series of management conditions that landowners must meet before the appropriate permits for planting, and subsequently harvesting, can be obtained. Although some progress has been made in the way government officials and legislators portray forest planning, the sector still does not play an important role in national planning. Since over 60 percent of the Dominican population rely on fuelwood to meet their energy needs, forestry planning should be therefore an essential part of national energy planning and hence, of national planning. It should be carried out in close coordination with the latter. However, policy implementation should rely mainly on market incentives and decentralized competitive forces (Munasinghe, 1988). Because physical controls (through the Armed Forces) have proven to be ineffective for the last 30 years.

2.5.1 Investment cost for energy farms

According to Knudson, et al., 1988, the yields for medium forest sites with a seven-year rotation is 175 cubic meters per hectare, when clearcut. The costs after seven years were estimated at DR$3,357 per hectare and the returns at RD$5,250 per hectare. Likewise, the costs after two cut and sprout regenerations, by age 19, were estimated at DR$7,000 and returns at DR$14,000 per hectare, in constant 1984 values. The internal rate of return for a 19-year investment was estimated at 20.6 percent in real terms. Serrata (1987) indicated that the cost of establishment was DR$ 2,447 per hectare varying from DR$1,363 to 3,702 per hectare. If recent inflation is considered, most plantations can be established for a nominal cost of DR$2,500 to 4,500 per hectare over one year or less over two years. Investment experience within the Dominican forestry sector is mostly limited to experimental cases conducted by some of the Dominican universities. A common aspect of these investment cases is the high initial income that is obtained through clearing of mature forest. Hence, the internal rate of return and discounted projected benefits would drop considerably if the plantations were proposed to be established in already cleared areas.

2.6 Efficiency and Yield Assumptions

2.6.1 National Cookstoves Program: Ceramic Cookstoves

A national program focussed on dissemination of high efficiency cookstoves such as *lorena* and/or ceramic stoves was thought to increase wood use efficiency by 20 to 35 percent over traditional methods (Munasinghe, 1988). Furthermore, the use of improved ceramic cookstoves in the Dominican Republic is thought to increase firewood efficiency up to 50 percent over traditional stoves (US Peace Corps, 1988). The present study assumed that improved cookstoves can increase efficiency by 30 percent over traditional stoves in the Dominican Republic (Table 2.9).

2.6.2 Brick Charcoal Kilns

The Instituto Superior de Agricultura (ISA) program on "Fuelwood and Charcoal Research in the Dominican Republic" yielded the most accurate and interesting results concerning charcoal production in the country. Under the project, studies conducted by Ferrer (1987), Rosado, et al., (1986), and Rodríguez (1987), among others, focused on the production efficiency of the traditional method, which consists of improvised soil kilns, and other technologies, such as the brick kilns. Their efficiency results suggests that brick kilns are at least 39 percent more efficient in weight yields than traditional kilns (Rosado, et al., 1986; Rodriguez, 1987; Ferrer, 1987). Accordingly, the present model assumed that brick kilns are 39 percent more efficient than the traditional soil kilns (Table 2.9).

2.6.3 Energy Farm Plantation Program

Most institutions relevant to the Dominican forestry sector have expressed a favorable opinion on initiating energy farm plantations to mitigate the demand for wood material from native forests. Furthermore, there have been several studies aimed at showing the financial profitability of such projects (Christiansen, 1987; Knudson, et al., 1988). Two plantation programs are analyzed in this study an "intensive" 20-year program which incorporates 25,000 hectares

Table 2.9. Assumptions considered for the policy programs included.

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1. A improved cookstoves program at a moderate or intensive rate will increase wood use efficiency by 30 percent for those households that adopt the program.

2. A moderate improved cookstoves program can be implemented within a 20-year period reaching either 50 or 70 percent of the households that consume firewood.

3. An intensive improved cookstoves program can be implemented in a 10-year period reaching either 50 or 70 percent of the households that consume firewood.

4. A national brick kilns program will increase wood use efficiency by 39 percent over the traditional soil-made kilns.

5. A moderate brick kilns program can be implemented gradually reaching to either 1000 or 1500 kilns at the end of a 55-year period.

6. An intensive brick kilns program can be implemented in a 30-year period, reaching either 1000 or 1500 at the end of the period.

7. A national energy plantation program can be implemented within a 20-year (moderate) or 10-year (intensive) period. Energy plantations are assumed to yield 15 cubic meters per hectare per year.

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in the first five years, and a "moderate" 17-year program (Table 2.9).

Plantation forests can be analyzed more easily than natural forests in the sense that given the first, second, third, and forth cutting cycles, a discrete approach can be used to model wood availability over time. Both the FAO (1987) and Knudson, et al. (1988) studies proposed using fast growing broadleaf species for the plantation programs. Moreover, they proposed the following cutting cycles for the original and regenerated stands. First, a 10-year cycle for the original stand; then, two seven-year cycles for the first and second regenerated stands; finally, an eight-year cycle for the third regenerated stand. Yield is estimated at 15 cubic meters per hectare per year (Christiansen, 1987; Knudson, et al., 1988).

2.6.3 **Allowable Harvest Parameters**

The loss of forest due to fuelwood and charcoal demand depends on two main variables: allowable harvest, and the yield obtainable through clearcutting. The first can be defined in terms of annual growth per hectare, while the second represents total standing volume per hectare, both in cubic meters. The allowable harvest is also a parameter of the climate regime and the species considered. In our case, allowable harvest estimates indicate the highest amount of wood that can be harvested without reducing the volume of wood standing in the forest (Table 2.10).

Table 2.10. Allowable yields per year and areas for the different forest types with potential to produce charcoal and firewood material (in thousand).

Forest Type	Area Hectares	Allowable Cut $m^3/ha/yr$
Dry Existing Production Forest	30.5	2.38
Dry Potential Production Forest	219.5	1.15
Humid Broadleaf* Forest	337.7	1.4
Baoruco Pine Forest	35	1.9

* Only the material suitable for charcoal and firewood production is considered.

INSTITUTIONAL ANALYSIS

Often the institutional framework surrounding the forestry sector of developing countries acts as a real constraint to forest policy implementation. An adequate framework should have three distinct and well-balanced elements: 1) policy making; 2) implementation; and 3) research and development (Munasinghe 1988). However, too often the three elements are mixed together, or even if they are delegated to different institutions, there is no coordination of efforts. In the case of the Dominican Republic, as well as other countries, the weakest areas are those of policy analysis and formulation.

The degree of complexity of the Dominican forestry sector was illustrated in chapter Two by the number of articles in the Law 5856-1962 concerning the conservation, management, and development of the Dominican forest resources. The FAO estimated that more than 400 laws, presidential mandates, rules, and other legal documents delineating forest policy in the Dominican Republic have been promulgated (FAO, 1987).

Further, most efforts have been directed toward conservation and/or preservation of forest resources. Nevertheless, the deforestation process has continued over time, reaching critical levels in the last ten years. At the same time, there has been a tremendous effort toward improving the situation in the last six years (Russo, et al., 1989). In light of this new effort, it is necessary to analyze the institutional framework surrounding the sector. Crucial to the concept of "wise management" of the forest resources is an understanding of institutional positions regarding forest policies. Furthermore, it is necessary to understand institutional differences, and group differences, regarding possible development paths and policy scenarios for the sector.

In this regard, a survey-interview study was conducted covering most of the relevant institutions for the forestry sector of the Dominican Republic. A census approach was considered to be more appropriate than a random sample due to the small size of the population covered. The questionnaire used in the study covered the present forestry national policy and two alternative scenarios. The objective was to identify institutional and group perceptions on how different national forestry policies may affect the forest resources of the country, as well as the country itself.

3.1 Institutional Framework

The institutions in the Dominican forestry sector were divided into five groups: a) Government Agencies; b) Donor Agencies; c) Environmental/Ecology groups; d) Non-Governmental Organizations (NGOs); and, e) Private Firms (Table 3.1).

a) Governmental Agencies. Four relevant governmental agencies are included in the study. They are: a) The General Direction of Forestry (FORESTA), which is in charge of executing all forestry policy in the country; b) The National Forestry Technical Commission (CONATEF), in charge of identifying and studying possible forestry policies in the country, yet with no execution power whatsoever; c) The Natural Resources Sub-secretariat (SURENA), which deals with all aspects of natural resources and may have limited execution power; and, d) The National Parks Commission (PARQUES), which is the authority responsible for the national parks of the country.

b) Donor Agencies. The most active agencies at this moment are the U.N. Food and Agricultural Organization (FAO) and the US Agency for International Development (USAID). Also, the Inter-American Development Bank (IADB) is involved in forestry projects from time to time. These three organizations are included in the study.

c) Environmental and Ecological Societies. There are several ecological societies in the Dominican Republic. The groups included in the study are: a) The National Commission for the Environment (NCE); b) The Institute for Bio-conservation (IBC); c) The environmental group HABITAT; d) Santiago Ecological Society (SECS); and, e) The Federation of Ecological Associations (FEDOMASEC). The latter institution is comprised of several ecological and environmental associations in the country.

d) Non-Governmental Organizations. There are several NGOs relevant to the forestry sector. Included in the study are: a) The Foundation for Human Development (PROGRESSIO), which is very active in proposing and financing small-scale projects on forestry and natural resources in general; b) The Superior Institute of Agriculture (ISA), a private university, which created and supervises the only legal commercial forest of the country; it also has a forest science curriculum; c) The National University Pedro Henríquez Ureña (UNPHU), which is conducting a five year experiment using the fast-growing species *leucaena*; d) The Autonomous University of Santo Domingo (UASD), which is also conducting research using fast-growing species; and, e) The US Peace Corps, which is working on small-scale forestry and soil conservation projects.

e) Private Firms. There are two active institutions in the business of forestry consulting and selling plants in the country: FLORESTA and Los Arbolitos. Both institutions are included in the study as representing private interests within the DR forestry sector.

Table 3.1. Institutional Framework for the Dominican Forestry Sector

Group	Institutions
Governmental Agencies	1. FORESTA 2. CONATEF 3. SURENA 4. PARQUES
Donor Agencies	1. USAID 2. FAO 3. IABD
Environmental/ Ecological societies	1. NCE 2. IBC 3. HABITAT 4. FEDOMASEC
Non-Governmental Organizations (NGOs)	1. PROGRESSIO 2. ISA 3. UNPHU 4. US Peace Corps 5. UASD
Private Firms	1. Los Arbolitos 2. FLORESTA

3.2 The Questionnaire

To conduct the institutional analysis, a 29-question questionnaire was used. The survey instrument was administered to the staff of all the institutions mentioned above (Table 3.1). No open questions were considered. Fourteen questions related to the perceived degree of importance of a particular issue, while 11 questions referred to the perceived degree of acceptance of a given issue. The questionnaire covered the present national forestry policy and its effects on the resource base plus two alternative scenarios. Additional issues such as the role of the government under a production areas policy, the time horizon involved in implementing a production areas policy, and the perceived importance of the different institutions in formulating forestry policies, were also covered in the questionnaire. Table 3.2 presents a list of the questions included. Questions have been rearranged to facilitate presentation of results.

3.2.1 Measurement Scale

The study responses were categorized into an interval scale of measurement. The questions which measured different degrees of acceptance toward a particular policy issue have scales which cover this range: Strongly Agree, Agree, No Opinion, Disagree, Strongly Disagree. Likewise, questions which measure the degree of importance attached to a specific issue, have scales which covered this range: Very Important, Somewhat Important, No Opinion, Little Importance, Not Important at all. For both cases described above, the spectrum of the interval scale for the answers goes from one to five. That is,

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 5          4          3          2          1
 |----------|----------|----------|----------|
SA          A         NO         DA         SD
VI          I         NO         LI         NI
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Table 3.2. Questionnaire: Attitude Analysis for the forestry sector of the Dominican Republic

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What degree of importance do you think each of the following reasons (Q#1, 2, and 3) have for the problem of deforestation in the DR.

1. The conversion of forest lands to agriculture uses through slash and burn practices.

2. The harvesting of wood material from native forests to produce charcoal and firewood for energy consumption.

3. The harvesting of wood material from native forests to produce roundwood for industrial purposes.

How important do you think each of the following institutions is in formulating forestry policies in the Dominican Republic?

4. Universities
5. Farmers' Organizations
6. Domestic wood-based industry (importers)
7. International organizations
   a. USAID
   b. FAO
   c. World Bank
   d. Inter-American Development Bank
8. FORESTA
9. Forestry Technical National Commission (CONATEF)
10. Non-profit Organizations
11. General public opinion
12. National Direction of Parks (PARKS)
13. Sub-secretariat of Natural Resources (SURENA)
14. Ecological/environmental groups
    a. FEDOMASEC
    b. HABITAT
    c. IBC
    d. NCE

15. The best way to conserve or preserve the Dominican forest resources is by forbidding the cutting of live trees throughout the entire country.

16. The best way to conserve or preserve the Dominican forest resources is through the use of the armed forces.

17. The problem of reforestation in the Dominican Republic could be solved by establishing enough production areas.

18. A national forestry policy that promotes the establishment of production areas in the country should focus on improving the standards of living of the small farmers.

19. A national forestry policy that promotes the establishment of production areas in the country should be directed toward the use of extensive private farms to produce the needed wood material.

Table 3.2. Questionnaire: Attitude Analysis for the forestry sector of the Dominican Republic

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20. A national forestry policy that promotes the establishment of production areas in the country should be directed toward obtaining self-sufficiency in wood products.

21. A national forestry policy that promotes the establishment of production areas could yield positive results even without receiving government subsidies.

22. A national forestry policy that promotes the establishment of production areas could be sustainable in the long-run.

23. The problem of the Dominican deforestation could be solved by means of a national policy which substitutes the consumption of charcoal and firewood with other imported energy materials, which could be sold to the public at subsidized prices.

24. The best way of alleviating the production pressure in the fragile forest sites, such as watershed and forest sites located on high slopes, is by conducting the policy described in question 14, at a rural level.

25. The best way of alleviating the production pressure in the fragile forest sites, such as watershed and forest sites located on high slopes, is by conducting the policy described in question 14, at the cities level.

26. From your institution's viewpoint, what do you think would happen to the availability of forest resources if the present national forestry policy continues active for ten more years?

27. What do you think would happen to the availability of forest resources after ten years as a result of a national forestry policy which focuses on the promotion of production areas in the present?

28. If a national forestry policy that promotes the establishment of production areas is accepted, what do you think would be an appropriate period of time to establish all the new plantations?

29. In what percentage of new plantations should the government keep all property rights, in order to sustain a production policy in the long-run?

Questions 26 and 27 of the questionnaire measured the perceived effects that a given policy may have on the forest resources themselves. Here, the appropriate range covered: Worsen more than 20 percent; Worsen between 10 and 20 percent; Worsen between 0 and 10 percent; No Change; Improve between 0 and 10 percent; Improve between 10 and 20 percent; and, Improve more than 20 percent. The spectrum of the interval scale for these questions cover the range from one to seven, respectively.

Questions number 28 and 29, however, measured the expected time horizon needed to actually implement the planting activities of a development policy, and the relative power that the government should maintain within new plantations, respectively. In the first case the spectrum represents a short (1, 2), medium (3), and long (4, 5) time horizon. In the second case, however, the scale represents a limited, moderate, and strong influence of the government within new plantations. Since the actual values of the answers measure the relative strength of the degree of acceptance or disapproval of a given policy issue, it seemed beneficial to consider them at the time of the data analysis. Particularly, these values are necessary to test whether or not there is a difference in position between any two groups for a particular policy issue. The complete set of institutional answers already converted to their respective interval scales is presented in Table 3.3.

3.3 Sample and Frequency Tables

Due to the small size of the population involved, a census was feasible. In total, 30 questionnaires were administered, corresponding to 16 different institutions. The responses were converted to intervals corresponding to response category. An institutional response was obtained by taking the mode for the institutional group (Table 3.3). In most cases there were three respondents per institution. However, in the case of Donor agencies only one respondent was available. In cases where multiple surveys were administered to the same institution, the institutional responses were calculated using the median of the responses.

A frequency table was calculated for each possible answer for a given question. There were actually two levels of analysis using frequency tables. The first shows the proportion of the 16 institutions involved that answered a particular question in a given way (Table 3.5). The second level presents the same information at a group level rather than the institutional level (Table 3.6).
The two levels of analysis are helpful in determining not only if there are differences among the institutions involved toward a particular policy issue but also if these

differences could be further associated to a particular group of institutions.

Also, questions were designed to be combined in order to allow analysis of some major policy issues. In that regard, the answers to questions #1, #2, and #3 were combined to determine the perceived importance of the three causes proposed to explain the Dominican deforestation problem, when considered as a set. Further, to discover the attitudes that the different institutions and groups of institutions have toward the present national forestry policy, the answers to question #15, #16, and #26 were combined, since each of these questions touches on a different aspect of the policy. Likewise, in order to get institutional and group attitudes toward the effect that a production policy would have on the forest resources themselves, questions #17 and #27 were considered together. The last combination compares the two proposed objectives: a) improving the standards of living of the small farmers; and b) utilizing extensive private farms under a production area scenario. Hence, the answers to question #18 and #19 were combined.

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In order to determine group attitudes toward the present policy, the combination process was as follows. First, the Strongly Disagree answers of questions #15 and #16 were combined with the Worsening over 20 percent of question #26 and divided by three, to obtain the strong negative attitude. Similarly, to obtain the percentage of institutions with a negative attitude, the Disagree answers of questions #15 and #16 were combined with the sum of the Worsening from 0 to 10 percent and from 10 to 20 percent of question #26. The positive attitude was found by combining the sum of Agree and Strongly Agree of questions #15 and #16 with the sum of Improving from 0 to 10 percent and from 10 to 20 percent of question #26. The same analogy was used in the case of determining attitudes toward a production areas policy.

Table 3.4. Summary of Broad Issues Considered

Issue	Questions to be aggregated
1. Explaining the causes for the Dominican deforestation	#1, #2, and #3
2. The attitude toward the present national forestry policy	#4, #6, and #7
3. The attitude toward a production areas national forestry policy	#5 and #8
4. The objective(s) that should accompany a production policy	#9 and #10

3.4 Results of Institutional Analysis

The results for this part of the study are presented below. For each question included, a frequency table is shown for every possible response, first at the institutional level (Table 3.5), then at the group level (Table 3.6).

The vast majority, or 88.2 percent of the institutions participating, believe that the conversion of forest land through slash and burn agriculture is a very important cause for the deforestation problem of the country (question #1). The remaining 11.8 percent consider this cause to be important rather than very important. Further, when considering groups of institutions one can see that 100 percent of the institutions in the Government, Donor and NGOs groups believe this cause is very important for Dominican deforestation, while only 75 and 50 percent of the institutions in the Environmental and Private groups, respectively, believe so.

In a similar manner the second frequency table shows that a majority (64.7 percent) of all institutions think that the harvesting of wood material to produce charcoal and firewood is a very important cause of the Dominican deforestation (question #2). The remaining 35.3 percent classify this cause as important. When analyzing how important the harvesting of wood material to produce roundwood for industrial purposes is (question #3), similar results were obtained for the percent of institutions that think this is a very important cause of Dominican deforestation. However, 17.6 percent of all the institutions think this reason is of little importance.

One important issue discussed in the questionnaire is the perceived role that the different institutions in the Dominican forestry sector play in formulating forestry policies for the country. (questions #4 through #14). The premise behind this issue is that it may be easier to accept a forestry policy emanating from an institution which is perceived as having an important role in formulating forestry policies for the country, than one coming from an institution which is perceived as having an unimportant role.

A majority of 70.6 percent of all institutions believe that the local universities have either a very important or somewhat important role in formulating forestry policies (question #4). However, the Environmental group is undecided, with 50 percent of the institutions placing some importance to the role of Universities, and the other 50 percent placing a rather unimportant role. In the case of Farmer Organizations (question #5), half of the institutions (52.9 percent) perceive them as playing either a very important or somewhat important role in formulating forestry policy. However, when one looks at the different groups it can be noted that the Government and Donor groups disagree about the importance they place on these organizations. The first group believes Farmer Organizations are either very important or somewhat important, while most institutions in the second group think that these organizations are either of little importance or not important at all in formulating forestry policies for the DR. The Environmental and NGOs groups are divided in their opinions.

Except for the Environmental and Private groups, all groups believe that the domestic wood-based industry (importers) plays either a very important or a somewhat important role in formulating forestry policies for the country (question #6). They believe, however, that importers play an indirect role using political favors or lobbying in both the Congress and the National Palace to oppose or favor any given potential policy that may affect negatively or positively their import operations.

The Donor Agencies are perceived as playing an important role in formulating forestry policies for the DR. Of all institutions participating, 76.4 percent believe that the Donor Agencies play either a very important or a somewhat important role (question #7). On the other hand, the Donor group sees itself as playing a rather unimportant role in formulating forestry policy.

Table 3.5. Institutional Analysis: Attitude Survey for the Dominican Forestry Sector

Question	Very Important	Somewhat Important	NO Opinion	Of Little Importance	No Important
1. How Important do you think is conversion of forest lands due to slash and burn?	88.2	11.8	0	0	0
2. How important do you think is conversion of forest lands due to charcoal and firewood production?	64.7	35.3	0	0	0
3. How important do you think is conversion of forest lands due to rowndwood production for the furniture industry?	64.7	17.65	0	17.65	0
How important do you think each of the following institutions is in formulating forest policies in the Dominican Republic.					
4. Universities	29.4	41.2	0	23.5	5.9
5. Farmer Organizations	17.6	35.3	5.9	29.4	11.8
6. Domestic wood-based Industry (importers)	41.2	17.6	5.9	11.8	23.5
7. Donor Agencies	29.4	47.0	5.9	17.7	0
8. FORESTA	64.7	23.5	0	11.8	0
9. CONATEF	35.3	58.8	0	5.9	0
10. NGOs	35.3	58.8	0	5.9	0
11. General public opinion	29.4	41.2	0	23.5	5.9
12. National Direction of Parks	47	23.5	5.9	17.7	5.9
13. Sub-secretariat of Natural Resources	11.8	64.7	5.9	17.6	0
14. Ecological and Environmental groups	17.7	58.8	0	23.5	0

* Answers represent frequency tables including all institutions in the study.

Table 3.5 Cont. Institutional Analysis: Attitude Survey for the Dominican Forestry Sector

Question	Strongly Agree	Agree	No Opinion	Dis-Agree	Strongly Disagree
15. The best way to conserve the Dominican forest resources is by forbidding the cutting of live trees in the country.	5.9	5.9	0	23.5	64.7
16. The best way to conserve the DR forests is through the use of the armed forces.	0	0	0	35.3	64.7
17. The problem of deforestation in the DR could be solved by establishing enough production areas in the country.	11.8	76.4	0	11.8	0
18. A national forest policy that promotes production areas should focus on improving the standard of living of small farmers.	64.7	29.4	0	5.9	0
19. A national forest policy that promotes production areas should be directed toward using extensive private farms.	41.2	29.4	0	23.5	5.9
20. A production areas forest policy should be directed toward obtaining self-sufficiency in wood material.	52.9	41.2	5.9	0	0
21. A production policy could be positive even without government subsidies.	0	29.4	5.9	47	17.7
22. A forest policy that promotes production areas could be sustainable in the long-run in the Dominican Republic.	41.2	47	5.9	5.9	0
23. The problem of Dominican deforestation could be solved by means of a forest policy that substitutes charcoal and firewood with alternative fuel sources sold at subsidized prices.	5.9	17.6	0	41.2	35.3
24. The best way of alleviating production pressure in critical sites is by implementing the energy substitution policy at the rural level.	11.8	17.7	0	47	23.5
25. The best way of alleviating production pressure in critical sites is by using the energy substitution policy at the city level.	11.8	29.4	0	35.3	23.5

* Answers represent frequency tables including all institutions in the study.

Table 3.5 Cont. Institutional Analysis: Attitude Survey for the Dominican Forestry Sector

Question	Improve > 20%	Improve 10-20%	Improve 0-10%	No Change	Worsen 0-10%	Worsen 10-20%	Worsen > 20%
26. What would happen to forest resources if present policy continues 10 more years into the future?	0	0	11.8	0	17.6	29.4	41.2
27. What would happen to forest resources after ten years, as a result of a production areas forest policy in the DR?	5.9	29.4	47	0	0	11.8	5.9

Question	> 20yrs	15-20yrs	10-15yrs	5-10yrs	1-5yrs	No Opinion
28. What would be an appropriate time period to establish all needed plantations under a production areas forest policy?	23.5	23.5	17.7	17.6	5.9	11.8

Question	> 50%	20-50%	10-20%	5-10%	0-5%	No Opinion
29. In what percent of the new plantations should the government keep all property rights for a production policy to be sustainable?	5.9	29.4	5.9	11.8	23.5	23.5

* Answers represent frequency tables including all institutions in the study.

Two of the most important institutions relevant to the Dominican forestry sector are FORESTA and CONATEF, which are both included in the government group (questions #8 and #9, respectively). As expected, the majority of the institutions (88.2 percent) believe FORESTA plays either a very important or somewhat important role in formulating forestry policies for the country. Likewise, 94.1 percent of all institutions believe that CONATEF plays either a very important or somewhat important role in formulating forestry policy for the country. One may recall that CONATEF is a national technical commission appointed by the President to formulate and analyze forestry policies for the country; hence, there should be no surprise that there is a consensus on this particular issue.

NGOs have been increasingly active in the last five years in their involvement with the Dominican forestry sector. The vast majority (94.1 percent) of all institutions believe that NGOs play either a very important or somewhat important role in formulating forestry policies for the country (question #10). Contrary to the Environmental group, the Government, Donors, and NGOs groups believe that general public opinion plays either a very important or somewhat important role in formulating forestry policies in the country (question #11). The Private group is equally divided regarding its perception of the importance of general public opinion.

The other two institutions comprising the Government group are the National Direction of Parks (PARQUES) and the Sub-secretariat of Natural Resources (SURENA). Of those polled, 70.5 percent of all institutions think that PARQUES plays either a very important or somewhat important role in formulating forestry policy for the country (question #12). On the other hand, 76.5 percent of all institutions believe that SURENA plays either a very important or somewhat important role (question #13). One difference between the two is that only 25 percent of the institutions in the Environmental group assign an unimportant role to SURENA, while 75 percent of the same group assign an unimportant role to PARQUES.

The last group of institutions considered is the Environmental/Ecological group, presented in the frequency table under question #14. Here, 76.5 percent of all the institutions surveyed believe that this group plays either a very important or somewhat important role in formulating forestry policies for the country. However, the Private group and the Environmental/ Ecological group are equally divided in their opinions with regard to the role that the Environmental/Ecological group plays in formulating forestry policies in the DR.

A majority of 88.2 percent of all institutions either disagree or strongly disagree with the proposition that the best way to conserve or preserve the Dominican forest resources is by forbidding the cutting of live trees in the entire country (question #15). All institutions in the Government, Donor, NGOs and Private groups either disagree or strongly disagree with the proposition. The Environmental/Ecological group is undecided on this issue.

All institutions in the study either disagree or strongly disagree with the proposition that the best way to conserve or preserve the Dominican forest resources is through the use of the armed forces (question #16). The answers here are very consistent across groups, showing a rather general consensus.

A majority of 88.2 percent of all institutions either agree or strongly agree that the problem of deforestation in the DR could be solved by establishing enough production areas in the country (question #17). All institutions in the Government, Environmental/Ecological, and NGOs groups either agree or strongly agree with this proposition. One-third of the Donor group and 50 percent of the Private group, however, disagree with this proposition.

Most of the institutions involved (94.1 percent) either agree or strongly agree that a production policy should focus on improving the standard of living of the small farmers (question #18). Similarly, the frequency table for question #19 shows that 70.6 percent of all institutions either agree or strongly agree that a production policy should be directed toward the use of extensive private farms in order to produce the needed wood material. The exception here is that 66.7 percent of the institutions in the Donor group either disagree or strongly disagree with the use of extensive private farms. In that sense, improving the standard of living of the small farmers should be of higher priority than using extensive private farms.

A vast majority of the institutions (94.1 percent) agree or strongly agree with including self-sufficiency in the production of wood material as an objective for any production areas policy (question #20). This suggests that self-sufficiency should be included as a long-term goal of any forestry production policy.

Government subsidies are thought to be needed for a production policy to yield positive results (question #21). Thus, more than half of all institutions (64.7 percent) either disagree or strongly disagree with the no-subsidy proposition. The NGOs group has the strongest position on this issue; 75 percent of the institutions in this group strongly disagree with the no-subsidy proposition. In addition, 66.7 of the Donors agree with the no-subsidy proposition. The Government group is undecided.

Another issue of relevance for the study was to identify the positions different institutions have with respect to the potential sustainability of a production policy in the country.

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The frequency table for question #22 shows that the majority of all institutions (88.2 percent) either agree or strongly agree that a production policy could be sustained in the long-run in the country. Surprisingly, 100 percent of the institutions in the Environmental/ Ecological group either agree or strongly agree with the proposition. These results may reflect the idea that a production policy should utilize new plantations rather than the natural forests to supply the needed materials. Also, all the institutions in the Government and Private groups either agree or strongly agree with the potential sustainability of a production policy.

Most of the institutions have a negative attitude toward the issue of substitution of charcoal and firewood consumption by imported energy materials which could be sold at subsidized prices. A majority (76.5 percent) of all institutions either disagree or strongly disagree with the substitution policy (question #23). However, 33.3 percent of the Donor group agree with such a policy, while 25 percent of the Environmental/Ecological group strongly agree with it. Even more interesting, 50 percent of the institutions in the NGOs group agree with the substitution policy.

Question #24 looked at the energy substitution policy but only at the rural level. The idea behind this proposition is that small farmers located in fragile forest sites could get alternative energy material; hence, they could ease some of the production pressures on those regions. The results here show that 70.5 percent of all institutions either disagree on strongly disagree with the proposition, while 29.5 percent either agree or strongly agree with this proposition. The Government group is the only one undecided on this issue. All the other groups have a negative attitude toward the proposed policy.

Another issue is whether the energy substitution policy would alleviate production pressure on fragile forest sites if implemented at the city level. The premise underlying this proposition is that the demand for charcoal and firewood for industry is greater in urban metropolises than in rural areas. A majority of 58.8 percent of all institutions either disagree or strongly disagree with the proposition, while the remaining 41.2 percent either agree or strongly agree with it (question #25). The scenario presented in this proposition seems to be more acceptable than the previous two mentioned above. All the institutions in the Government and Private groups disagree with the proposition, while 75 percent of the institutions in both Environmental/Ecological and NGOs groups either agree or strongly agree with it. Further, 66.7 percent of the institutions in the Donor group either disagree or strongly disagree with this proposition.

The last issues discussed concerned the forest resource base under both the present policy and the production areas policy. Almost half of all institutions (41.2 percent) believe that the availability of forest resources would worsen by more than 20 percent if the current policy is continued for ten more years (question #26). Another 29.4 percent of all institutions believe they would worsen between 10 and 20 percent, while 17.6 percent of them think availability would worsen between 0 and 10 percent. The vast majority (88.2 percent) of all institutions believe that the forest resources would worsen at some level if the present forestry policy continues ten years into the future. As expected, only the Government and the NGOs groups believe there could be a small improvement under the present policy. In the Environmental/Ecological group, 75 percent of the institutions believe the resources would worsen by more than 20 percent under the present policy framework. Likewise, all the institutions in the Private group believe the same.

A majority of 82.3 percent of all institutions believe that under a ten-year policy which would focus on production areas the forest resources would show some improvement (question #27). Contrary to what was expected, 100 percent of the Government and Donor groups believe the resources would improve at least from 0 to 10 percent under the alternative policy. Twenty-five percent of Environmental/Ecological and NGOs groups believe the forest resources would worsen under such a policy. The Private firms are undecided on whether the proposed policy would improve the resource base. These results suggest that although Private, Environmental/Ecological, and NGOs groups favor the establishment of a production areas policy, they remain cautious about the implementation of such a policy.

There is some disagreement among the groups with regard to the issue of how long it would take to establish all new plantations (question #28) in the event a production policy were accepted. Government, Donor, NGOs, and Private groups all believe it would take from a moderate (10 to 15 years) to a long (15 to 20 and +20 years) period to establish all the needed plantations to account for domestic demand of wood products. The Environmental/Ecological group, however, believes all needed plantations could be established in a short period of time (less than 10 years).

Likewise, there is disagreement on the level of influence that the government should have on the new plantations for a production policy to be sustained in the long-run (question #29). Accordingly, 23.5 percent of all institutions believe that the influence of the government on the new plantations should be kept to a minimum. However, another 35.3 percent of all institutions believe that the government should keep all property rights in more than 20 percent of the new plantations. Further, there are 23.5 percent of all the institutions which found it difficult to give an opinion on this issue.

3.4.1 Results on Broad Issues

A. How important as a set are the three causes presented for explaining Dominican deforestation?

One question that arises is how important, as a set, are the three causes mentioned at the beginning of the questionnaire toward explaining the problem of Dominican deforestation. To address this question, it would be helpful to consider the answers to questions #1, #2, and #3 simultaneously. A majority of 72.5 percent of all institutions consider this set of causes to be very important (figure 3.1). An additional 21.6 percent of all institutions consider them to be somewhat important. Further, when considering the groups separately, 83.3 percent of the institutions in both the Government group and the Private group consider this set of three causes to be very important in explaining the Dominican deforestation problem. Only the Donor and the Environmental/ Ecological groups have more than 20 percent of their institutions which consider this set of causes as only somewhat important. Likewise, the Donor group is the only one with more than 10 percent of its institution placing a rather unimportant role on this set of causes.

B. What is the perceived attitude toward the present forestry policy?

Several aspects of the current forestry policy were emphasized in different questions throughout the questionnaire. To get a broad idea of the attitudes that the different groups have toward the present policy, it is necessary to combine the answers to questions #15, #16, and #26 (Figure 3.2).

The NGOs and Private groups presented the strongest negative attitude toward the present forestry policy with 67 and 100 percent of their institutions in the strong negative range, respectively. On the contrary, the Environmental/Ecological group presented the most positive attitude toward the present policy, with 16.6 percent of its institutions in the positive range. In addition, this group has equal percentages of institutions, 41.7 percent, in the range of negative and strongly negative. Incidently, 91.7 percent of the Government group's institutions have either a negative or a strongly negative attitude toward the present official forestry policy. This finding suggests a difference of views between the central government and the different government agencies.

C. What is the perceived attitude toward a national forestry policy which emphasizes production areas?

Another point of interest is to determine the perceived effects that a production area policy is likely to have on the Dominican forestry resource base. Answers to questions #17 and #27 were combined to shed light on this question (Figure 3.3).

Contrary to what was expected, all the institutions in the Government group believe that a production area policy is likely to have a positive effect on the resource base.

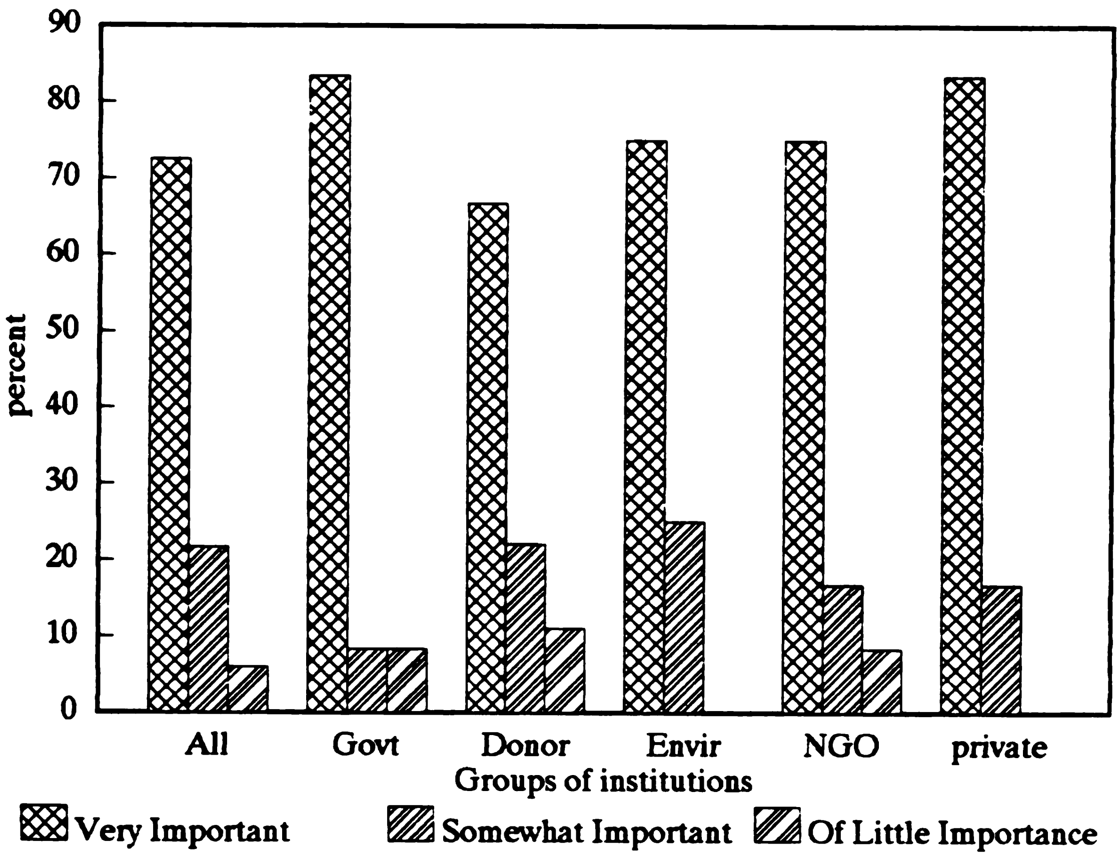

Figure 3.1. Importance of slash and burn practices, conversion of forest lands, and harvesting of wood material, as a set of causes for the DR deforestation.

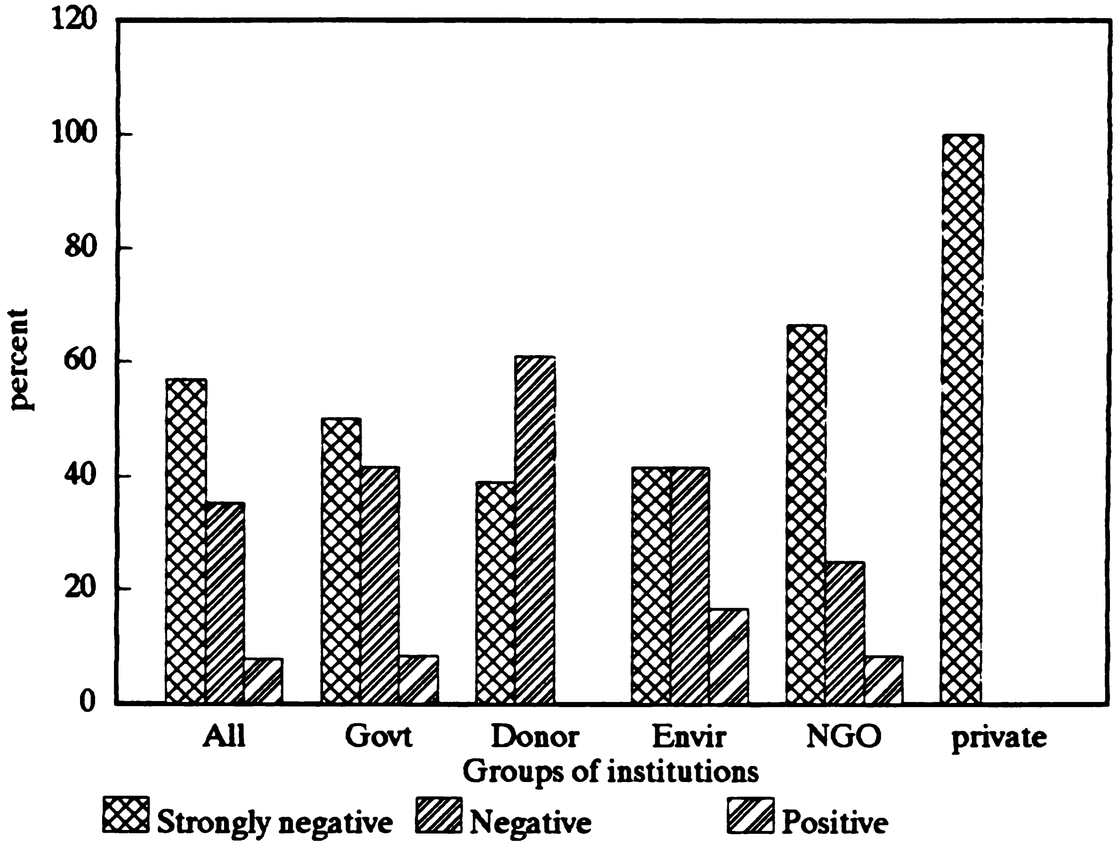

Figure 3.2. Institutional attitude toward the present national forestry policy

This finding contrasts with the official policy which presupposes a deterioration in the resource base if a production policy were implemented. The NGOs and Environmental/Ecological groups also have a positive impression of the effects that the proposed policy may have on the resource base, with 87.5 and 75 percent of their institutions in the positive range, respectively. The Donors have the highest strongly positive percentage (33.3). The Private group, however, is divided in its opinion. The evidence that most groups expect the proposed policy to have a positive rather than a strongly positive effect on the resource base may reflect skepticism toward how property rights would be re-arranged under a production area scheme.

D. Which objectives should drive a production policy alternative?

One question of interest is what objectives should be included in a production area policy if one were implemented (Figure 3.4). Here, two prospective objectives were studied: a) improving the standard of living of small farmers; and, b) utilizing extensive private farms for wood production. There is greater consensus for including the first objective compared to the second objective in a forestry production policy.

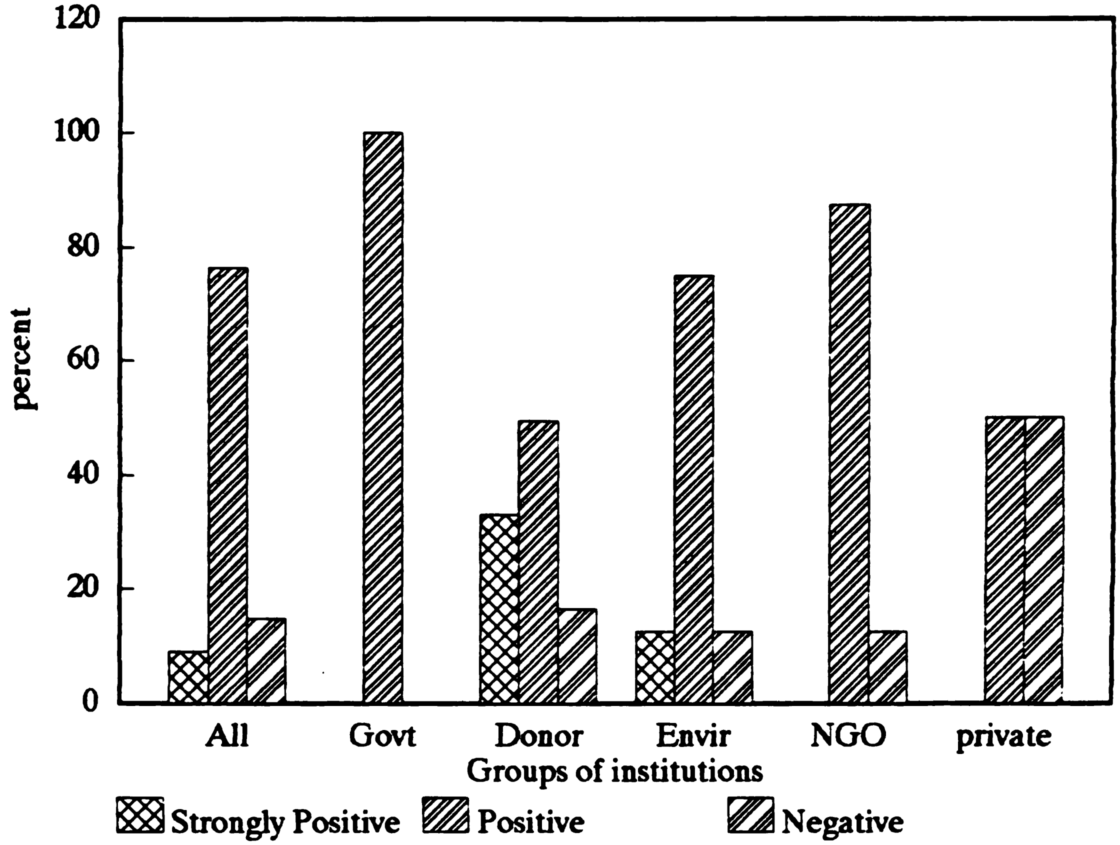

Figure 3.3. Institutional attitude toward a national forestry policy which focuses on production areas in the DR.

Accordingly, 64.7 percent of all institutions strongly agree with the first objective versus only 41.2 percent who agree with the second objective. More institutions explicitly disagree with the second objective as compared to the first. That is, 5.9 and 29.4 percent of all institutions either disagree or strongly disagree with the first objective and the second objective, respectively. However, most institutions believe that a production area policy should include these two objectives, to some degree, as an integral part of the central focus.

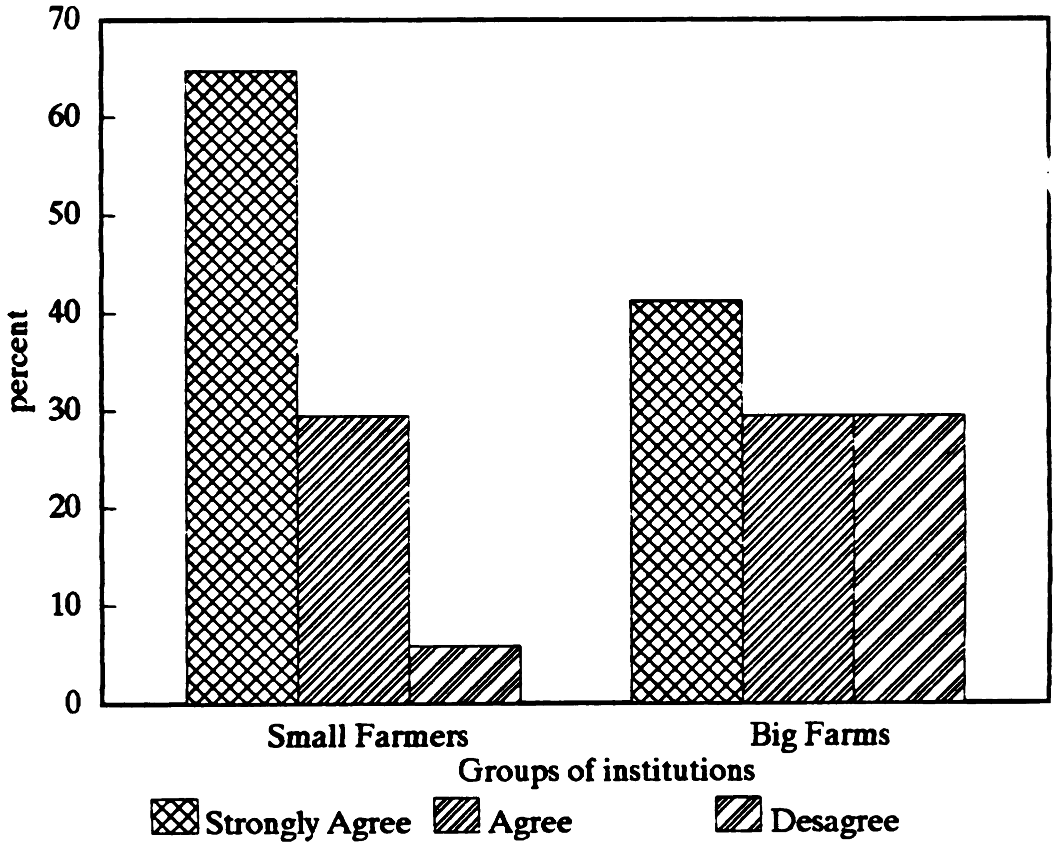

Figure 3.4. Primary objective to be included in a national forestry policy which focus on production areas in the DR.

3.5 Summary of Findings and Recommendations

The use of frequency tables for analyzing institutional and group responses in a population can be very helpful in explaining differences. The scope of the questionnaire used is appropriate for this level of analysis. The institutional analysis undertaken in this study considered three major forestry policy structures for the Dominican Republic: the current national forestry policy; a national policy which focuses on production areas; and, a national policy which focuses on the use of imported energy sources to substitute for charcoal and firewood consumption in the country. The following findings should be emphasized:

The present national forestry policy, as represented by its several features, does not have the approval of the different groups of institutions relevant to the Dominican forestry sector. This finding suggests that a new forestry policy is needed to guarantee the long-term sustainability of the forest resource base.

On the other hand, all groups seem to favor a national forestry policy which focuses on production areas and which has self-sufficiency as an objective. Further, most groups believe that such a policy can be sustained in the long-run and may actually improve the resource base over time. Except for the Environmental/ Ecological group, they all believe that it would take a relatively long period of time, more than ten years, before a production policy could be fully implemented in the country. Only NGOs, Environmental/ Ecological, and Private groups see government subsidies as necessary elements for a production policy to be sustained in the long-term.

There are some disagreements among the groups on whether a production areas policy should have as a primary objective to improve the living standard of the small peasants or use extensive private farms to produce the needed material. A more general consensus exists for improving the standard of living of small farmers as an primary objective, as compared to favoring the use of extensive production farms. Even though there is controversy with regard to the utilization of extensive production farms, most institutions believe both objectives could form part of a production policy simultaneously. The Donor group, however, is split on the issue of using extensive farms for production. Likewise, there is not agreement with regard to the level of influence that the government should have within the new plantations for a production policy to be sustainable.

Moreover, most groups have a negative attitude toward the undertaking of an energy substitution policy in the country. This attitude may be reinforced by the inability of the government to meet the present levels of consumption for imported energy material. Most institutions believe the government does not have the necessary level of foreign exchange needed to implement such a policy on a sustainable basis. However, any movement toward the substitution of charcoal and firewood seems to be more acceptable if done at the city level.

There are disagreements among the groups regarding the perceived role that each institution plays in formulating forestry policies. This suggests that a policy proposal emanating from an institution which is perceived as important may be taken more seriously than a policy coming from one which has been labelled as unimportant. Further, the answers to this question may prove helpful in building alliances among institutions. CONATEF and NGOs are thought to be the most important institutions in formulating forestry policies for the country. Donor agencies are also thought to be very important by other institutions. FORESTA and SURENA are also considered to be important. Conversely, farmer organizations and the National Direction of Parks are considered to be the least important institutions in formulating forestry policies. This may reflect the inactivity of the first with respect to the Dominican forestry sector, and the isolation and quiescence of the second.

The simulation model developed as the second part of the dissertation analyzes the proposed production policy of this part together with two additional forestry programs: a cookstove and a brick-kiln program.

METHODS: THE FORESTRY SIMULATION MODEL (FOSIM)

4.1 Modeling forest growth and forest dynamics

Scarcity of forest resources represents a limit to the development of the forest sector not only in the developing regions but also in the developed ones. Hence, long-term planning and policy analysis is becoming an important issue for all regions. To that effect, several techniques have been used for assessment and planning analyses.

In particular, mathematical programming is a widely applied technique for operations management and planning in forestry (e.g., Dantzig, 1974; Kilkki, et al., 1986; Williams, 1986; Ware and Clutter, 1971; Newham, 1975; Weintraub and Navon, 1976). Models and approaches are available for both assessment and policy analysis (Marose, et al., 1988). Indeed, optimization, general equilibrium, and simulation approaches are all being extensively used in forestry today.

Optimization techniques are commonly used in approaches such as linear programming (Dantzig, 1974). These models have land management and resource production activities driven by an either single or multiple objective function (e.g., Kallio, et al., 1986) that in most cases maximize/minimize financial returns/costs within a particular framework. Optimization models are also combined with simulation techniques to perform policy analysis (Kallio, et al., 1986; and Barros and Weintraub, 1979). Adams and Haynes combined both techniques in a spatial equilibrium model for planning and policy analysis of the U.S. Forest products markets (1986). Their model assumed perfect competition, and it is not flexible enough to be used for analysis in the developing regions.

Applications of systems analysis or simulation models are also widely used to consider the long-term policy making process. Simulation models focus on strategic rather than tactical or operational issues (Lonnstedt, 1983; Anderson, et al., 1986). Long-term policy analysis involves both "well behaved" and "non-well behaved" uncertainties. Simulation models deal with uncertainty by producing scenarios rather than forecasts; the first produced numerical solutions based on a set of conditions, while the second uses the most "likely" values of the parameters to produce an optimal solution. Simulation techniques allow for understanding of the basic relationships influencing the development of the forest sector (Jerger et al., 1978; Randers, 1976). The use of optimization models becomes more problematic when the target forest sector is poorly developed and has a diverse set of objectives which are not well-defined. Attempts to produce a realistic model formulation under these circumstances can lead to large, costly, complex models that are often neither understood nor trusted by outside parties.

Other types of models used for planning and policy analysis are those which use a general equilibrium approach. Such models focus on prices and output levels of various resource commodities under different market conditions (Marose, et al., 1988; Solberg, 1986). General equilibrium models use econometric techniques based on a set of interrelated equations that describe the underlying structure of the market under consideration. An example of these models is the IIASA Forest Sector Model (Dysktra, et al., 1987). An advantage of these models is their ability to incorporate market feedback effects caused by changing output levels, through structural equations.

The Latin America forest sector situation, and specifically the D.R. situation, limits the applicability of general equilibrium models, however. The lack of time series data relating prices to output levels of non-industrial forest products imposes great limitations. It is also difficult to explicitly recognize multiple strategic and institutional considerations affecting forest resources over time within this region in the context of a general equilibrium model.

The present study draws on several systems analysis and mathematical programming techniques and subroutines developed by Manetsch (1971, 1976, and 1991). Specifically, a simulation model is developed to analyze the long-term effects on the forest resource base of different forestry programs proposed for the Dominican Republic. A technique used to model aggregated systems called *Distributed Delay* is used to model forest growth and forest dynamics. The approach undertaken allows for flexibility in terms of reliability and availability of economic data. Nevertheless, data availability limits the scope of the study.

4.2 Model Overview

The Forestry Simulation Model (FOSIM) is a simulation model intended to be used for long-term analysis of forestry policy proposals. In particular, the effects that the national forest policies of fuelwood conservation through a) improved ceramic cookstoves program, b) the charcoal conservation program which uses improved brick kilns, and c) the energy plantation program are analyzed for the forestry sector of the Dominican Republic. FOSIM consists of one domestic forest sector which covers different activities, ranging from timber growth and charcoal production to the consumption of forest products.

The model has three general modules (Figure 4.1). First, a production module which estimates potential availability of wood material to be used for one of the three forest products under consideration. Second, a consumption module estimates potential demand for each of the forest products at any point in time within the time horizon. The consumption module includes a population sub-module which projects population dynamics in the Dominican Republic for the time horizon considered. The consumption module draws on the population sub-module to obtain estimates on population demographics.

The price for lumber is considered exogenous to the system and, hence, a given. The price of charcoal is determined in the forest product module by potential supply and potential demand at any given time within the horizon considered. Potential demand, which depends on the policy scenario under study, is determined through the consumption module. The model then determines the ability of the natural forest to meet potential demand based on allowable harvest. If necessary, the model then determines the potential supply from forest plantations. If potential supply from the natural forest plus the potential supply from current plantations is less than potential demand for wood for charcoal and firewood at time "t," the model looks back to the natural forest to meet demand. The process of meeting the demand for raw material might cause both the depletion of all merchantable wood within the natural forests and the reduction of forest lands over time. Each individual module is analyzed in detail below.

4.3 Forest Production Module

4.3.1 Sources of Raw Material

There are three sources of raw material suitable for the production of charcoal and firewood. Two of these sources are located within the Dominican natural forests. The main source of raw material for charcoal and firewood is the Dominican dry forest located in the southwest and northwest regions of the country (Figure 4.1). Another important source of raw material for these products is the subtropical broadleaf humid forest, located in the southwest, central and eastern regions of the country. A third, but limited, source of raw material for charcoal and firewood is the pine forest located in the Baoruco region. It has been studied by the FAO (1973), Potter (1985) and Ramm (1986). Energy plantations may offer yet another source of raw material for these forest products. However, their influence is rather limited by the current national forestry policy which does not specify all relevant property rights.

The raw material from the natural forests can be obtained in two ways: through allowable yield and through the mining of the natural forests. Harvesting the natural forests according to the allowable yield criterion would not affect the area under forest cover over time. However, mining of the natural forests would result in forests being clearcut and not converted back to forest. The policy implications of clearcutting forest areas will be shown in the results section where the different scenarios are analyzed. Plantation forests are negatively related to the depletion of forest land as the more wood material is available from plantations, the less mining of natural forest is necessary to meet potential demand.

In the case of raw material suitable for lumber, three sources are identified: the foreign supply of sawnwood, the natural subtropical broadleaf humid forest, and the natural pine forest. The most important source is imported foreign sawnwood. The potential for raw material production within the Dominican pine forest is thus particularly important to the country in terms of forest policy.

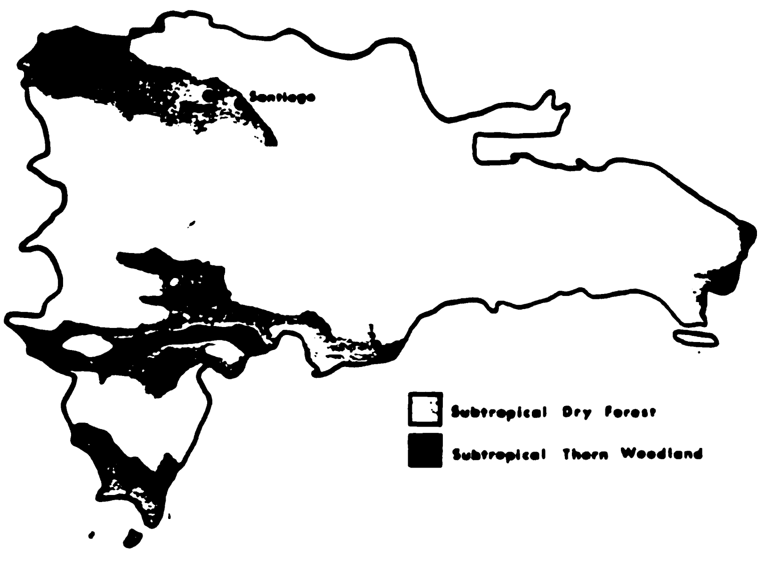

Figure 4.1. Existing and potential dry forest areas with wood material suitable for charcoal and firewood in the Dominican Republic.

Source: Knudson, et al., 1988.

4.3.2 Factors Affecting Supply over Time

Forest dynamics is a crucial element of FOSIM. In order to determine potential supply of a given forest product at any time within the horizon, it is necessary to understand the dynamics of forest growth. In that sense, the forest (F_t) can be thought of as capable of producing material for charcoal and firewood (F_{cf}) and sawtimber for lumber (F_l). The raw material could then be used to produce charcoal, firewood, or lumber products, accordingly. After Manetsch (71), potential availability of a particular kind of raw material can be represented as

$$F_{jt} = f(L_{ft}, PL_{ft}, delay_i, Store_{it}, Harvest_t) \qquad (1)$$

For forest harvesting the potential availability of the raw material at time "t" is determined as a function of the amount of land under forest cover (L_{ft}); the proportional loss of forest due to natural causes (fires, diseases, insects, etc.) per unit of time (PL_{ft}); age or diameter distribution within the different stands ($delay_i$); the stock of forest within each diameter class ($Store_{i(t)}$); and the harvested material from the forest ($Harvest_t$). All variables occur at period "t." In the case of plantation forests, the potential availability of raw material j will also be a function of management costs and capacity.

The forest production module indicates how much raw material from harvestable timber is available from natural forests, based on allowable yield, and from forest plantations. It also tells how much material is in storage in the different diameter classes.

4.4 The Distributed Delays

An appropriate way of representing forest dynamics is through distributed delay techniques. Distributed delays have been widely used in the modeling of aggregate behavior in large systems. Abkin (1976) used this model extensively to simulate the development, production, and aging phases in the life cycle of economic perennial crops in Nigeria. This technique has also been used to model industrial systems and capital formation in macroeconomic systems (Forester, 1961; Holland, 1966).

In that sense, a k^{th} order time-invariant distributed delay is defined by the following k^{th}-order differential equations.

$$dr_1/dt=\frac{k}{DEL}(x(t)-r_1(t))$$

$$dr_2/dt=\frac{k}{DEL}(r_1(t)-r_2(t))$$

$$\vdots$$

$$\frac{dr_k}{dt}=\frac{k}{DEL}(r_{k-1}(t)-r_k(t))$$

Here the input is x(t) and the output is $r_k(t) = y(t)$. The variables $r_1(t)$, $r_2(t)$,...$r_k(t)$ are the so-called intermediate rates of the distributed delay.

One important property of the delay process is that it conserves flow. All entities that enter the delay process at the input either leave at the output or remain stored inside the process. The quantity of storage inside this delay is readily computed as

$$Q(t) = DEL/k \sum_{i=1}^{k} (r_i(t)) \qquad (3)$$

The constant parameters DEL and K are very important in relation to the real-world process being modeled. According to Manetsch (1966), the parameter DEL represents the mean of the probability density function describing the *transit times* of the population of entities passing through the process. The parameter K specifies a member of the Erlang family of density functions to describe the transit times of individual entities. Here, the transit times of individual trees as they pass from one diameter class to the other is modeled.

4.4.1 The Erlang Family of Density Functions

The Erlang density function is given as

$$f(\tau) = \frac{(\frac{DEL}{k})^{k} (\tau)^{(k-1)} \exp[-\frac{k\tau}{DEL}]}{(k-1)!}$$

The density function f(tau) describes the transit times of individual entities tau_1, tau_2, ... tau_n through the distributed delay process. The mean and variance of the random variable tau are: Mean = DEL and $Sigma^2 = DEL^2/k$

The mode of this family of density function m is m = DEL (k-1)K where k=1 results in the familiar exponential distribution. As k goes to infinite, the density function approaches normal N(DEL,0)--a discrete delay (Figure 4.2).

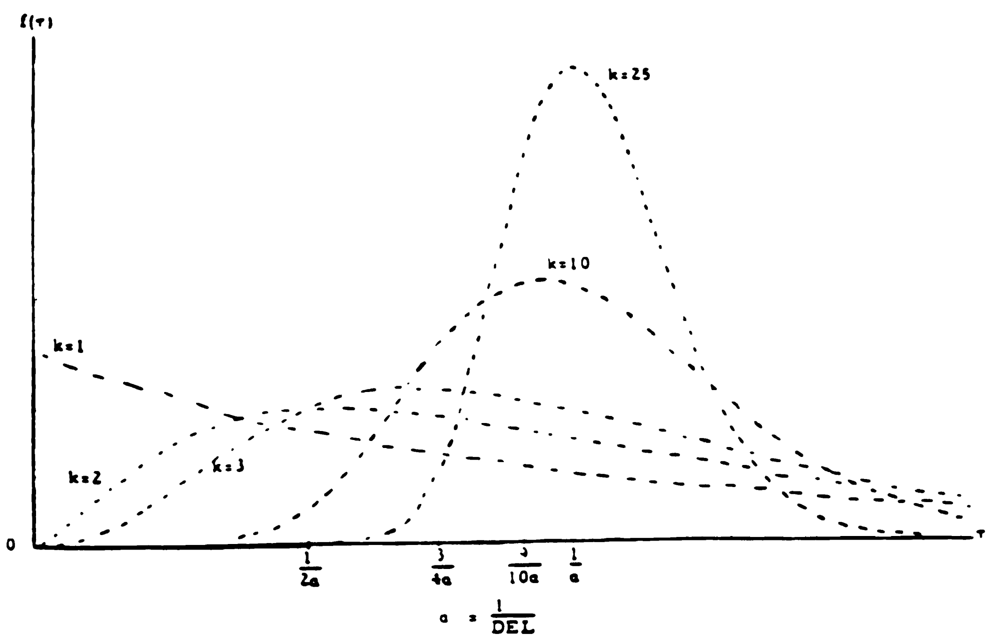

Figure 4.2. Erlang family of density functions.
Source: Manetsch, 1976.

4.4.2 Modeling Forest Growth

Several real-world phenomena, for example biological populations and forest populations, however, do not present a fixed mean delay over time. The time varying distributed delay is particularly important in cases where losses or attrition occur during the delay process (Manetsch, 1991). Losses due to natural causes are relevant in modeling forest growth over time. The lack of data on forest growth for the Dominican Republic makes it difficult to employ a time varying distributed delay. Hence, the time invariant version will be used to simulate forest growth. However, this constraint needs to be released in further versions of the model.

A common approach in simulating distributed delays is to use Euler's method for numerical integration. This method has proven convenient for ordinary distributed delay (without losses or time varying delay parameters). However, Manetsch (1991) has found Euler's method to be inappropriate if not used with a corrector formula, for the case where losses and time varying delays exist. To make use of this new finding, the distributed delay subroutine has been modified to minimize the simulation error. The main difference from previous versions is that a more accurate predictor-corrector solution of the differential equations is attained.

The differential equations describing the enhanced distributed delay can be obtained by assuming unilateral flows. Here, $Q_k, \ldots Q_1$ are the storage in the k delay stages. From conservation of flow we have

$$dQ_k/dt = U(t) - r_k(t) - PLR(t)\ Q_k(t)$$
$$dQ_{k-1}/dt = r_k(t) - r_{k-1}(t) - PLR(t)\ Q_{k-1}(t)$$
$$\cdot$$
$$\cdot$$
$$\cdot$$
$$dQ_1/dt = r_2(t) - r_1(t) - PLR(t)\ Q_1(t) \qquad (5)$$

where U(t) = input rate to the delay process; $r_i(t) = Q_i(t)/D(t)$ (6); $r_1(t) = y(t)$ (7), the output of the delay process; D(t) = DEl(t)/k; DEL(t) = mean total delay in the k stage process; and PLR(t) = proportional loss rate--proportion of the storage in each stage lost per unit of time. Combining equations (5), (6) and (7) one gets the defining equations for the process as

$$dQ_k/dt = u(t) - Q_k(t)/D(t) - PLR(t)\ Q_k(t)$$
$$dQ_{k-1}/dt = Q_k(t)/D(t) - Q_{k-1}(t)/D(t) - PLR(t)\ Q_{k-1}(t)$$
$$\cdot$$
$$\cdot$$
$$\cdot$$
$$dQ_1/dt = Q_2(t)/D(t) - Q_1(t)/D(t) - PLR(t)\ Q_1(t) \qquad (8)$$
$$y(t) = Q_1(t)/D(t) \qquad (9)$$

The numerical solution of the equation (8) is carried out using Euler's formula as a predictor and then the trapezoidal rule as a corrector. Thus, applying Euler predictor one gets

$$Q^P_k(t+DT) = Qhat_k(t) + DT(u(t) - (1/D(t) + PLR(t))\ Qhat_k(t))$$

$$Q^P_{k-1}(t+DT) = Qhat_{k-1}(t) + DT(Qhat_k(t)/D(t) - (1/D(t) + PLR(t))\ Qhat_{k-1}(t))$$

.
.
.

$$Q^P_1(t+DT) = Qhat_1(t) + DT(Qhat_2(t)/D(t) - (1/D(t) + PLR(t))\ Qhat_1(t)) \qquad (10)$$

Here, the $Qhat_i(t)$s are the best previous estimates of $Q_i(t)$, i=1,2...k.

According to the trapezoidal rule we have

$$\int_t^{(t+DT)} f(t)\,dt \approx \frac{DT}{2}\,[f(t) + f(t+DT)]$$

Thus, using the predictor results in the first iteration of a trapezoidal rule corrector, we get Q^1_k, Q^1_{k-1},...Q^1_1 as

$$Q^1_k(t+DT) = Qhat_k(t) + DT/2\ [\ u(t) - (1/D(t)+PLR(t))\ Qhat_k(t) + u(t+DT)-(1/D(t+DT) + PLR(t+DT))\ Qhat^P_k(t+DT)]$$

.
.
.

$$Q^1_1(t+DT) = Qhat_1(t) + DT/2\ [Qhat_2(t)/D(t)-(1/D(t) + PLR(t))\ Qhat_2(t) + + Q^P_2(t+DT)/D(t+DT) - (1/D(t+DT) + PLR(t+DT)) * Q^P_2(t+DT)] \qquad (12)$$

Equations (10) and (12) give the numerical solution to the system and can be readily converted into computer codes (Manetsch, 1976).

4.5 Forest Consumption Module

4.5.1 Population Module and Population Dynamics

FOSIM includes a population module which projects population in both urban and rural areas, to any point in time. The projections are used to estimate the number of households in each area, which in turn is used to estimate charcoal and firewood consumption for the country. The projections are also used as one of the beta parameters for the demand equations of lumber and paper products. The population module uses basic demographic variables such as age-sex distribution, the age-specific birth and death rates, sex ratio at birth, and the rate of decline of birth, death, and infant mortality rates.

FOSIM looks at population along three different dimensions: region, age, and sex. The number of people in the rural areas in a specific age-sex cohort is given by:

$$POPRU(t)_{kage,jsex} = POP(t)_{kage,jsex} * RURAL(t)_{kage,jsex} \qquad (13)$$

where $POPRU_{kage,jsex}$ = the total population in the rural region in a given age-sex cohort; $POP_{kage,jsex}$ = the total country's population in a given age-sex cohort; and, $RURAL_{kage,jsex}$ = proportion of total population living in the rural areas.

The number of people in the urban areas in a given age-sex cohort is given by:

$$POPUR(t)_{kage,jsex} = POP(t)_{kage,jsex} - POPRU(t)_{kage,jsex} \quad (14)$$

where POPUR = the total population in the urban region in a given age-sex cohort.

The total urban and rural populations are readily computed by summing over all the age classes and both sexes

$$TPOPRU(t) = SUM_{k=1}^{14} SUM^{2}_{j=1} \quad POPRU(t)_{kage,jsex} \quad (15)$$

$$TPOPUR(t) = SUM_{k=1}^{14} SUM^{2}_{j=1} \quad POPUR(t)_{kage,jsex} \quad (16)$$

4.5.2 Population Dynamics

The updating mechanism for the population component operates on two different cycles: a major cycle DTY of five years and a minor cycle DT equal to the time increment used in the simulation model (DT=.25 years). The reason for employing a major cycle DTY is that the population is divided into 14 five-year age groups. Thus, the population may be shifted between the age cohorts only once every five years.

Birth rates ($BIRTHR_{kage}$), infant mortality ($INMOR_t$), and death rates ($DEATHR_{kage, jsex}$) are assumed to be declining during the duration of a simulation run as a result of the introduction of effective birth control programs and improved health practices. The decline in birth rates is computed as:

BIRTHR(tm) = BIRTHR(tm-DTY)*(1.0-DECBIRTH)^DTY (17) where tm = average time during major time cycle, tm = t + (DTY/2); DTY = major time cycle of five years; BIRTHR = average birth rate during major cycle of DTY years; and, DECBIRTH = fractional decline per year in birth rate. The decline in infant mortality[4] is given by:

$$INMOR(tm) = INMOR(tm-DTY) + (1.0 - DECINMOR) \wedge DTY \qquad (18)$$

where INMOR = average infant mortality rate during the major cycle of DT years; and DECINMOR = fractional decline per year in the infant mortality rate.

Likewise, the decline in death rates is computed as follows:

$$DEATHR(tm)_{kage,jsex} = DEATHR(tm-DTY)_{kage,jsex} * (1.0-DECDEATH) \wedge DTY \qquad (19)$$

where $DEATHR_{kage,jsex}$ = age-sex-specific death rates in the country; and DECDEATH = fractional decline per year in the age-sex-specific death rates in the country.

The next step in the updating process is to delete the decedents from each age-sex cohort and shift the remaining population into the next older age-sex cohort using the equation

$$POP(t+DTY)_{kage,jsex} = POP(t)_{kage-1,jsex} * [1.0-DEATHR(tm)_{kage-1,jsex}] \wedge DTY \qquad (20)$$

[4] Infant mortality calculated in equation (POP 5) will decline asymptotically to 80 per thousand by the year 2010.

The number of males that enter the youngest age cohort is a function of the total number of births, infant mortality, and the sex ratio at birth, as in

$$POP(t+DTY)_{kage=1,male} = TBIRTH(tm) * (1.0 - INMOR(tm)) * [SRATIO/(1.0+SRATIO)] \quad (21)$$

where TBIRTH = total number of births during the major time cycle (see 17); and SRATIO = the number of male born per female born.

Likewise, the number of females who enter the youngest age cohort is given by

$$POP(t+DTY)_{kage=1,female} = TBIRTH(tm) * (1.0 - INMOR(tm)) * [1.0/(1.0+SRATIO)] \quad (22)$$

The total number of births during a major time cycle is

$$TBIRTH(tm) = SUM^{14}_{kage=1} (POP(t)_{kage,\ female} * BIRTHR(tm)_{kage} * DTY) \quad (23)$$

In order to consider urban-rural migration (an externally defined parameter), the proportion of the population that is located in rural areas is updated as

$$RURAL\ (t+DTY)_{kage,jsex} = RURAL\ (t)_{kage,jsex} * [1.0 - RUM_{jsex}] \wedge DTY \quad (24)$$

where RUM_{jscx} = "rural-urban" migration rate.

In this version of the model RUM_{jscx} does not change over time. However, the model could be modified to incorporate changes in the rural-migration rate over time fairly easily.

The computational procedure for the simulation model uses the above equations to estimate the total population per region at the beginning and at the end of each major cycle. These two values for each variable are then used to calculate a rate of change of the variable which holds during a major cycle, as in

RTPRU(tm) = [TPOPRU(t+DTY) - TPOPRU(t)] / DTY (25)

RTPUR(tm) = [TPOPUR(t+DTY) - TPOPUR(t) / DTY (26)

where RTPRU = rate of change of total population in the rural area during a major cycle, tm; and RTPUR = rate of change of total population in the urban area during a major cycle, tm.

Thus, the values of TPOPRU(t) and TPOPUR(t) as used in the equations (15) and (16) are computed each time increment, DT, by the following equations

TPOPRU(t) = TPOPRU(t-DT) + RTPRU(tm) * DT (27)

TPOPUR(t) = TPOPUR(t-DT) + RTPUR(tm) * DT (28)

where DT = time increment used in overall simulation model.

4.5.3 Factors Affecting Demand of Forest Products

The demand for lumber as well as for charcoal and fuelwood is estimated using a system of simultaneous equations. The price of charcoal and firewood are endogenous to the system.

Equations (29) through (31) represent the demand equations that would be estimated with the model if economic data were available, using the Two Stage Least Square technique, as in

$$D_{lumber} = b_0 + b_1 * P_{lumber} + b_2 * GDP + b_3 * Subst + U_t \qquad (29)$$

$$D_{charcoal} = b_4 + b_5 * P_{char} + b_6 * GDP + b_7 * P_{fuel} + b_8 * P_{gas} + b_9 * Urban_{pop} + b_{10} * Rural_{pop} + U_t \qquad (30)$$

$$D_{fuelwood} = b_{11} + b_{12} * P_{fuel} + b_{13} * GDP + b_{14} * P_{char} + b_{15} * Urban_{pop} + b_{16} * Rural_{pop} + U_t \qquad (31)$$

where D_{lumber}, $D_{charcoal}$, $D_{fuelwood}$ = demand for lumber, charcoal, and fuelwood respectively; P_{lumber}, P_{char}, P_{fuel} = lumber, charcoal, and fuelwood prices, respectively; GDP = Gross Domestic Product; P_{gas} = price of LPG; $Urban_{pop}$ = Urban population in # of inhabitants; $Rural_{pop}$ = Rural population in # of inhabitants; and, b_i = constant parameters.

According to these equations, fuelwood and charcoal are treated as close substitutes for each other. In addition, imported liquid petroleum gas (LPG) is also considered a potential substitute for charcoal. Demographic variables such as urban and rural population are very important since changes in demand for charcoal and firewood will follow relative changes within these variables. Accordingly, the demand for charcoal is expected to increase as urban population increases. Firewood demand would increase as rural population increases. In addition, relative demand of charcoal over firewood is expected to increase as urban population increases relative to rural population.

4.5.4 Limiting Factors in Estimating Demand Equations

In order to estimate the demand of any given final product using the Two-Stage Least Squares technique, it is necessary to obtain relevant time series data on variables such as price of charcoal, firewood, and lumber; actual quantities consumed at a given price for all products; wood products imports (lumber) data; domestic supply of raw material for processing industry; prices of substitutes (LPG, Kerosene, etc.), and so forth.

The most critical limitation of the study is the lack of primary, or even secondary, data relating prices to consumption of firewood and charcoal. Since there are no time series data which could help to identify price, income, and supply elasticities for these products, two stage least square was not used. Modifications to FOSIM, therefore, were made.

The first modification is in the way the model estimates demand equations for firewood and charcoal. Since there are no data on actual quantities consumed or prices, the demand for either of these product is thought to be a function of both rural and urban population dynamics. It is possible to see the relationship by using the per-capita consumption estimates from the National Commission on Energy (COENER, 1987) and Knudson, et al., (1988).

FOSIM estimates the number of urban and rural households at any given point in time t, from the population module. Then, using per-capita consumption figures, an estimate for both firewood and charcoal consumption is determined for time t. The consumption estimates are considered as national needs which have to be meet either through the natural forests, based on allowable harvest; the forest plantations; or the clearcutting of forest areas. However, to account for some of the effects of prices and income, the model uses price and income elasticity estimates developed by Sedjo for countries similar to the DR (Sedjo, 1989). Hence, a price elasticity of -.2 was used for charcoal, and an income elasticity of -.7 was used for both charcoal and firewood demand equations.

According to the Instituto de Estudios de Población y Desarrollo, 80 percent of the clearcut areas within the dry forest cannot be recovered through natural regeneration (IEPD, 1985). This figure is considered to be extreme and not in line with the Dominican reality. Hence, the study assumes that 20 percent of the clearcut areas cannot be regenerated back to forestry uses. In the event that allowable harvest from natural forests, plus wood material from forest plantations, are not sufficient to meet potential demand of wood for charcoal and firewood for time t, the program calculates how many hectares need to be clearcut to meet demand. Hence, the area under forest cover in the country is reduced by 20 percent of the clearcut area, for the time period t+1. Under the restricted model equations (29) through (31) are reduced to:

$$D_{charcoal} = (b_1 * Urban_{pop} + b_2 * Rural_{pop}) * (Price_{ch}(t) / Price_{ch}(t-1))\hat{\ } e_p * (GDP(t) / GDP(t-1))\hat{\ } e_I \quad (32)$$

$$D_{fuelwood} = (b_3 * Urban_{pop} + b_4 * Rural_{pop}) * (GDP(t) / GDP(t-1))\ \hat{\ }\ e_{I2} \quad (33)$$

$$D_{lumber} = A * Ppanel^{epp} * Pround^{epr} * Psawn^{eps} * GDP^{eI3} \quad (34)$$

where b_1 and b_3 = per-household consumption of charcoal and firewood, respectively, in urban areas; b_2 and b_4 = per-household consumption of charcoal and firewood, respectively, in rural areas; e_p, e_{pp}, e_{pr}, and e_{ps} = own price elasticities; and, e_I, e_{I2}, and e_{I3} = income elasticities for charcoal, firewood, and lumber respectively.

The unrestricted model which uses the equations (29) though (31) in estimating demand for final products is considered to be superior to the restricted model since it captures the important effects of prices, GDP, and income. The restrictions on available data, however, do not allow for the use of these equations.

4.6 Market Product Module

4.6.1 Equilibrium Dynamics Between Demand and Supply of wood material

The growth rate of a given kind of forest, suitable for charcoal and firewood or lumber, is a function of the total available forest at time t and the specific amount of wood available for both charcoal and firewood and lumber at time t, in cubic meters. The quantities of wood material harvested for charcoal and firewood and lumber at time t are determined from the potential supply and potential demand equations of raw material. In the case of charcoal and firewood material, two separate markets are identified. A fraction of the harvested material is used in the charcoal processing industry, while the rest is sold directly in the firewood market. Hence, three markets are relevant to the study: the lumber market, the charcoal market, and the firewood market. The prices for charcoal should be determined internally. Therefore, problems of simultaneity should be considered only when estimating supply and demand for charcoal and firewood. However, the lack of time series data relating price and quantity makes it difficult for the model to estimate prices internally; instead, charcoal prices are assumed to increase at a specified rate during the simulation period. This particular constraint can be relaxed once price data become available. The supply function in the case of final products is specified through the estimation of recovery ratios. Capacity and production cost information can be readily added to the model, pending data availability, for better specification of the supply curve. Lumber prices are external to the system.

4.7 Policy Scenarios

The main strength of FOSIM is its ability to analyze different policy scenarios for the Dominican forestry sector. Nine different policy scenarios are analyzed here (Table 4.1). The policy scenarios are labelled from A) to K). Case A) looks at the present situation, where there is neither a national cookstove program or brick-kiln program, nor a fuel wood plantation program. Cases B) and C) analyze the effects of a national cookstove program in the country with two assumptions on the dissemination rate. Cases D) and E) incorporate a brick-kiln program which increases the efficiency of charcoal production. Two implementation levels are analyzed. Cases F) and G) introduce a plantation program with low and high plantation rates, respectively. Likewise, Cases H) and I) combine the three programs: a cookstove program, a brick-kiln program, and an energy plantation program.

These policy scenarios look at the future of the Dominican forestry sector in terms of three major national policy issues in the country. The issues were introduced in the Attitude Analysis presented in Chapter Three of the study. First, the effects of continuing with the present forest policy on the Dominican forest resource base was analyzed.

Table 4.1. Policy Scenarios for the Dominican Forestry Sector

Case	Proposed Program
A)	Present situation with no forestry programs
B)	20-year cookstove program at a low and/or high dissemination rate
C)	10-year cookstove program at a low and/or high dissemination rate
D)	55-year brick-kiln program with low and high implementation rates
E)	30-year brick-kiln program with low and high implementation rates
F)	A moderate 17-year energy plantation program
G)	An intensive 20-year energy plantation program
H)	Combination of scenarios B), D), and F
I)	Combination of scenarios C), E), and G

Second, a national forest policy which emphasizes the use of production areas and its effects on the resource base was considered. Third, the opportunity costs in terms of an energy substitution policy was also considered. In all cases the crucial question is what is the direct effect of the policy on the forest resource base over time. The policy scenarios result from analyzing the present situation together with the three forestry programs outlined in Section 2.6. The study considers two cookstove programs: a) an intensive 10-year program (Figure 4.1) and b) a more realistic 20-year program (Figure 4.2). In each case, two dissemination rates are used. Thus, the programs are assumed to reach either 50 or 70 percent of the households that use firewood in the country at the end of the implementation period.

Likewise, two brick-kiln programs are considered: a) an intensive 30-year program (Figure 4.3) and b) a gradual 55-year program (Figure 4.4). In both cases, two levels of implementation are analyzed. Thus, at the end of the implementation period it is assumed that there will be either 1,000 or 1,500 brick-kilns in place. These adoption rates were modeled from those for proposed FAO programs (Christiansen, 1987). Though brick kilns have proven to be superior in research studies, they carry a costly initial investment and require a rather large amount of+ wood to operate at an efficient level. Most producers, however, produce on a small or medium scale, which might impede the dissemination of the improved technology.

Finally, two energy plantation programs are analyzed a) a moderated plantation program that starts in 1990 with an available amount of wood material that increases from 236,000 cubic meters in the year 2000 to 1,211,000 cubic meters by the year 2041 (Table 4.2); and, b) In the event

Table 4.2. Moderate 17-year energy plantation program

Plantation Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	TOTAL PRODUCTION
Hectares Planted	2100	2100	2800	3500	3500	4800	4800	5800	8800	8800	6400	6400	4500	2600	2600	1400	1400	700	PER YEAR IN 000 M3
Production Year										Thousand m3									
2000	236																		236
2001		236																	236
2002			315																315
2003				394															394
2004					394														394
2005						540													540
2006							540												540
2007	165							653											818
2008		165							990										1155
2009			221							990									1211
2010				276							720								996
2011					276							720							996
2012						378							506						884
2013							378							293					671
2014	165							457							293				915
2015		165							693							158			1016
2016			221							693							158		1071
2017				276							504							79	858
2018					276							504							780
2019						378							354						732
2020							378							205					583
2021								457							205				662
2022	189								693							110			992
2023		189								693							110		992
2024			252								504							55	811
2025				315								504							819
2026					315								354						669
2027						432								205					637
2028							432								205				637
2029								522								110			632
2030									792								110		902
2031										792								55	847
2032	236										576								812
2033		236										576							812
2034			315										405						720
2035				394										234					628
2036					394										234				628
2037						540										126			666
2038							540										126		666
2039	165							653										63	881
2040		165							990										1155
2041			221							990									1211
2042				276							720								996
2043					276							720							996
2044						378							506						884
2045							378							293					671

Table 4.3. Intensive 20-year energy plantation program

Plantation Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL PRODUCTION
Hectares Planted	4400	4400	5000	5600	5600	7200	7200	9000	10800	10800	6400	6400	4700	3000	3000	1400	1400	1300	1200	1200	PER YEAR IN 1000 M3
Production Year										Thousand m3											
2000	495																				495
2001		495																			495
2002			563																		563
2003				630																	630
2004					630																630
2005						810															810
2006							810														810
2007	347							1013													1359
2008		347							1215												1562
2009			394							1215											1609
2010				441							720										1161
2011					441							720									1161
2012						567							529								1096
2013							567							338							905
2014	347							709							338						1393
2015		347							851							158					1355
2016			394							851							158				1402
2017				441							504							146			1091
2018					441							504							135		1080
2019						567							370							135	1072
2020							567							236							803
2021								709							236						945
2022	396								851							110					1357
2023		396								851							110				1357
2024			450								504							102			1056
2025				504								504							95		1103
2026					504								370							95	969
2027						648								236							884
2028							648								236						884
2029								810								110					920
2030									972								110				1082
2031										972								102			1074
2032	495										576								95		1166
2033		495										576								95	1166
2034			563										423								986
2035				630										270							900
2036					630										270						900
2037						810										126					936
2038							810										126				936
2039	347							1013										117			1476
2040		347							1215										108		1670
2041			394							1215										108	1717
2042				441							720										1161
2043					441							720									1161
2044						567							529								1096
2045							567							336							905

that an intensive plantation program starts in 1990, the amount of wood material available will increase from 495,000 cubic meters in the year 2000 to 1,717,000 cubic meters by the year 2041 (Table 4.3).

The energy plantation programs are modeled in a discrete fashion. That is, the plantation established in 1990 is harvested in the year 2000 for the first time. Then, after seven, seven, and eight years, the sprout regenerations are harvested. If there is time (within the simulation horizon) to establish a new plantation the model start with the harvesting schedule from the beginning.

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RESULTS AND DISCUSSION

5.1 Population Dynamics and Projections

The population model outlined in Chapter Four, equations 4.15 through 4.30, was used to estimate urban and rural population for the Dominican Republic to the year 2045. First, the model was validated by producing estimates for the period 1980 to 1990. The model estimated a total population of 5.645, 6.194, and 6.825 millions of inhabitants, respectively. These figures are in line with the official demographic census of 1980 and the estimates for 1990. The population estimates are updated once every five year. Hence, urban and rural population estimates are presented for each five year-period to the year 2045 (Table 5.1).

The urban population is expected to increase by 63 percent by the year 2035, while the rural population is estimated to increase by only 15 percent by the year 2035. The results support the idea of an urban population increasing at an accelerated rate to the year 2000, increasing by 11.5 and 9 percent for 1995 and 2000, respectively, and then continuing to increase at a decreasing rate to the year 2035, going from a 7.9 percent increase from 2000 to 2005, to a decrease of 0.89 percent

Table 5.1. Dominican Republic Urban and Rural population Projections to the Year 2045 (thousands)

Year	Urban Population	Rural Population	Country population
1990	3688	3137	6825
1995	4111	3390	7501
2000	4480	3537	8017
2005	4833	3644	8477
2010	5147	3702	8854
2015	5344	3695	9039
2020	5495	3648	9143
2025	5651	3600	9252
2030	5846	3591	9438
2035	6012	3597	9608
2040	5942	3431	9372
2045	5889	3279	9167

from 2040 to 2045. On the other hand, rural population increases at a decreasing rate through the simulation period changing from a 8.1 percent increase from 1990 to 1995, to a negative increase (actually a decrease) after the year 2015 (Table 5.1). The results in this case show the effects that both in-country rural-urban migration and international migration will have on the rural population of the country.

5.1.1 Number of households that use charcoal and firewood

Population projections are used in the model to estimate the number of households that use charcoal and/or firewood in the DR at any point within the time frame considered. To obtained the number of households per region the total population of the region is divided by the average number of persons per household and multiply by the proportion of households that use either charcoal or firewood in the region. Urban households which use these products increased from 327,000 in 1990 to 522,000 by 2045. Likewise, rural households increased from 542,000 in 1990 to 567,000 by 2045 (Table 5.2).

Two main factors affect the increase in the number of urban households which use charcoal and/or firewood. First, the direct effect of an increase in urban population per set; second, the resulting increase from a positive rural-urban migration pattern in the country. The increase in the number of households in the urban areas brings as a consequence an increase in the relative demand for charcoal compared to that of firewood; hence, an increase in the relative demand of the raw material uses for these two products.

5.2 Potential demand for wood material for charcoal and firewood

In order to estimate the potential demand for wood material suitable for charcoal and firewood, several forms of the model were run. Each subsequent form incorporates an additional variable to the original demand equations. First, potential demand for wood material for these products is

Table 5.2. Projected number of households that use charcoal and firewood in the Dominican Republic (thousands)

Year	No. households Urban areas	No. households Rural areas	Total
1990	327	542	869
1995	364	586	950
2000	397	611	1008
2005	428	630	1058
2010	456	640	1096
2015	474	639	1113
2020	487	630	1117
2025	501	622	1123
2030	518	621	1139
2035	533	622	1155
2040	526	593	1119
2045	522	567	1089

thought to be a function of the number of urban and rural households which use charcoal and firewood as energy sources and the per-household consumption estimates developed by the National Energy Commission (COENER 1987).

Other per-household estimates developed by Knudson, et. al. 1988, were also considered at this point. Both per-household consumption estimates yielded similar results in terms of the total potential demand for wood material. However, they differ in the amount of wood material that is demanded by each product market. Using COENER estimates, potential demand for wood material for charcoal production is estimated at 2.3 million cubic meters for 1990, and it is thought to increase to 3.3 million cubic meters by 2035 and then decrease to 3.2 million cubic meters by the end of the simulation period. Using Knudson's estimates, potential demand for wood material for charcoal is calculated at 1.9 million cubic meters in 1990, and it is estimated to increase to 2.8 million cubic meters by 2035 and decrease to 2.7 million cubic meters by the year 2045. On the other hand, Knudson estimates yielded a higher potential demand for firewood wood material than that obtained by using COENER estimates (Table 5.3).

Table 5.3. Projected consumption of wood for charcoal and firewood 1985-2045 in the DR. (thousands cubic meters)

Year	With COENER Estimates*		With Knudson Estimates**	
	Charcoal[a]	Firewood[b]	Charcoal[a]	Firewood[b]
1990	2306	1633	1942	1924
1995	2542	1770	2140	2086
2000	2728	1855	2296	2186
2005	2897	1921	2439	2264
2010	3039	1964	2558	2315
2015	3114	1968	2622	2319
2020	3162	1953	2662	2301
2025	3211	1937	2703	2283
2030	3286	1942	2766	2288
2035	3354	1952	2823	2300
2040	3281	1871	2762	2204
2045	3219	1797	2710	2118

[a] The expected charcoal consumption = f(population, pcc)
[b] The expected firewood consumption = f(population, pcc)

Previous studies have estimated potential demand for wood material in the Dominican Republic as a function of the number of households and per-capita consumption. However, there are additional factors, such as charcoal and firewood prices and gross domestic product (GDP), which affect potential demand for wood material. Hence, the model incorporates charcoal prices and GDP estimates into the potential demand equations. Firewood prices are not included due to the degree of uncertainty involved in predicting this value[7]. Both potential demand estimates decreased when charcoal price and GDP were incorporated. The decrease in raw material for charcoal production, however, was only of one percent with respect to the original estimate. This reflects the inelasticity of the charcoal demand function with respect to both price and income. The decrease in the firewood raw material potential demand was considerably higher, about 6.2 percent, with respect to the original estimate. This reflects a more income elastic demand function (Table 5.4). The rest of the potential demand equation forms used are presented in the sections corresponding to the specific policy program analyzed later in this chapter.

5.3 Potential supply of wood material from native forests

Chapter Two specified the different sources of wood raw material suitable for charcoal, firewood, and lumber products. Two fundamental questions the study raised are: a)

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[7] There is virtually no data on the dependent variable (firewood consumption) in relation to firewood prices.

what is the potential availability of standing timber in each source at any point in time; and b) what level of allowable harvesting schedules can each source support over time.

Table 5.4. Projected consumption of wood for charcoal and firewood 1990-2045 in the D.R. (thousands cubic meters)

Year	With COENER Estimates* Charcoal[a]	Firewood[b]	With Knudson Estimates** Charcoal[a]	Firewood[b]
1990	2145	1612	1805	1900
1995	2369	1743	1994	2054
2000	2528	1820	2128	2144
2005	2700	1892	2273	2229
2010	2828	1942	2380	2288
2015	3018	1943	2540	2290
2020	3055	1923	2572	2266
2025	3101	1900	2610	2239
2030	3176	1913	2673	2254
2035	3251	1930	2737	2274
2040	3175	1847	2673	2177
2045	3115	1770	2623	2086

[a] Expected charcoal consumption = f(population, pcc, GDP, price)
[b] The expected firewood consumption = f(population, pcc, GDP)

Potential availability of raw material and allowable harvesting schedules in the case of the Dominican dry forest, broadleaf humid forest, and Baoruco's pine forest are presented in Tables 5.5, 5.6, and 5.7, respectively. There are an estimated seven million cubic meters of standing wood material suitable for charcoal and firewood within the Dominican dry forest (FAO, 1987). The area considered includes the existing production zones, 30,500 hectares, as well as 219,500 hectares of potential production areas. If the dry forest is managed under a allowable harvesting schedule, then on average the forest can support harvests of 324,000 cubic meters per year without decreasing the original standing volume (Table 5.5). Within the Dominican broadleaf forest there is an estimated standing volume of 5.9 million cubic meters suitable for charcoal and firewood production. Furthermore, this forest can support an annual harvest of 476,000 cubic meters without decreasing original stocking levels (Table 5.6).

Table 5.5. Charcoal and firewood raw material from the Dominican dry forest, with standing volumes and allowable harvests for existing and potential production areas (thousand cubic meters).

	Existing Area (30,515 has)		Potential area (219,485 has)		Total
Year	Standing Volume	Allowable Harvest	Standing Volume	Allowable Harvest	Allowable Harvest
1990	1206	60	7067	162	222
1995	1205	76	7063	201	278
2000	1215	80	7049	283	363
2005	1228	76	7092	282	358
2010	1240	74	7138	274	348
2015	1251	74	7181	269	342
2020	1262	73	7223	265	338
2025	1273	72	7265	261	333
2030	1284	71	7306	258	328
2035	1295	70	7346	254	324
2040	1306	69	7386	250	319
2045	1317	68	7426	247	314

Table 5.6. Charcoal and firewood raw material from the Dominican broadleaf humid forest, with standing volumes and allowable harvests for potential production areas (thousands cubic meters).

Year	Potential area (337,700 has) Standing Volume	Allowable Harvest	Total after Harvest Volume
1990	5880	199	5681
1995	5878	159	5718
2000	5904	199	5705
2005	5973	335	5638
2010	6062	492	5570
2015	6144	598	5546
2020	6209	645	5564
2025	6262	656	5607
2030	6311	654	5658
2035	6358	649	5709
2040	6406	646	5760
2045	6453	644	5810

Wood availability within the Baoruco's pine forest is estimated at 1.9 million cubic meters of standing volume. This forest can support allowable harvests of 66,000 cubic meters per year (Table 5.7). However, only a fraction of this volume is suitable for charcoal and firewood production. According to Ramm (1985), up to 70 percent of the wood material produced within the Baoruco's pine forest is suitable for lumber production, with the remaining 30 percent suitable for charcoal and firewood production (Ramm, 1985). Thus on average, 20,000 cubic meters per year are available for charcoal and firewood production. In sum, all sources of wood material can support allowable harvests from 0.5 million cubic meters in 1990 to 1.0 million cubic meters by 2045 (Table 5.8).

Table 5.7. Charcoal and firewood raw material from the Baoruco's pine forest, with standing volumes and allowable harvests for existing production areas (thousands cubic meters)

Year	PART I Standing Volume	 Allowable Harvest	PART II Standing Volume	 Allowable Harvest	PART III Standing Volume	 Allowable Harvest
1990	659	39	667	41	629	35
1995	607	34	657	31	646	47
2000	580	25	587	25	624	18
2005	564	15	523	17	610	22
2010	536	15	483	12	611	28
2015	524	15	467	12	638	28
2020	530	15	446	12	634	28
2025	534	15	426	12	627	28
2030	538	15	408	12	621	28
2035	542	15	392	12	616	28
2040	544	15	378	12	611	28
2045	547	15	365	12	607	28

Table 5.8. Charcoal and firewood raw material summary table on allowable harvests for existing and potential Dominican forest production areas (thousand cubic meters).

Year	Dry forest*	Humid forest**	Pine forest***	All forests
1990	226	203	81	510
1995	276	160	93	529
2000	458	180	80	718
2005	452	304	69	825
2010	427	486	64	977
2015	417	642	64	1123
2020	411	731	64	1206
2025	406	763	64	1233
2030	400	767	64	1231
2035	394	763	64	1221
2040	388	758	64	1210
2045	383	754	64	1201

* Both existing and potential production areas within the dry forest are considered.

** Areas included represent potential production areas. Actual production areas are only a fraction.

*** Only Baoruco pine forest is considered.

5.4 Potential demand versus potential supply of wood material

One can readily appreciate a major discrepancy between potential demand and potential supply for wood material for charcoal and firewood production in the DR. As outlined in Section 4.4, the model first turns to the allowable harvest and compares it to the potential demand estimate for a given year. Then, the model estimates the amount of land that needs to be clearcut to meet the deficit in allowable production. Finally, an accounting system keeps track of the amount of forest land that is converted to other uses as a consequence of the clearcutting. The most critical situation is found within the Dominican dry forest when trying to equate potential supply to potential demand. Here, excess demand will surpass allowable production by more than two million cubic meters per year by 1995. There has to be a clearcut area of 50 - 60,000 hectares to be able to meet potential demand from the dry forest. Furthermore, due to the clearcut there is a net loss of forest area of 10 - 13,000 hectares per year. Accordingly, the country would use up all mature standing timber within the dry forest by the year 2002. At that time, the area under forest cover would be reduced to 53,000 hectares in which only immature timber would exist. This area would represent only 26 percent of the original area (Table 5.9).

Table 5.9. Meeting potential demand of wood material for charcoal and firewood from the Dominican dry forest (includes existing and potential production areas).

Year	Forest	Available	Allowable	Deficit in	Hectares	Hectares
has	000 has					
1990	200.5	5324.9	138.6	1793.3	53.6	10.7
1991	189.4	4927.6	121.2	1856.5	55.4	11.1
1992	178.0	4511.0	113.7	1899.0	56.7	11.3
1995	142.7	3266.1	128.6	2007.3	60.1	12.0

The situation for the broadleaf humid forest is somewhat similar to that of the dry forest. However, it would not be until the year 2015 that the country would use up all the mature standing timber in the broadleaf humid forest. Nevertheless, the reduction of forest land due to clearcutting to meet potential demand, is just as drastic. By the year 2015 forest land within the broadleaf humid forest would decrease to 45,000 hectares, or 15 percent of the original area (Table 5.10).

Baoruco's pine forest presents a somewhat different situation. Due to the small relative demand for pine material for charcoal and firewood production, allowable harvests are closer to potential demand than in the previous two cases. Accordingly, the mature standing timber within this region would not be used up until the year 2028. Forest

Table 5.10. Equating projected demand of wood material for charcoal and firewood from the Dominican humid broadleaf forest.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares to be clearcut	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.7	5069.0	146.4	1524.6	40.4	8.1
1992	284.5	4940.6	133.8	1564.2	41.4	8.3
1993	275.9	4807.6	122.7	1611.3	42.6	8.5
1994	267.3	4669.0	113.3	1646.7	43.4	8.7
1995	258.3	4525.6	106.2	1689.8	44.5	8.9
1996	249.3	4376.5	101.3	1710.7	45.1	9.0
1997	240.2	4223.7	98.9	1740.1	45.9	9.2
1998	230.9	4066.4	98.7	1758.3	46.4	9.3
1999	221.5	3905.7	100.6	1784.4	47.1	9.4
2000	212.0	3741.1	103.9	1798.1	47.5	9.5
2001	202.3	3574.1	108.5	1820.5	48.2	9.6
2002	192.6	3404.1	113.3	1830.7	48.6	9.7
2003	182.8	3232.7	118.2	1849.8	49.2	9.8
2004	172.8	3059.5	122.1	1860.9	49.6	9.9
2005	162.8	2885.5	124.9	1883.1	50.4	10.1
2006	152.6	2709.9	125.6	1894.4	50.8	10.2
2007	142.3	2534.1	124.5	1915.5	51.5	10.3
2008	131.9	2357.3	120.7	1929.3	52.0	10.4
2009	121.3	2180.1	114.8	1956.2	52.8	10.6
2010	110.6	2001.6	105.9	1976.1	53.5	10.7
2011	99.8	1822.3	95.0	2002.0	54.3	10.9
2012	88.8	1641.5	81.7	2018.3	54.8	11.0
2013	77.7	1460.0	66.9	2043.1	55.5	11.1
2014	66.5	1276.9	50.3	2062.7	56.1	11.2
2015	55.3	1092.5		1031.5	55.3	11.1

Table 5.11. Equating projected demand of wood material for charcoal and firewood from the Bahoruco's pine forest.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares to be Clearcut	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	61.197	1.129	0.226
1992	35.1	1828.6	138.6	59.379	1.101	0.220
1993	34.9	1815.1	129.5	72.538	1.348	0.270
1994	34.6	1776.9	123.6	81.380	1.522	0.304
1995	34.3	1739.5	113.5	95.452	1.799	0.360
1996	34.0	1687.2	105.7	105.295	2.007	0.401
1997	33.6	1643.9	86.5	127.531	2.449	0.490
1998	33.1	1573.7	83.1	132.941	2.590	0.518
1999	32.6	1521.8	74.5	144.511	2.851	0.570
2000	32.0	1457.4	71.1	149.891	3.006	0.601
2001	31.4	1406.1	58.9	165.143	3.347	0.669
2002	30.7	1341.4	55.6	170.387	3.498	0.700
2003	30.0	1285.7	52.9	176.133	3.662	0.732
2004	29.3	1228.2	51.6	179.424	3.784	0.757
2005	28.5	1170.8	53.4	180.642	3.873	0.775
2006	27.8	1117.2	53.5	181.505	3.950	0.790
2007	27.0	1066.3	52.0	185.030	4.082	0.816
2008	26.1	1013.3	50.4	187.608	4.197	0.839
2009	25.3	966.6	42.5	198.540	4.467	0.893
2010	24.4	911.0	41.3	200.749	4.554	0.911
2011	23.5	867.1	39.7	204.289	4.649	0.930
2012	22.6	821.9	38.1	205.860	4.701	0.940
2013	21.6	778.0	36.6	208.447	4.780	0.956
2014	20.7	735.7	31.0	214.995	4.931	0.986
2015	19.7	689.0	29.5	217.474	4.990	0.998
2016	18.7	645.4	28.0	218.972	5.030	1.006
2017	17.7	599.2	30.4	217.647	5.019	1.004
2018	16.7	555.3	28.7	218.324	5.056	1.011
2019	15.7	509.7	27.0	221.015	5.140	1.028
2020	14.6	462.2	25.3	222.737	5.202	1.040
2021	13.6	415.6	23.5	225.481	5.289	1.058
2022	12.5	368.0	21.7	227.258	5.354	1.071
2023	11.5	321.4	19.9	229.058	5.420	1.084
2024	10.4	275.2	18.1	230.882	5.487	1.097
2025	9.3	229.4	16.3	233.730	5.578	1.116
2026	8.2	183.5	14.4	236.611	5.671	1.134
2027	7.0	139.2	12.5	239.526	5.765	1.153
2028	5.9	98.3	10.5	241.474	5.836	1.167
2029	3.6	67.6		185.396	3.556	0.711

land which is estimated at 35,500 hectares would decrease to 6,000 hectares at that point (Table 5.11).

5.5 Forestry programs that affect potential demand for raw material

The model was run twenty four times to determine the effects on the forest resource base of different forestry programs which have been proposed for the Dominican Republic. Three programs are particularly important to the DR situation: a national cookstoves program; a brick-kiln program for charcoal production; and, an energy plantation program. Usually, two levels of adoption and/or implementation rates were considered for each program. The specific results are presented below.

5.5.1 A national cookstoves program for the DR

A national cookstove program aims at increasing the efficiency firewood consumption at the individual household level. Such a program directly reduces the demand for wood material for firewood production by lowering per-household consumption in the households that use firewood. Two cookstove programs were considered. The first is a 20-year program, the second an intensive 10-year program. In each case, two levels of adoption rate were analyzed. One assumed that the program will reach 50 percent of the households that use firewood by the end of the program, while the other assumed that the program will reach 70 percent of the households that use firewood.

A 20-year cookstove program which reaches either 50 or 70 percent of the households that use firewood, would have little effect on efforts to decrease potential demand for wood material from the native forests. There is virtually no change in the way the dry forest would be depleted as compared to the no-program option (Table 5.12). The only effect of an intensive program is to delay the depletion for three years for the broadleaf humid forest (Table 5.13) and two years for the Baoruco's pine forest (Table 5.14).

The results did not change when a 10-year intensive cookstove program was analyzed. Here, the depletion of the mature standing timber within the dry, broadleaf humid, and pine forests was delayed by one, four, and three years, respectively. Most wood materials taken from the native forests are used in the charcoal production industry. The level of demand for such an industry is not affected by the introduction of efficient wood cookstoves. Appendix B presents the year-to-year results of the intensive cookstove program.

Table 5.12. Equating projected demand of wood material from Dominican dry forests, including a national cookstoves program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.5	5324.9	138.6	1789.3	53.5	10.7
1991	189.5	4932.0	121.2	1847.5	55.2	11.0
1992	178.2	4521.6	113.7	1884.9	56.2	11.2
1993	166.7	4117.6	114.8	1922.9	57.4	11.5
1994	155.1	3703.8	121.2	1945.0	58.1	11.6
1995	143.3	3300.3	129.0	1977.8	59.2	11.8
1996	131.3	2884.9	134.6	1990.1	59.6	11.9
1997	119.2	2490.3	136.3	2019.1	60.5	12.1
1998	107.0	2084.1	133.5	2043.3	61.2	12.2
1999	94.5	1688.7	126.6	2081.7	62.4	12.5
2000	81.9	1294.4	116.4	2112.6	63.2	12.6
2001	69.0	942.9	104.1	2144.5	64.1	12.8
2002	56.2	744.7		1508.3	56.2	11.2

Table 5.13. Equating projected demand of wood material from humid broadleaf forest, including a national cookstoves program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares to be Clearcut	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1473.0	39.1	7.8
1991	292.8	5069.3	146.5	1517.5	40.2	8.0
1992	284.6	4941.6	133.9	1553.1	41.1	8.2
1993	276.1	4809.6	122.9	1595.1	42.1	8.4
1994	267.6	4672.5	113.6	1627.4	42.9	8.6
1995	258.8	4530.8	106.6	1665.4	43.9	8.8
1996	249.9	4383.9	101.8	1681.2	44.3	8.9
1997	240.9	4233.7	99.6	1705.4	44.9	9.0
1998	231.9	4079.5	99.5	1718.5	45.3	9.1
1999	222.7	3922.3	101.7	1738.3	45.9	9.2
2000	213.5	3761.8	105.3	1747.7	46.2	9.2
2001	204.2	3599.2	110.3	1753.7	46.4	9.3
2002	194.9	3435.1	115.8	1747.2	46.4	9.3
2003	185.6	3271.1	121.6	1750.4	46.6	9.3
2004	176.3	3106.7	126.7	1744.3	46.5	9.3
2005	166.9	2942.9	131.0	1748.0	46.7	9.3
2006	157.5	2779.2	133.5	1749.5	46.9	9.4
2007	148.1	2616.1	134.3	1762.7	47.4	9.5
2008	138.5	2452.7	132.6	1766.4	47.6	9.5
2009	128.9	2289.8	128.9	1784.1	48.2	9.6
2010	119.2	2126.4	122.4	1792.6	48.5	9.7
2011	109.4	1963.2	114.1	1815.9	49.2	9.8
2012	99.4	1798.9	103.1	1829.9	49.7	9.9
2013	89.4	1634.0	90.6	1853.4	50.3	10.1
2014	79.2	1467.8	76.1	1869.9	50.8	10.2
2015	68.9	1300.6	60.5	1896.5	51.6	10.3
2016	58.5	1131.4	43.6	1912.4	52.0	10.4
2017	48.0	961.1	26.5	1935.5	52.6	10.5
2018	37.5	788.8		1173.2	37.5	7.5

Table 5.14. Equating projected demand of wood material from the Baoruco's pine forest, including a national cookstoves program.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	61.197	1.129	0.226
1992	35.1	1828.6	138.6	57.379	1.064	0.213
1993	34.9	1817.5	129.5	70.510	1.310	0.262
1994	34.6	1779.7	123.7	78.327	1.465	0.293
1995	34.4	1743.9	113.6	92.365	1.741	0.348
1996	34.0	1692.2	105.8	101.176	1.929	0.386
1997	33.6	1650.7	86.6	123.392	2.370	0.474
1998	33.1	1581.3	83.2	127.766	2.489	0.498
1999	32.6	1531.3	74.7	139.306	2.748	0.550
2000	32.1	1467.8	71.4	143.645	2.881	0.576
2001	31.5	1418.7	59.1	157.889	3.200	0.640
2002	30.9	1356.3	55.9	161.089	3.307	0.661
2003	30.2	1304.2	53.2	164.776	3.426	0.685
2004	29.5	1250.8	52.0	165.984	3.500	0.700
2005	28.8	1197.8	53.9	164.070	3.518	0.704
2006	28.1	1150.1	54.2	164.778	3.586	0.717
2007	27.4	1102.5	52.8	167.163	3.688	0.738
2008	26.7	1053.8	51.4	169.588	3.794	0.759
2009	25.9	1010.7	43.5	178.526	4.017	0.803
2010	25.1	960.6	42.4	180.566	4.096	0.819
2011	24.3	920.8	41.0	182.951	4.163	0.833
2012	23.5	880.8	39.6	185.358	4.233	0.847
2013	22.6	840.0	38.2	187.787	4.306	0.861
2014	21.8	801.9	32.6	193.377	4.435	0.887
2015	20.9	760.2	31.3	196.707	4.514	0.903
2016	20.0	719.8	29.9	197.062	4.527	0.905
2017	19.1	678.6	32.7	195.340	4.505	0.901
2018	18.2	639.0	31.2	196.845	4.558	0.912
2019	17.2	596.5	29.6	199.369	4.637	0.927
2020	16.3	552.7	28.1	200.923	4.693	0.939
2021	15.4	509.9	26.5	202.496	4.750	0.950
2022	14.4	467.0	24.9	204.092	4.808	0.962
2023	13.5	424.1	23.3	206.708	4.891	0.978
2024	12.5	380.2	21.6	208.354	4.951	0.990
2025	11.5	337.3	20.0	211.022	5.036	1.007
2026	10.5	293.6	18.3	213.721	5.122	1.024
2027	9.5	250.0	16.5	216.450	5.209	1.042
2028	8.4	207.0	14.8	218.211	5.274	1.055
2029	7.4	165.9	13.0	220.995	5.363	1.073
2030	5.2	126.4		108.644	5.227	1.045

5.5.2 A brick-Kiln program for the DR

Two brick-kiln programs were considered: a 55-year program and an intensive 30-year program. Each program has two levels of implementation rates.

A 55-year brick-kiln program at a low or high level of implementation has the same effect on the forest resource base as a national cookstove program with a 70 percent adoption rate (Tables 5.15 though 5.17). An intensive 30-year brick-kiln program presents similar results. Short-term production pressure on forest resources outweighs any benefit that a brick-kiln program might have to offer. Indeed, it would take about 10 years before any brick-kiln program would be fully operational; hence, this type of program offers medium-term solutions to a short-term problem. Appendix C shows the results of the other combinations of a brick-kiln program.

5.5.3 An energy plantation program

The two plantation programs outlined in Chapter Four were incorporated into the model to analyze the impacts that energy farms might have on the forest resource base in the short, medium, and long-term. A moderate 17-year plantation program does not seem to delay the rate at which the dry forest is depleted (Table 5.18). The mature standing timber within the dry forest would be used up by the year 2002, which is the same as the non-program scenario developed in

Table 5.15. Equating projected demand of wood material from Dominican dry forest, including a national brick-kiln program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.5	5324.9	138.6	1793.3	53.6	10.7
1991	189.4	4927.6	121.2	1850.5	55.2	11.0
1992	178.2	4517.5	113.7	1886.0	56.3	11.3
1993	166.7	4115.1	114.8	1921.9	57.4	11.5
1994	155.1	3703.2	121.2	1943.0	58.1	11.6
1995	143.3	3301.0	128.9	1973.9	59.1	11.8
1996	131.3	2888.0	134.6	1992.1	59.7	11.9
1997	119.3	2488.1	136.3	2010.1	60.3	12.1
1998	107.1	2092.4	133.5	2031.2	60.9	12.2
1999	94.7	1701.2	126.7	2067.6	61.9	12.4
2000	82.2	1310.2	116.6	2096.3	62.8	12.6
2001	69.4	960.7	104.4	2136.1	63.9	12.8
2002	56.6	748.7		1505.3	56.6	11.3

Table 5.16. Equating projected demand of wood material from the Dominican humid broadleaf forest, including a national brick-kilns program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares to be Clearcut	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.8	5069.0	146.4	1519.6	40.3	8.1
1992	284.5	4941.1	133.9	1553.1	41.1	8.2
1993	276.1	4809.0	122.9	1594.1	42.1	8.4
1994	267.5	4672.0	113.6	1625.4	42.9	8.6
1995	258.8	4530.5	106.6	1662.4	43.8	8.8
1996	249.9	4383.9	101.8	1676.2	44.2	8.8
1997	241.0	4234.1	99.6	1698.4	44.8	9.0
1998	232.0	4080.5	99.6	1708.4	45.0	9.0
1999	222.9	3924.3	101.9	1726.1	45.6	9.1
2000	213.7	3764.8	105.6	1733.4	45.8	9.2
2001	204.5	3603.5	110.6	1746.4	46.2	9.2
2002	195.2	3440.1	116.2	1747.8	46.4	9.3
2003	185.8	3276.0	121.9	1758.1	46.8	9.4
2004	176.5	3110.8	126.8	1759.2	46.9	9.4
2005	167.0	2945.7	130.8	1772.2	47.4	9.5
2006	157.5	2779.9	133.0	1773.0	47.5	9.5
2007	147.9	2614.7	133.5	1784.5	48.0	9.6
2008	138.2	2449.3	131.6	1788.4	48.2	9.6
2009	128.5	2284.6	127.8	1804.2	48.7	9.7
2010	118.7	2119.4	121.2	1812.8	49.1	9.8
2011	109.0	1954.4	112.6	1792.4	48.6	9.7
2012	99.2	1792.1	103.3	1798.7	48.8	9.8
2013	89.3	1630.1	91.4	1813.6	49.3	9.9
2014	79.4	1467.4	77.5	1823.5	49.6	9.9
2015	69.2	1304.3	62.7	1877.3	51.0	10.2
2016	59.2	1136.9	44.8	1838.2	50.0	10.0
2017	49.2	973.2		910.8	49.2	9.8

Table 5.17. Equating projected demand of wood material from the Baoruco's pine forest, including a national brick-kilns program.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	61.197	1.129	0.226
1992	35.1	1828.6	138.6	57.379	1.064	0.213
1993	34.9	1817.5	129.5	70.510	1.310	0.262
1994	34.6	1779.7	123.7	78.327	1.465	0.293
1995	34.4	1743.9	113.6	92.365	1.741	0.348
1996	34.0	1692.2	105.8	101.176	1.929	0.386
1997	33.6	1650.7	86.6	122.392	2.351	0.470
1998	33.1	1582.4	83.2	126.756	2.470	0.494
1999	32.7	1532.7	74.7	138.288	2.728	0.546
2000	32.1	1469.4	71.4	142.619	2.860	0.572
2001	31.5	1420.5	59.1	156.859	3.179	0.636
2002	30.9	1358.3	55.9	161.052	3.306	0.661
2003	30.2	1305.2	53.3	165.741	3.446	0.689
2004	29.6	1250.7	52.0	166.955	3.521	0.704
2005	28.8	1197.4	54.0	167.047	3.582	0.716
2006	28.1	1147.3	54.2	167.779	3.651	0.730
2007	27.4	1099.1	52.8	170.190	3.755	0.751
2008	26.6	1049.8	51.4	171.641	3.839	0.768
2009	25.9	1007.1	43.4	181.585	4.086	0.817
2010	25.1	955.6	42.3	182.650	4.143	0.829
2011	24.2	916.2	40.9	181.052	4.120	0.824
2012	23.4	880.3	39.6	181.444	4.144	0.829
2013	22.6	842.2	38.2	183.843	4.216	0.843
2014	21.7	804.9	32.6	188.400	4.321	0.864
2015	20.9	765.2	31.3	194.696	4.468	0.894
2016	20.0	722.4	30.0	189.037	4.342	0.868
2017	19.1	688.2	32.7	186.251	4.295	0.859
2018	18.3	651.4	31.3	186.686	4.323	0.865
2019	17.4	611.7	29.9	189.132	4.399	0.880
2020	16.5	570.0	28.4	183.605	4.288	0.858
2021	15.7	536.7	27.0	191.043	4.482	0.896
2022	14.8	490.7	25.5	192.548	4.536	0.907
2023	13.8	449.9	23.9	194.073	4.592	0.918
2024	12.9	409.2	22.4	195.619	4.649	0.930
2025	12.0	368.5	20.8	202.185	4.825	0.965
2026	11.0	322.8	19.2	198.812	4.765	0.953
2027	10.1	286.5	17.6	201.421	4.848	0.970
2028	9.1	245.5	15.9	203.059	4.907	0.981
2029	8.1	205.8	14.3	205.719	4.992	0.998
2030	7.1	166.4	12.6	202.410	4.932	0.986
2031	6.1	134.4	10.9	211.081	5.164	1.033
2032	4.1	99.2		122.765	4.081	0.816

Section 5.1. This energy program, however, seems to have a positive effect on the broadleaf humid and pine forests. The mature standing timber of these forests would not be totally utilized until the year 2020 for the broadleaf humid forest (Table 5.19) and 2034 for the pine forest (Table 5.20). This represents a delay of five and six years, respectively, as compared to the original situation.

An intensive 20-year energy plantation program presents slightly superior results in terms of delaying the process of depleting the mature forest resources in the country. Accordingly, mature standing timber would not be depleted until the year 2022 in the case of the broadleaf humid forest (Table 5.21) and 2036 in the case of the pine forest (Table 5.22). Hence, depletion of standing mature forest resources in these areas would be delayed by seven and eight years, respectively, as compared to the without scenario without an energy plantation program. The situation for the Dominican dry forest, however, is still the same with or without an energy plantation program (Table 5.23). Basically, potential demand for wood material from the Dominican dry forest is too great in relation to potential supply; hence, any individual program, such as a national cookstove program, a brick-kiln program, or an energy plantation program would have little, if any, effect on efforts to improve the situation.

Table 5.18. Equating projected demand of wood material from Dominican dry forest, including a 17-year energy plantation program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.5	5324.9	138.6	1793.3	53.6	10.7
1991	189.4	4927.6	121.2	1856.5	55.4	11.1
1992	178.0	4511.0	113.7	1899.0	56.7	11.3
1993	166.5	4100.0	114.7	1941.0	58.0	11.6
1994	154.7	3679.2	121.1	1969.2	58.9	11.8
1995	142.7	3266.1	128.6	2007.3	60.1	12.0
1996	130.5	2841.2	134.1	2024.8	60.7	12.1
1997	118.2	2436.4	135.6	2061.2	61.8	12.4
1998	105.6	2017.8	132.4	2091.8	62.7	12.5
1999	92.8	1610.9	125.2	2137.8	64.0	12.8
2000	79.8	1206.6	114.6	2176.1	65.1	13.0
2001	67.2	855.0	101.9	2103.6	62.9	12.6
2002	54.6	788.7		1398.3	54.6	10.9

Table 5.19. Equating projected demand of wood material from humid broadleaf forest, including a 17-year energy plantation program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares to be Clearcut	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.7	5069.0	146.4	1524.6	40.4	8.1
1992	284.5	4940.6	133.8	1564.2	41.4	8.3
1993	275.9	4807.6	122.7	1611.3	42.6	8.5
1994	267.3	4669.0	113.3	1646.7	43.4	8.7
1995	258.3	4525.6	106.2	1689.8	44.5	8.9
1996	249.3	4376.5	101.3	1710.7	45.1	9.0
1997	240.2	4223.7	98.9	1740.1	45.9	9.2
1998	230.9	4066.4	98.7	1758.3	46.4	9.3
1999	221.5	3905.7	100.6	1784.4	47.1	9.4
2000	212.0	3741.1	103.9	1798.1	47.5	9.5
2001	202.9	3574.1	108.5	1718.5	45.5	9.1
2002	193.9	3413.2	115.5	1692.5	44.9	9.0
2003	185.0	3254.1	121.9	1677.1	44.6	8.9
2004	176.0	3096.2	127.8	1686.2	45.0	9.0
2005	167.2	2937.6	132.1	1643.9	44.0	8.8
2006	158.3	2783.2	136.5	1650.5	44.3	8.9
2007	150.0	2628.9	138.0	1550.0	41.7	8.3
2008	142.4	2484.4	141.5	1412.5	38.1	7.6
2009	134.8	2353.1	145.7	1405.3	38.0	7.6
2010	126.6	2223.3	144.0	1509.0	40.8	8.2
2011	118.3	2085.2	135.5	1532.5	41.5	8.3
2012	109.7	1945.9	127.7	1592.3	43.2	8.6
2013	100.4	1802.2	116.2	1705.8	46.3	9.3
2014	91.6	1649.0	100.0	1620.0	44.0	8.8
2015	82.9	1504.1	91.1	1596.9	43.4	8.7
2016	74.3	1361.7	79.0	1582.0	43.0	8.6
2017	65.1	1221.0	66.0	1694.0	46.0	9.2
2018	55.6	1070.5	46.4	1745.6	47.4	9.5
2019	45.9	915.5	28.6	1790.4	48.6	9.7
2020	36.2	756.5		1125.5	36.2	7.2

Table 5.20. Equating projected demand of wood material from the Baoruco's pine forest, including a 17-year energy plantation program.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	61.197	1.129	0.226
1992	35.1	1828.6	138.6	59.379	1.101	0.220
1993	34.9	1815.1	129.5	72.538	1.348	0.270
1994	34.6	1776.9	123.6	81.380	1.522	0.304
1995	34.3	1739.5	113.5	95.452	1.799	0.360
1996	34.0	1687.2	105.7	105.295	2.007	0.401
1997	33.6	1643.9	86.5	127.531	2.449	0.490
1998	33.1	1573.7	83.1	132.941	2.590	0.518
1999	32.6	1521.8	74.5	144.511	2.851	0.570
2000	32.0	1457.4	71.1	149.891	3.006	0.601
2001	31.4	1406.1	58.9	154.143	3.124	0.625
2002	30.8	1354.0	55.7	154.306	3.168	0.634
2003	30.1	1306.2	53.1	155.939	3.243	0.649
2004	29.5	1256.5	51.9	159.081	3.355	0.671
2005	28.8	1203.0	53.9	152.118	3.262	0.652
2006	28.2	1162.5	54.3	153.729	3.345	0.669
2007	27.5	1116.2	53.0	143.021	3.156	0.631
2008	26.9	1084.5	51.8	129.241	2.891	0.578
2009	26.3	1064.8	44.1	135.930	3.058	0.612
2010	25.7	1024.9	43.4	148.631	3.371	0.674
2011	25.0	981.4	42.2	151.772	3.454	0.691
2012	24.3	946.6	41.1	158.939	3.630	0.726
2013	23.6	906.4	39.8	172.165	3.948	0.790
2014	22.8	861.4	34.2	165.824	3.803	0.761
2015	22.0	836.3	33.0	162.965	3.740	0.748
2016	21.3	808.2	31.9	161.087	3.700	0.740
2017	20.5	775.7	35.1	169.860	3.917	0.783
2018	19.8	731.1	33.8	174.168	4.033	0.807
2019	18.9	690.0	32.5	179.517	4.175	0.835
2020	18.1	647.1	31.1	187.916	4.389	0.878
2021	17.2	600.1	29.6	186.388	4.372	0.874
2022	16.4	562.6	28.1	170.856	4.025	0.805
2023	15.6	541.0	26.8	173.209	4.098	0.820
2024	14.7	503.1	25.4	183.589	4.363	0.873
2025	13.9	456.2	23.9	185.059	4.416	0.883
2026	13.0	417.3	22.5	194.548	4.663	0.933
2027	12.0	370.0	20.9	199.122	4.792	0.958
2028	11.1	326.6	19.3	200.742	4.851	0.970
2029	10.1	285.9	17.6	204.383	4.960	0.992
2030	9.1	243.7	15.9	193.062	4.704	0.941
2031	8.2	216.2	14.3	198.657	4.860	0.972
2032	7.2	175.7	12.7	202.305	4.969	0.994
2033	6.2	139.0	11.0	204.993	5.055	1.011
2034	4.2	109.3		111.697	4.197	0.839

5.5.4 Combining the three forestry programs together

A complete forestry strategy for the country would target more than one of the outlined forestry program for implementation. Therefore, a combination of the cookstove, brick-kiln, and energy plantation programs was analyzed.

The combination of the three programs does not significantly delay the depletion of the Dominican dry forest when implemented at a moderate level. Mature standing timber is depleted by the year 2003 (Table 5.24). In the case of the broadleaf humid forest, the depletion of mature standing timber is delayed until the year 2025, which represents a significant improvement with respect to the no-program scenario. Forest land, however, would decrease to 31,000 hectares, representing only 9.4 percent of the original forest land (Table 5.25). Mature standing timber would not be depleted within the time horizon considered when the three forestry programs are combined together, in the case of the pine forest. Although the 35,000 hectares of pine forest land within this forest would almost completely disappear by the year 2045, the pine forest would have some mature standing timber at the end of the period covered (Table 5.26).

Even though the implementation of the three programs in an intensive fashion represents an unrealistically optimistic outlook since this scenario is unlikely to happen, it is still interesting to evaluate such a

Table 5.21. Equating projected demand of wood material from humid broadleaf forest, including an intensive 20-year energy plantation program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares to be Clearcut	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.7	5069.0	146.4	1524.6	40.4	8.1
1992	284.5	4940.6	133.8	1564.2	41.4	8.3
1993	275.9	4807.6	122.7	1611.3	42.6	8.5
1994	267.3	4669.0	113.3	1646.7	43.4	8.7
1995	258.3	4525.6	106.2	1689.8	44.5	8.9
1996	249.3	4376.5	101.3	1710.7	45.1	9.0
1997	240.2	4223.7	98.9	1740.1	45.9	9.2
1998	231.4	4066.4	98.7	1658.3	43.7	8.7
1999	222.0	3914.6	102.2	1782.8	47.0	9.4
2000	212.5	3750.2	104.3	1797.7	47.5	9.5
2001	204.0	3583.1	108.8	1607.2	42.6	8.5
2002	195.6	3432.2	118.3	1583.7	42.0	8.4
2003	187.2	3282.7	125.4	1572.6	41.8	8.4
2004	178.8	3134.0	132.1	1579.9	42.1	8.4
2005	170.6	2984.8	137.4	1522.6	40.7	8.1
2006	162.5	2841.1	143.5	1527.5	41.0	8.2
2007	155.4	2697.6	146.4	1309.6	35.2	7.0
2008	148.8	2574.3	155.9	1223.1	33.0	6.6
2009	142.2	2459.6	160.8	1219.2	32.9	6.6
2010	134.5	2346.2	161.3	1420.7	38.4	7.7
2011	126.7	2215.8	150.7	1447.3	39.2	7.8
2012	118.6	2084.0	144.2	1483.8	40.3	8.1
2013	110.0	1949.8	135.1	1585.9	43.1	8.6
2014	102.5	1807.3	120.8	1393.2	37.9	7.6
2015	94.7	1682.6	119.1	1421.9	38.7	7.7
2016	87.0	1555.8	106.9	1412.1	38.4	7.7
2017	78.6	1430.4	95.5	1563.5	42.5	8.5
2018	69.9	1291.7	75.3	1587.7	43.1	8.6
2019	61.2	1151.0	59.7	1613.3	43.8	8.8
2020	51.7	1008.1	43.7	1744.3	47.3	9.5
2021	42.5	853.5	22.6	1708.4	46.2	9.2
2022	33.2	701.9		851.1	33.2	6.6

Table 5.22. Equating projected demand of wood material from the Baoruco's pine forest, including an intensive 20-year energy plantation program.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	61.197	1.129	0.226
1992	35.1	1828.6	138.6	59.379	1.101	0.220
1993	34.9	1815.1	129.5	72.538	1.348	0.270
1994	34.6	1776.9	123.6	81.380	1.522	0.304
1995	34.3	1739.5	113.5	95.452	1.799	0.360
1996	34.0	1687.2	105.7	105.295	2.007	0.401
1997	33.6	1643.9	86.5	127.531	2.449	0.490
1998	33.1	1573.7	83.1	132.941	2.590	0.518
1999	32.6	1521.8	74.5	144.511	2.851	0.570
2000	32.0	1457.4	71.1	149.891	3.006	0.601
2001	31.4	1406.1	58.9	141.143	2.861	0.572
2002	30.8	1368.9	55.8	142.211	2.919	0.584
2003	30.2	1322.6	53.2	143.758	2.989	0.598
2004	29.6	1275.3	52.2	146.812	3.096	0.619
2005	29.0	1224.1	54.3	138.735	2.975	0.595
2006	28.4	1187.2	54.8	139.224	3.030	0.606
2007	27.8	1144.7	53.6	115.395	2.546	0.509
2008	27.3	1130.8	52.6	107.378	2.402	0.480
2009	26.8	1110.0	45.0	115.025	2.588	0.518
2010	26.3	1073.2	44.4	139.551	3.165	0.633
2011	25.7	1020.1	43.4	142.622	3.245	0.649
2012	25.0	987.1	42.3	146.719	3.351	0.670
2013	24.4	952.1	41.2	158.850	3.642	0.728
2014	23.6	910.7	35.4	140.563	3.224	0.645
2015	23.0	902.0	34.5	144.530	3.317	0.663
2016	22.3	871.2	33.5	143.525	3.297	0.659
2017	21.7	841.1	37.0	155.976	3.597	0.719
2018	20.9	795.5	35.8	157.178	3.640	0.728
2019	20.2	760.3	34.6	160.396	3.730	0.746
2020	19.5	722.8	33.4	174.645	4.079	0.816
2021	18.6	672.6	32.0	169.013	3.965	0.793
2022	17.9	642.0	30.7	150.345	3.542	0.708
2023	17.1	627.3	29.5	151.535	3.586	0.717
2024	16.4	594.2	28.3	167.742	3.986	0.797
2025	15.6	544.5	26.9	168.085	4.011	0.802
2026	14.8	509.5	25.6	176.438	4.229	0.846
2027	14.0	465.8	24.1	183.866	4.425	0.885
2028	13.1	422.0	22.6	185.361	4.480	0.896
2029	12.2	383.4	21.1	185.877	4.511	0.902
2030	11.3	345.9	19.6	180.404	4.396	0.879
2031	10.4	314.9	18.1	182.894	4.474	0.895
2032	9.5	277.1	16.6	180.411	4.431	0.886
2033	8.6	244.5	15.1	182.916	4.511	0.902
2034	7.7	208.4	13.6	194.449	4.814	0.963
2035	6.8	165.4	11.9	201.086	4.997	0.999
2036	4.8	130.0		80.965	4.776	0.955

Table 5.23. Equating projected demand of wood material from Dominican dry forest, including a 20-year intensive energy plantation program.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.5	5324.9	138.6	1793.3	53.6	10.7
1991	189.4	4927.6	121.2	1856.5	55.4	11.1
1992	178.0	4511.0	113.7	1899.0	56.7	11.3
1993	166.5	4100.0	114.7	1941.0	58.0	11.6
1994	154.7	3679.2	121.1	1969.2	58.9	11.8
1995	142.7	3266.1	128.6	2007.3	60.1	12.0
1996	130.5	2841.2	134.1	2024.8	60.7	12.1
1997	118.2	2436.4	135.6	2061.2	61.8	12.4
1998	105.6	2017.8	132.4	2091.8	62.7	12.5
1999	92.8	1610.9	125.2	2137.8	64.0	12.8
2000	79.8	1206.6	114.6	2176.1	65.1	13.0
2001	68.0	855.0	101.9	1968.6	58.9	11.8
2002	56.3	859.6		1198.4	56.3	11.3

combination. An intensive implementation of these programs would delay the depletion of mature standing timber to the year 2006 within the Dominican dry forest (Table 5.27). The situation improves significantly in the case of the broadleaf humid forest where it would take twice as many years to deplete the mature standing timber as compared to a no-program situation (Table 5.28). There are still 348,000 cubic meters of mature standing timber remaining within the Baoruco's pine forest at the end of the time horizon considered, with this intensive program. Moreover, out of the initial 35,500 hectares of forest land within the pine forest 10,000 hectares would remain by the year 2045, when the intensive combination is considered (Table 5.29).

Table 5.24. Equating projected demand of wood material from Dominican dry forests, including a moderate combination of the three forestry programs.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.0	5324.2	137.1	1791.5	54.1	10.8
1991	188.9	4926.9	119.5	1842.2	55.5	11.1
1992	177.6	4523.3	111.6	1871.8	56.4	11.3
1993	166.2	4127.6	112.2	1900.8	57.3	11.5
1994	154.6	3724.3	117.9	1914.9	57.8	11.6
1995	142.9	3331.5	124.8	1939.8	58.6	11.7
1996	131.2	2927.1	129.5	1941.2	58.7	11.7
1997	119.3	2546.5	130.3	1961.5	59.4	11.9
1998	107.3	2150.7	126.7	1974.9	59.8	12.0
1999	95.2	1763.3	119.1	2004.7	60.7	12.1
2000	82.9	1363.2	108.5	2025.6	61.2	12.2
2001	71.3	973.9	95.8	1923.6	58.1	11.6
2002	59.9	703.1	82.7	1888.7	57.0	11.4
2003	48.5	395.6		1564.4	48.5	9.7

Table 5.25. Equating projected demand of wood material from humid broadleaf forests, with a moderate combination of the three forestry programs.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Clearcut Hectares 1000 has	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.8	5069.0	146.4	1514.6	40.1	8.0
1992	284.6	4941.5	133.9	1544.1	40.8	8.2
1993	276.3	4810.3	123.0	1581.0	41.8	8.4
1994	267.8	4674.4	113.8	1606.2	42.4	8.5
1995	259.1	4534.6	106.9	1639.1	43.2	8.6
1996	250.5	4390.1	102.2	1646.8	43.4	8.7
1997	241.7	4243.0	100.2	1663.8	43.8	8.8
1998	232.9	4092.5	100.4	1668.6	44.0	8.8
1999	224.0	3939.8	102.9	1681.1	44.4	8.9
2000	215.1	3784.3	106.9	1682.1	44.5	8.9
2001	206.8	3627.5	112.4	1577.6	41.8	8.4
2002	198.7	3479.1	120.8	1526.2	40.5	8.1
2003	190.8	3334.7	129.0	1485.0	39.5	7.9
2004	183.0	3193.7	137.1	1466.9	39.1	7.8
2005	175.5	3054.4	144.2	1397.8	37.4	7.5
2006	168.0	2921.6	152.0	1386.0	37.2	7.4
2007	161.2	2790.5	157.0	1266.0	34.0	6.8
2008	155.3	2670.8	164.6	1107.4	29.8	6.0
2009	149.4	2566.2	173.5	1079.5	29.2	5.8
2010	143.2	2465.1	176.8	1162.2	31.5	6.3
2011	136.8	2357.5	173.5	1173.5	31.8	6.4
2012	130.2	2250.0	170.9	1220.1	33.1	6.6
2013	123.0	2139.1	164.7	1321.3	35.9	7.2
2014	116.3	2020.1	153.6	1223.4	33.3	6.7
2015	109.9	1910.5	150.4	1185.6	32.2	6.4
2016	103.6	1804.9	143.9	1162.1	31.6	6.3
2017	96.7	1701.9	136.2	1263.8	34.3	6.9
2018	89.6	1590.2	121.0	1307.0	35.5	7.1
2019	82.3	1474.9	107.4	1342.6	36.4	7.3
2020	74.7	1356.5	93.3	1414.7	38.3	7.7
2021	67.1	1231.8	76.7	1399.3	37.9	7.6
2022	60.2	1108.5	63.8	1266.2	34.2	6.8
2023	53.4	996.9	57.2	1276.8	34.4	6.9
2024	46.0	884.4	44.3	1363.7	36.7	7.3
2025	38.7	763.9		645.1	38.7	7.7

Table 5.25. Equating projected demand of wood material from humid broadleaf forests, with a moderate combination of the three forestry programs.

Year	Land Under Forest 000 has	Available Volume 000 m3	Allowable Harvest 000 m3	Deficit in Production 000 m3	Hectares has
1990	300.8	5192.2	160.0	1477.0	8.
1991	292.8	5069.0	146.4	1514.6	0.
1992	284.6	4941.5	133.9	1544.1	8.
1993	276.3	4810.3	123.0	1581.0	8.
1994	267.8	4674.4	113.8	1606.2	5.
1995	259.1	4534.6	106.9	1639.1	8.
1996	250.5	4390.1	102.2	1646.8	4.
1997	241.7	4243.0	100.2	1663.8	8.
1998	232.9	4092.5	100.4	1668.6	0.
1999	224.0	3939.8	102.9	1681.1	[illegible].
2000	215.1	3784.3	106.9	1682.1	9.
2001	206.8	3627.5	112.4	1577.6	8.
2002	198.7	3479.1	120.8	1526.2	5.
2003	190.8	3334.7	129.0	1485.0	9.
2004	183.0	3193.7	137.1	1466.9	8.
2005	175.5	3054.4	144.2	1397.8	5.
2006	168.0	2921.6	152.0	1386.0	2.
2007	161.2	2790.5	157.0	1266.0	0.
2008	155.3	2670.8	164.6	1107.4	0.
2009	149.4	2566.2	173.5	1079.5	8.
2010	143.2	2465.1	176.8	1162.2	9.
2011	136.8	2357.5	173.5	1173.5	8.
2012	130.2	2250.0	170.9	1220.1	6.
2013	123.0	2139.1	164.7	1321.3	2.
no good 2014	116.3	2020.1	153.6	1223.4	3 6.7
2021	67.1	1231.8	76.7	1399.3	0.
2022	60.2	1108.5	63.8	1266.2	8.
2023	53.4	996.9	57.2	1276.8	[illegible].
2024	46.0	884.4	44.3	1363.7	3.
2025	38.7	763.9	763.9	645.1	7.

Table 5.26. Equating projected demand of wood material from the Baoruco pine forest, including a moderate combination of the three forestry programs.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.2	0.887	0.177
1991	35.3	1864.2	132.8	60.2	1.110	0.222
1992	35.1	1829.8	138.6	56.4	1.045	0.209
1993	34.9	1818.9	129.5	68.5	1.273	0.255
1994	34.7	1782.5	123.7	76.3	1.427	0.285
1995	34.4	1747.1	113.7	89.3	1.683	0.337
1996	34.0	1697.0	105.9	97.1	1.850	0.370
1997	33.7	1657.3	86.7	118.2	2.271	0.454
1998	33.2	1589.8	83.4	122.6	2.389	0.478
1999	32.7	1540.9	74.9	132.1	2.606	0.521
2000	32.2	1480.6	71.6	136.4	2.735	0.547
2001	31.7	1432.9	59.4	136.6	2.769	0.554
2002	31.1	1388.0	56.3	135.7	2.785	0.557
2003	30.6	1344.7	53.8	134.2	2.790	0.558
2004	30.0	1301.9	52.8	134.2	2.829	0.566
2005	29.4	1255.9	55.0	124.0	2.658	0.532
2006	28.9	1223.7	55.7	123.3	2.683	0.537
2007	28.4	1185.1	54.7	111.3	2.456	0.491
2008	27.9	1160.5	53.7	94.3	2.109	0.422
2009	27.5	1151.0	46.0	100.0	2.249	0.450
2010	27.0	1118.7	45.6	110.4	2.504	0.501
2011	26.5	1084.9	44.8	112.2	2.554	0.511
2012	26.0	1059.0	43.9	118.1	2.697	0.539
2013	25.5	1027.8	43.0	130.0	2.981	0.596
2014	24.9	992.3	37.3	122.7	2.814	0.563
2015	24.3	976.9	36.4	118.6	2.721	0.544
2016	23.7	959.0	35.6	116.4	2.673	0.535
2017	23.2	935.1	39.6	123.6	2.845	0.569
2018	22.6	900.7	38.7	127.3	2.948	0.590
2019	22.1	868.5	37.7	131.3	3.053	0.611
2020	21.4	835.6	36.7	138.3	3.231	0.646
2021	20.8	798.7	35.6	136.4	3.200	0.640
2022	20.2	770.8	34.5	120.5	2.838	0.568
2023	19.6	759.4	33.6	121.4	2.873	0.575
2024	19.0	732.0	32.6	131.4	3.123	0.625
2025	18.4	694.4	31.6	132.4	3.161	0.632
2026	17.8	665.1	30.5	141.5	3.392	0.678
2027	17.1	626.7	29.3	144.7	3.482	0.696
2028	16.4	593.4	28.2	145.8	3.525	0.705
2029	15.7	561.9	27.0	148.0	3.592	0.718
2030	15.0	529.2	25.8	136.2	3.320	0.664
2031	14.3	511.6	24.6	141.4	3.459	0.692
2032	13.6	477.8	23.5	144.5	3.550	0.710
2033	12.9	445.4	22.3	146.8	3.619	0.724
2034	12.2	413.6	21.0	152.0	3.762	0.752
2035	11.4	378.4	19.7	159.6	3.958	0.792
2036	10.6	340.4	18.4	158.6	3.957	0.791
2037	9.8	309.7	17.0	156.9	3.930	0.786
2038	9.1	280.6	15.7	156.3	3.928	0.786

Table 5.26. Equating projected demand of wood material from the Baoruco pine forest, including a moderate combination of the three forestry programs.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
2039	8.3	251.4	14.4	145.6	3.674	0.735
2040	7.5	232.8	13.1	131.9	3.339	0.668
2041	6.9	219.6	12.0	129.0	3.279	0.656
2042	6.2	199.8	10.8	139.2	3.548	0.710
2043	5.5	173.8	9.6	140.4	3.592	0.718
2044	4.8	177.5	8.4	145.6	3.739	0.748
2045	3.3	40.7		131.7	3.283	0.657

Table 5.27. Equating projected demand of wood material from Dominican dry forests, with an intensive combination of the three forestry programs[1].

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.0	5324.2	137.1	1791.5	54.1	10.8
1991	189.0	4926.9	119.5	1829.2	55.1	11.0
1992	177.9	4537.5	111.7	1845.7	55.6	11.1
1993	166.7	4158.4	112.4	1848.6	55.7	11.1
1994	155.7	3787.9	118.3	1820.3	54.9	11.0
1995	144.9	3449.8	125.7	1801.5	54.4	10.9
1996	134.1	3108.7	131.2	1780.8	53.9	10.8
1997	123.3	2776.3	133.2	1776.6	53.8	10.8
1998	112.6	2434.0	130.9	1769.3	53.6	10.7
1999	101.8	2099.4	125.0	1779.1	53.8	10.8
2000	91.1	1752.4	116.0	1781.0	53.8	10.8
2001	81.7	1415.6	105.1	1554.7	47.0	9.4
2002	72.4	1306.4	94.6	1535.5	46.3	9.3
2003	63.2	1035.7	83.7	1528.5	46.0	9.2
2004	53.9	760.4	72.7	1543.5	46.4	9.3
2005	45.1	472.0	61.7	1478.5	44.4	8.9
2006	36.2	260.7		1301.3	36.2	7.2

[1] Combination program: 30-year brick-kilns program with 39 percent efficiency and 1500 kilns at end of 30-year; 10-year cookstove program with 30 percent efficiency and a 70 percent adoption rate; and, an intensive energy plantation program.

Table 5.28. Equating projected demand of wood material from humid broadleaf forests, with an intensive combination of the three forestry programs.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Sustainable Harvest 1000 m3	Deficit in Production 1000 m3	Clearcut Hectares 1000 has	Hectares Lost 1000 has
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.8	5069.0	146.4	1504.6	39.9	8.0
1992	284.8	4942.4	134.1	1522.9	40.3	8.1
1993	276.7	4813.1	123.4	1536.6	40.6	8.1
1994	268.6	4681.2	114.6	1527.4	40.3	8.1
1995	260.6	4548.4	108.2	1524.8	40.2	8.0
1996	252.6	4414.1	104.2	1513.8	39.9	8.0
1997	244.6	4278.9	102.8	1511.2	39.8	8.0
1998	236.7	4142.0	103.8	1499.2	39.5	7.9
1999	228.8	4004.3	107.2	1496.8	39.5	7.9
2000	221.0	3865.2	112.4	1482.6	39.2	7.8
2001	214.2	3726.1	119.3	1275.7	33.8	6.8
2002	207.7	3604.3	131.6	1235.4	32.8	6.6
2003	201.2	3485.5	142.0	1208.0	32.1	6.4
2004	194.8	3368.7	152.6	1199.4	32.0	6.4
2005	188.8	3252.8	162.5	1123.5	30.0	6.0
2006	182.8	3143.9	173.9	1118.1	30.0	6.0
2007	178.1	3036.0	182.4	888.6	23.9	4.8
2008	173.8	2949.4	198.2	789.8	21.3	4.3
2009	169.6	2872.5	209.8	774.2	20.9	4.2
2010	164.4	2797.9	217.3	963.7	26.1	5.2
2011	159.1	2707.6	213.6	980.4	26.6	5.3
2012	153.6	2616.8	214.2	1008.8	27.4	5.5
2013	147.6	2524.4	212.3	1100.7	29.9	6.0
2014	142.8	2424.9	205.0	898.0	24.4	4.9
2015	137.8	2344.3	211.1	916.9	24.9	5.0
2016	132.9	2262.8	206.0	899.0	24.4	4.9
2017	127.2	2183.5	201.7	1043.3	28.3	5.7
2018	121.5	2091.8	187.3	1060.7	28.8	5.8
2019	115.6	1998.9	177.8	1079.2	29.3	5.9
2020	109.1	1904.7	167.5	1203.5	32.6	6.5
2021	102.8	1799.6	150.5	1164.5	31.5	6.3
2022	97.4	1698.1	141.1	995.9	26.9	5.4
2023	92.0	1611.6	139.2	1004.8	27.1	5.4
2024	85.8	1524.4	128.7	1144.3	30.8	6.2
2025	79.6	1424.6	110.8	1149.2	30.9	6.2
2026	73.1	1324.4	98.9	1224.1	32.9	6.6
2027	66.2	1217.2	83.3	1286.7	34.5	6.9
2028	59.2	1104.3	67.8	1304.2	34.9	7.0
2029	52.2	989.7	54.2	1313.8	35.1	7.0
2030	45.5	874.0	41.1	1259.9	33.6	6.7
2031	38.6	762.9	31.3	1284.7	34.2	6.8
2032	31.8	649.4		628.6	31.8	6.4

Table 5.29. Equating projected demand of wood material from the Baoruco's pine forest, with an intensive combination of the three forestry programs.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Sustainable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	59.197	1.092	0.218
1992	35.1	1831.0	138.7	54.350	1.008	0.202
1993	34.9	1821.5	129.6	63.442	1.179	0.236
1994	34.7	1789.0	123.8	67.167	1.256	0.251
1995	34.4	1759.4	113.9	76.078	1.434	0.287
1996	34.2	1715.8	106.3	81.715	1.558	0.312
1997	33.8	1681.2	87.2	100.819	1.936	0.387
1998	33.5	1618.8	84.0	101.989	1.987	0.397
1999	33.1	1576.9	75.6	110.366	2.177	0.435
2000	32.6	1521.6	72.5	112.479	2.256	0.451
2001	32.2	1480.6	60.3	101.671	2.061	0.412
2002	31.8	1452.8	57.5	101.501	2.084	0.417
2003	31.3	1415.2	55.2	101.804	2.117	0.423
2004	30.9	1376.6	54.4	102.551	2.163	0.433
2005	30.5	1335.3	57.0	92.990	1.994	0.399
2006	30.1	1308.1	58.0	92.018	2.002	0.400
2007	29.7	1275.4	57.2	66.792	1.474	0.295
2008	29.4	1271.9	56.6	58.361	1.305	0.261
2009	29.1	1261.1	48.8	65.185	1.467	0.293
2010	28.8	1234.2	48.7	88.277	2.002	0.400
2011	28.4	1192.2	48.0	90.954	2.070	0.414
2012	28.0	1169.6	47.3	94.654	2.162	0.432
2013	27.6	1144.8	46.6	106.384	2.439	0.488
2014	27.1	1114.4	40.7	87.347	2.003	0.401
2015	26.7	1117.6	40.1	90.948	2.087	0.417
2016	26.3	1097.8	39.4	88.574	2.035	0.407
2017	25.9	1079.2	44.1	100.876	2.326	0.465
2018	25.4	1043.6	43.3	101.653	2.354	0.471
2019	24.9	1019.0	42.6	103.440	2.406	0.481
2020	24.5	993.3	41.8	117.246	2.738	0.548
2021	23.9	953.5	40.8	112.165	2.631	0.526
2022	23.4	933.0	40.0	92.048	2.169	0.434
2023	23.0	931.0	39.2	93.777	2.219	0.444
2024	22.5	907.9	38.5	109.524	2.603	0.521
2025	22.0	868.4	37.6	108.401	2.587	0.517
2026	21.5	845.3	36.7	117.274	2.811	0.562
2027	20.9	811.2	35.8	123.222	2.966	0.593
2028	20.3	778.9	34.8	125.225	3.026	0.605
2029	19.7	750.0	33.8	125.248	3.039	0.608
2030	19.1	723.1	32.7	118.278	2.882	0.576
2031	18.5	704.3	31.7	121.254	2.966	0.593
2032	17.9	675.7	30.7	118.261	2.905	0.581
2033	17.4	653.4	29.8	120.247	2.965	0.593
2034	16.8	626.2	28.7	130.254	3.225	0.645
2035	16.1	589.7	27.6	137.351	3.413	0.683
2036	15.4	554.7	26.5	136.513	3.406	0.681
2037	14.7	527.3	25.3	134.673	3.372	0.674
2038	14.1	501.3	24.2	133.823	3.364	0.673

Table 5.29. Cont. Equating projected demand of wood material from the Baoruco's pine forest, with an intensive combination of the three forestry programs.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Sustainable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
2039	13.4	474.7	23.0	106.970	2.699	0.540
2040	12.9	477.1	22.1	96.892	2.453	0.491
2041	12.4	466.4	21.3	94.730	2.407	0.481
2042	11.9	448.9	20.4	121.553	3.100	0.620
2043	11.3	400.0	19.4	121.613	3.112	0.622
2044	10.6	375.6	18.3	124.679	3.202	0.640
2045	10.0	348.2	17.2	134.776	3.473	0.695

5.5.5 Economic Assessment of the Cookstove and Brick-kiln Programs

Another way of assessing the national benefits of a forestry program, such as a national cookstove and a national brick-kiln programs, is through economic assessment. In other words, how much can the country save by implementing a given forestry program for the time horizon considered. For this purpose shadow prices or economic opportunity costs are used to determine whether the forestry programs are cheaper than the traditional technologies.

First, an economic assessment of a national cookstove program was carried out. The study assumed an average consumption of 3.64 cubic meters per family per annum (COENER, 1987). It has been estimated that the improved ceramic stoves will reduce the firewood consumption by approximately 25 to 45 percent. Thus three efficiency levels, viz. 25 percent, 30 percent, and 40 percent were considered.

The opportunity cost of firewood was determined on the basis of Liquid Propenyl Gas (LPG) displacement. The LPG equivalent is regarded as the upper bound on the economic value of firewood. This argument becomes increasingly relevant as firewood scarcity and overall deforestation progressively worsens.

Assuming that,

1 m^3 of wood material = 0.3 Barrels of LPG (COENER, 1987)

1 LPG Barrel = US$12.70 and US$1 = DR$12.00

the value of 3.64 cubic meter per family annual consumption can be obtain as:

3.64 m^3 of wood material = 0.3 x 3.64 x 12.7 x 12.0

= DR$166.42

The per-family calculated value was then multiplied by the number of families in the country that use firewood to determine the total cost to the country. Assuming a life of four years for the ceramic cookstove, an initial capital cost of DR$100 per stove, and a discount rate of 10 percent, the present value of economic costs over the 55-year period was calculated. The total cost to the country in present value of continuing with traditional cookstoves was determined at DR$849 million at the end of the 55-year period considered (Table 5.30).

A national cookstove program that reaches 70 percent of the households that use firewood after a 20-year implementation period would save the country DR$184, DR$227, or DR$312 million over the 55-year period analyzed, depending on whether a 25, 30, or 40 percent efficiency is obtained with the improved cookstove, respectively. These results represent an average saving of DR$3.4, DR$4.1, and DR$5.7 million respectively. The figures under the 30 percent efficiency level correspond to the moderate national cookstove program outlined and analyzed in previous sections.

The economic evaluation of a national brick-kiln program is conducted in similar fashion. Here, brick-kilns cost DR$2000 each and were assumed to last 5 years (Rodríguez, 1987). Furthermore, brick-kilns have been estimated to reduce the amount of wood material used for charcoal by 30 to 50 percent as compared to traditional soil-made kilns. Hence, the three efficiency levels considered were 30, 39 and 45 percent, respectively. Using a 10 percent discount rate, the present value of economic costs over the 55-year period were calculated. The total cost to the country in present value of continuing with the traditional kilns was determined at DR$1,332 million over the 55-year period considered (Table 5.32).

Table 5.30. Economic Assessment of a National Cookstove Program.

Year	Cost Fuel Traditional Methods	PV of Costs	PV of Savings Cookstove Efficiency 25%	30%	40%
0	70284	70284	17571	21085	28114
1	71466	64969	15702	18950	25447
2	72647	60039	14518	17520	23524
3	73829	55468	13420	16194	21741
4	75010	51233	11996	14558	19681
5	76191	47309	11089	13454	18185
6	76925	43422	10053	12224	16567
7	77659	39851	9247	11240	15225
8	78393	36571	8215	10043	13700
9	79127	33558	7546	9224	12579
10	79861	30790	6823	8362	11441
11	80427	28189	5881	7291	10110
12	80992	25807	5174	6465	9045
13	81558	23624	4683	5865	8227
14	82124	21626	4289	5371	7533
15	82689	19795	3703	4693	6672
16	83062	18077	3289	4193	6001
17	83435	16507	2970	3795	5446
18	83808	15074	2523	3276	4784
19	84181	13764	2314	3002	4379
20	84554	12568	2046	2674	3931
21	84584	11430	2067	2639	3782
22	84615	10395	1763	2282	3322
23	84645	9453	1620	2093	3038
24	84676	8597	1577	2007	2867
25	84706	7818	1415	1806	2587
26	84574	7096	1203	1558	2268
27	84441	6441	1102	1425	2069
28	84309	5846	1071	1363	1948
29	84177	5306	958	1223	1754
30	84044	4816	814	1055	1537
31	83913	4372	746	965	1402
32	83732	3968	725	924	1321
33	83650	3602	649	829	1189
34	83519	3269	551	714	1041
35	83388	2967	505	653	950
36	83429	2699	493	627	897
37	83469	2455	442	564	810
38	83510	2233	376	488	711
39	83551	2031	346	447	650
40	83591	1847	337	430	614
41	83674	1681	303	387	555
42	83757	1529	258	335	488
43	83840	1392	237	307	446
44	83922	1266	232	295	422
45	84005	1152	208	265	381
46	83309	1039	175	227	331
47	82613	937	159	206	299
48	81917	844	153	195	280
49	81221	761	135	174	250
50	80524	686	114	148	216
51	79891	619	103	134	196
52	79258	558	100	128	184
53	78625	503	88	114	164
54	77991	454	74	97	142
55	77358	409	67	88	128
Total PV 55-year =		848997	184217	226667	311567

A national brick-kiln program that establishes 1500 kilns at the end of the 55-year period, would save the country DR$398, DR$518, or DR$598 million depending on whether a 30, 39, or 45 percent efficiency level is obtained, respectively. These results represent an average saving of DR$7.2, DR$9.4, and DR$10.9 million respectively. The figures under the 39 percent efficiency level correspond to the moderate national brick-kiln program outlined and analyzed in previous sections.

Accordingly, a combination of these two programs would save the country from DR$582 to DR$909 million in present value over the 55-year period considered, depending on the efficiency levels obtained. These figures correspond to an average annual savings from DR$10.6 to DR$16.6 million. However, institutional overhead costs due to coordinating efforts to implement these programs were not considered.

Table 5.32. Economic Assessment of a National Brick-kiln Program.

Year	Cost of fuel Traditional Method	PV of cost	PV of savings Brick-kiln Efficiency 30%	39%	45%
0	105505	105505	31652	41147	47477
1	107663	97875	29304	38113	43986
2	109820	90760	27175	35344	40789
3	111978	84130	25191	32763	37811
4	114135	77956	23343	30359	35036
5	116292	72208	21583	28082	32414
6	117994	66604	19895	25890	29886
7	119695	61422	18349	23877	27562
8	121396	56632	16919	22016	25414
9	123097	52205	15597	20296	23428
10	124798	48115	14342	18672	21559
11	126347	44284	13198	17183	19840
12	127896	40752	12146	15814	18259
13	129446	37496	11176	14551	16801
14	130995	34495	10283	13387	15457
15	132544	31730	9436	12291	14195
16	133839	29127	8662	11283	13031
17	135134	26736	7951	10357	11961
18	136430	24538	7298	9507	10979
19	137725	22519	6698	8725	10076
20	139021	20665	6132	7992	9232
21	139711	18879	5605	7304	8436
22	140400	17248	5120	6673	7708
23	141090	15757	4678	6096	7042
24	141780	14394	4274	5569	6433
25	142470	13149	3896	5080	5869
26	142903	11990	3555	4634	5354
27	143336	10933	3242	4226	4882
28	143769	9969	2956	3854	4452
29	144202	9090	2696	3514	4059
30	144635	8289	2455	3201	3698
31	145088	7559	2240	2920	3374
32	145541	6893	2043	2663	3077
33	145993	6286	1863	2428	2806
34	146446	5732	1699	2215	2559
35	146898	5227	1548	2018	2332
36	147586	4774	1414	1844	2130
37	148274	4361	1292	1684	1946
38	148962	3982	1180	1538	1777
39	149650	3637	1077	1405	1623
40	150338	3322	983	1282	1482
41	150954	3032	898	1171	1353
42	151570	2768	820	1069	1235
43	152186	2526	748	976	1127
44	152802	2306	683	890	1029
45	153419	2105	623	812	939
46	152756	1905	564	736	850
47	152094	1724	511	666	769
48	151432	1561	462	603	696
49	150769	1413	418	545	630
50	150107	1279	378	494	570
51	149541	1158	343	447	516
52	148975	1049	310	405	468
53	148408	950	281	367	424
54	147842	860	255	332	384
55	147276	779	231	301	347
Total PV 55-year	=	1332644	397668	517606	597565

SUMMARY AND CONCLUSIONS

This study's main objective was to establish the basis for evaluating feasible and workable forestry policies and programs in the Dominican Republic. National cookstove, brick-kiln, and energy plantation programs were evaluated along with the current national forestry policy. Further, this study was concerned with the institutional framework surrounding the Dominican forestry sector. An institutional analysis was conducted and presented in Chapter Three.

Evaluating forestry programs in terms of policy scenarios is particularly appropriate were data limitations dwarf the economic analysis. It would be difficult to produce reliable forecasts for the three forestry programs included in this study. However, policy scenarios present an appealing and suitable technique since they leave it up to the decision makers to decide on the probability of occurrence of the different scenarios. Hence, one scenario might become more relevant as decision makers agree that the underlying conditions are more likely to occur. Nevertheless, this technique imposes an additional responsibility on the analyst who must ultimately decide which scenarios are included in the analysis. On the other hand, the use of frequency tables to evaluate institutional attitudes toward forestry policy issues and programs is considered helpful in determining relative strengths. Non-parametric techniques are required for those cases where an institutional sample is more feasible than a census. The remainder of this chapter is divided into three sections: a) findings, which emphasizes the major conclusions derived from the study; b) implications of findings, which places the conclusions into both the institutional and economic framework of the DR forestry sector; and, c) future research, which emphasizes the different studies that could be undertaken both to expand this research and to further the development of the Dominican forestry sector.

6.1 Findings

The following conclusions should be emphasized:

a) The Erlang family of density functions is considered to be appropriate for modeling stand growth projections and should be considered as a candidate together with the other densities commonly used for this purpose (e.g. Normal, Weibull, etc.). The mathematical property of the conservation of flow within the distributed delay with losses makes it suitable to model stand growth.

b) The present forestry policy does not have the support of most of the institutions surrounding the Dominican forestry sector. Most institutions agree that the best way to protect the resources is through development and research as opposed to policing activities. Environmental and government groups, however, are cautious as to what extent energy farm plantation programs can be implemented.

c) The simulation results agree with most of the DR forestry institutions that Dominican forest resources will significantly deteriorate if the present policy structure continues (scenario A) for 10 or 20 years.

d) Perceived differences among institutional attitudes toward preservation, conservation, production, and development of the Dominican forestry sector are much greater than actual differences.

e) A moderate or intensive national cookstoves program has little effect in preventing or delaying the depletion of the Dominican forest resources, especially the dry forest, even in the short run. A cookstove program would mainly affect rural areas and in the best situation would only decrease total firewood consumption by 21 percent.

f) Likewise, a moderate or intensive brick-kiln program would not have any profound effect in delaying the process of depletion of the Dominican forest, especially the dry forest, which supplies most of the wood material used to produce charcoal. Brick kilns represent an expensive technology for small charcoal producers who have virtually no costs other than labor. Furthermore, brick kilns can only be used by medium and big producers due to the amount of wood material they require to operate efficiently.

g) An energy plantation program at either a moderate or an intensive level also failed to slow down the process of depletion of the Dominican forests. A plantation program takes at least 10 years to be fully implemented; however, the production pressures on the native forests require faster remedies for the situation to be improved. This forestry program, nevertheless, produces slightly better results than the brick-kiln and the cookstove programs, especially in the case of broadleaf humid and pine forests.

h) Combining the three forestry programs together can significantly delay the depletion process of mature timber within the broadleaf and pine forests in the Dominican Republic. However, such a combination can only delay depletion until the year 2006 in the case of the Dominican dry forest.

i) Both a moderate national cookstove program and a brick-kiln program are economically feasible and promise to produce substantial savings in terms of opportunity cost of wood material used for firewood and charcoal. Therefore, to continue with the present policy will not only result in deterioration of the forest resource base, but also in a costly alternative to the country.

6.2 Implications of Findings

Promotion of alternative national forestry policies in the Dominican Republic is both appealing from a institutional standpoint and attractive from an economic perspective. The study results indicate that the situation and future outlook for the Dominican forest resources is critical. A massive effort in the areas of institutional reform, policy programs, investment forestry, and research programs need to be considered in the short-run if the resources are to be available for present and future generations. Hence, the DR forestry sector needs to be considered as a crucial element in the future of the Dominican economy.

It is imperative that the Dominican authorities participate actively in the forestry policy evaluation process at this time. Production pressures are too great to be ignored. Present and projected demand for wood material for charcoal and firewood surpass allowable production by a factor of four or more. The Dominican forestry sector faces a rather complex reality; hence, solutions have to be targeted at several areas within the sector.

Forestry programs, such as ceramic cookstove, brick-kiln, and energy plantation programs should be all considered as important elements of a revised national forestry policy. The institutional analysis showed that the timing is right for the DR to begin a process of institutional reform which could culminate in speeding up the process of forestry policy formulation and implementation. All institutions surveyed indicated a great deal of interest on forestry policy in the country. They all agree that the present situation does not represent a coordinated effort to either protect or develop the sector.

6.3 Further Research

The Forestry Simulation and Economic Model (FOSIM) should be considered as a first generation model which presents limitations in the way forestry proposals and programs are analyzed. There are still several research projects needed on the areas of policy analysis, production studies, and economic data collection for the model to be fully operational for the case of the Dominican forestry sector.

One aspect of major concern is the availability of economic data on consumption and supply of forest products and raw material. There is a need to obtain basic economic data which can be used with FOSIM to estimate income and price elasticity of demand and supply equations. Such data will be helpful in evaluating the present structure at a greater level of detail. To accomplish such a data collection task, a survey is recommended of the major markets in the country, to take place three times a year.

Specifically, data on quantity, prices, transportation costs, and production cost are considered important.

Second, the Dominican forestry sector needs to formalize the process of policy formulation, evaluation, and implementation. This can be achieved by re-arranging specific tasks within the already existing institutional framework rather than by creating new institutions. Once a policy is identified as positive to the country, there should be a way to materialize the gains into specific programs and projects. However, this task is limited by the degree of uncertainty surrounding the sector.

Third, more research is needed to further evaluate the economic feasibility of cookstove, brick-kiln, and energy plantation programs. Specifically, the opportunities of large-scale implementation of these programs need to be assessed in the short-run. Delaying the evaluation and implementation of such programs may result in a catastrophic situation.

The facilitation of forestry policy dialogue in the DR is considered to be crucial at this time. A comprehensive discussion of forestry policy issues could speed up the process of evaluation and implementation of policy alternatives that are crucial to the country in the imminent future.

One major limitation to the allocation of forest resources over time in the DR is the existing government institutional framework. Hence, FORESTA and CONATEF should be involved at all levels of discussion in the hope that they can call attention to and facilitate implementation of feasible policies. Many of the institutions surveyed expressed their support for the formation of a *Natural Resource Secretariat* which would group all the government institution together. Such a proposal need to be further evaluated as it could drastically change the existing institutional framework. Specifically, whether an overall coordination effort could be better achieved by having all the government institutions together, need to be assessed.

APPENDIX A. The Dominican Republic: Background

A.1 The Dominican Republic

A.1.1 Location and Climate

The Dominican Republic (DR) is located in the Caribbean region between the northern latitudes 17° and 20° and the western longitudes 68° and 71°. The DR has a terrestrial extension of 48,442 square kilometers and occupies two-thirds of the Hispaniola island. The western one-third of the island is occupied by the Republic of Haiti (OAS, 1987).

The climate is subtropical with mean temperatures varying between 22°C and 28°C. The amount of precipitation ranges from 1500 to 2750 millimeters per year in the northern and eastern parts of the country, to 350 to 1000 for the southwest and northwest. Most areas have two distinct rainy seasons.

A.1.2 Topography and Ecology

The topography of the country varies from fertile valleys to high and partially deforested and eroded mountains to desert-like plains. There are five mountain ranges throughout the country, four of which are located in the western part of the country and extend in a northeasterly direction. The fifth mountain range is located in the eastern part of the country and it extends in a western direction. There are eight major watersheds crucial to maintain the water supply in the country.

Table A1. Life Zones in The Dominican Republic

Life Zone	Hectares 1000	Percent
1. Subtropical Thorn Woodland	100.1	2.1
2. Subtropical Dry Forest	918.2	20.3
3. Subtropical Moist Forest	2,213.9	45.7
4. Subtropical Wet Forest	683.4	14.1
5. Subtropical Rain Forest	5.6	.1
6. Subtropical Lower Montane Moist Forest	348.0	7.2
7. Subtropical Lower Montane Wet Forest	357.7	7.4
8. Subtropical Lower Montane Rain Forest	36.0	.7
9. Subtropical Montane Wet Forest	30.0	.6
10. Other areas	88.0	1.8
Total	4,844,200	100%

Source: Holdridge, 1982.

In 1982, Holdridge classified nine different Life Zones in the DR (Table 1.1). The most important for forest resource analysis are the Subtropical Moist Forest which covers 22,139 square kilometers and the Subtropical Dry Forest which covers 9,812 square kilometers. These two Life Zones cover 66 percent of the nation. A third Zone, the Subtropical Lower Montane Wet Forest, which covers 3,480 square kilometers, is very important for water and hydro-electrical power supplies.

A.1.3 Economic Trends

The Dominican Republic had economic growth of only one percent in 1988 (Table 1.2). Inflation declined in 1987, but intensified until reaching an unprecedented level of 58 percent by December 1988. The reasons for this inflationary spiral include: 1) a steady increase in the government deficit, 2) the monetarization of foreign exchange gains, and 3) a 60 percent devaluation of the Dominican peso (CEPAL, 1989). The inflationary process as well as the devaluation of the Dominican peso continued their negative trends, reaching levels above 100 percent of the 1987 levels, at the end of 1990. The official exchange rate depreciated from US$1 = DR$6.35 in April 1988 to US$1 = DR$13 in January 1991. At the same time, the US dollar was being exchanged at 31 percent higher than the official rate in the foreign exchange parallel market.

The drastic deterioration of the whole economic system in the country during the late 1980s was the impetus for a new economic adjustment program by the Dominican government. Under the adjustment program there would be no increases in wages or in consumer prices. The construction sector, which has been the most active sector of the economy in the last four years, became less active as compared to the previous three years. Short term results of the economic adjustment program seem to be positive. The exchange rate has stabilized around US$1 = DR$12 in both the official and the parallel market. Also, the inflation rate in March 1991 was considered to be zero percent.

Figure 1.1. Growth rate in GDP at Constant 1980 Prices (1955-1988).

Source: CEPAL, 1988.

Moreover, the consumer price index actually decreased over 10 percent during March. However, some local economists maintain that such an economic program cannot be sustained in the medium or long-term due to the high social costs involved (e.g. a doubling of gasoline prices in 1990). Even the president of the country recognizes that the success of the program depends upon the level of sacrifice of the Dominican population. Short-term obstacles to the program include several national strikes that are being planned by the medical and educational communities who are seeking salary increases.

One obvious limitation of the government is its ability to service its ever-increasing foreign debt, which was approximately US$4,000 million at the end of 1988 (CEPAL, 1989). Increasing pressure from the international financing community has forced the Dominican government to sign an economic adjustment agreement with the International Monetary Fund (IMF) before new credits can be opened to the country. The present government has had a history of reluctance in signing economic adjustment agreements with the IMF due to the conditionality involved in such agreements: reduction of government spending, which would imply a slow down of the government policy on construction; devaluation of the Dominican peso; and elimination of subsidies to the agriculture and energy sectors. Hence, a new agreement with the IMF may ask for even more severe measures in an economy already under adjustment.

APPENDIX B

FOSIM Computer Codes: The Dry Forest Case

```
REM *** FOSIM COMPUTER CODES IN QUICK-BASIC ***

DECLARE SUB PINEWOOD (VHARV1!(), VHARV2!(), VHARV3!(), VOL1!(), VOL2!(),
      VOL3!(), DT!)
DECLARE SUB DRYWOOD (VOLUME!(), VOLUME2!(), VOLHARV!(), VOLHARV2!(),
      DT!)
DECLARE SUB HUMIDW  (VOLUMEHU!(), VHARVHU!(), DT!)
DECLARE SUB CONSUMP (TPOPUR!(), TPOPRU!(), DT!, TCHARC!(), TFIREW!(),
      tt, numhhdur(), numhhdru(), GDPB(), CHARCPR(), housefire,
      housechar)
DECLARE SUB POPULAT (POP(), POPUR(), POPRU(), TPOP(), TPOPUR(),
      TPOPRU(), BIRTHR(), INMOR(), DEATHR(), TBIRTH(), RURAL(), t,
      RTPPOP(), RTPUR(), RTPRU(), RUM(), DT, DTY, tm, SRATIO,
DECLARE SUB DTDTR (VIN!, VOUT!, R(), DEL!, DT, KM, AR!)
DECLARE SUB tablim (VTL!(), SMALL!, DXL!, KP!, tef!, F!)
CLEAR ALL

      DIM POP(65, 14, 2), POPRU(65, 14, 2), POPUR(65, 14, 2), TPOP(65)
      DIM TPOPRU(65), TPOPUR(65), BIRTHR(70, 14), INMOR(70), DEATHR(70,
      14, 2)
      DIM TBIRTH(70), RURAL(70, 14, 2), RTPRU(70), RTPUR(70),
      RTPPOP(70), RUM(2)
      DIM CHARCPR(65), TCHARC(65), TFIREW(65), numhhdru(65),
      numhhdur(65)
      DIM GDPB(65), TTCHARC(70), TTFIREW(70), DRYMAT(60), HUMIDMAT(60)
      DIM PINEMAT(60), CHARMAT(60), FIREWMAT(60), efll(65), eflm(65),
      eflh(65)
      DIM efhl(65), efhm(65), efhh(65), sbl(65), sbm(65), sbh(65),
      valll(15)
      DIM vallm(15), vallh(15), valhl(15), valhm(15), valhh(15),
      valkl(15)
      DIM valkm(15), valkh(15), vahkl(15), vahkm(15), vahkh(15),
      sbhl(65)
      DIM sbhm(65), sbhh(65), ENER(65), ENER1(65)

CLS

REM *** PROGRAM MAIN ****

REM *** Initial conditions--relevant to all****
tt = 0
DT = .25
DURDTY = 12
CHARCPR(0) = 25
SMALL = 0

REM ***Tablim values for Brick-kiln 55-year Program with two efficiency
levels
KPKL = 7: KPKM = 11: KPKH = 11: DXLK = 5

valkm(1) = 0!  : valkm(2)  = 100 : valkm(3)  = 250 : valkm(4)  = 425
valkm(5) = 610 : valkm(6)  = 750 : valkm(7)  = 860 : valkm(8)  = 920
valkm(9) = 960 : valkm(10) = 980 : valkm(11) = 995 : valkm(12) = 1000
valkh(1) = 0!  : valkh(2)  = 160 : valkh(3)  = 380 : valkh(4)  = 625
valkh(5) = 880 : valkh(6)  = 1095: valkh(7)  = 1245: valkh(8)  = 1340
valkh(9) = 1415: valkh(10) = 1470: valkh(11) = 1490: valkh(12) = 1500


REM ***Tablim values for Brick-kiln 30-year Program  with two efficiency
levels
KPHKH = 6
```

```
vahkh(1) = 0!  : vahkh(2) = 240 : vahkh(3) = 900: vahkh(4) = 1260
vahkh(5) = 1400: vahkh(6) = 1470: vahkh(7) = 1500
vahkm(1) = 0!  : vahkm(2) = 100 : vahkm(3) = 280: vahkm(4) = 625
vahkm(5) = 880 : vahkm(6) = 960 : vahkm(7) = 1000

REM ** Tablim values for Ceramic Cookstove 20-year Program with two
       efficiency levels **

DXLL = 5
vallm(1) = 0: vallm(2) = .065: vallm(3) = .147: vallm(4) = .34
vallm(5) = .5
vallh(1) = 0: vallh(2) = .11: vallh(3) = .223: vallh(4) = .554
vallh(5) = .7

REM ** Tablim values for Ceramic Cookstove 10-year Program with two
       efficiency levels **

KPLO = 4: DXLH = 2.5
valhm(1) = 0: valhm(2) = .084: valhm(3) = .26: valhm(4) = .457
valhm(5) = .5
valhh(1) = 0: valhh(2) = .154: valhh(3) = .574: valhh(4) = .662
valhh(5) = .7

REM *** Tablim values for a Moderated Energy Plantation Program **

ENER(20) = 236: ENER(21) = 236: ENER(22) = 315: ENER(23) = 394
ENER(24) = 394: ENER(25) = 540: ENER(26) = 540: ENER(27) = 818
ENER(28) = 1155: ENER(29) = 1211 ENER(30) = 996 : ENER(31) = 996
ENER(32) = 884:ENER(33) = 671: ENER(34) = 915 ENER(35) = 1016
ENER(36) = 1071: ENER(37) = 858: ENER(38) = 780: ENER(39) = 732
ENER(40) = 583 : ENER(41) = 662 : ENER(42) = 992: ENER(43) = 992
ENER(44) = 811 ENER(45) = 819 : ENER(46) = 669 : ENER(47) = 637
ENER(48) = 637: ENER(49) = 632 ENER(50) = 902 : ENER(51) = 847
ENER(52) = 812: ENER(53) = 812: ENER(54) = 720 ENER(55) = 628
ENER(56) = 628 : ENER(57) = 666: ENER(58) = 666: ENER(59) = 881
ENER(60) = 1155: ENER(61) = 1211: ENER(62) = 996: ENER(63) = 996
ENER(64) = 884 ENER(65) = 671

REM *** Tablim values for an Intensive Energy Plantation Program **

ENER1(20) = 495 : ENER1(21) = 495 : ENER1(22) = 563 : ENER1(23) = 630
ENER1(24) = 630 : ENER1(25) = 810 : ENER1(26) = 810 : ENER1(27) = 1359
ENER1(28) = 1562: ENER1(29) = 1609: ENER1(30) = 1161: ENER1(31) = 1161
ENER1(32) = 1096: ENER1(33) = 905 : ENER1(34) = 1393: ENER1(35) = 1355
ENER1(36) = 1402: ENER1(37) = 1091: ENER1(38) = 1080: ENER1(39) = 1072
ENER1(40) = 803 : ENER1(41) = 945 : ENER1(42) = 1357: ENER1(43) = 1357
ENER1(44) = 1056: ENER1(45) = 1103: ENER1(46) = 969 : ENER1(47) = 884
ENER1(48) = 884 : ENER1(49) = 920 : ENER1(50) = 1082: ENER1(51) = 1074
ENER1(52) = 1166: ENER1(53) = 1166: ENER1(54) = 986 : ENER1(55) = 900
ENER1(56) = 900 : ENER1(57) = 936 : ENER1(58) = 936 : ENER1(59) = 1476
ENER1(60) = 1670: ENER1(61) = 1717: ENER1(62) = 1161: ENER1(63) = 1161
ENER1(64) = 1096: ENER1(65) = 905


REM *** Executable Phase ***

CALL PRODUCE(DRYMAT(), HUMIDMAT(), PINEMAT(), CHARMAT(), FIREWMAT(), DT)

FOR II = 1 TO 13
CALL POPULAT(POP(), POPUR(), POPRU(), TPOP(), TPOPUR(), TPOPRU(),
      BIRTHR(), INMOR(), DEATHR(), TBIRTH(), RURAL(), RTPPOP(), RTPUR(),
      RTPRU(), RUM(), DT, DTY, tm, SRATIO, t)
```

```
FOR JJ = 1 TO DTY
FOR KK = 1 TO 1 / DT
tt = tt + DT
TPOPRU(tt) = TPOPRU(tt - DT) + RTPRU(tm) * DT
TPOPUR(tt) = TPOPUR(tt - DT) + RTPUR(tm) * DT
TPOP(tt) = TPOP(tt - DT) + RTPPOP(tm) * DT

CALL CONSUMP(TPOPUR(), TPOPRU(), DT, TCHARC(), TFIREW(), tt, numhhdur(),
             numhhdru(), GDPB(), CHARCPR(), housefire, housechar)

NEXT KK

REM ** Brick-kiln Efficiency Estimates **

      CALL tablim(valkm(), SMALL, DXLK, KPKM, tef, FBM)
      CALL tablim(valkh(), SMALL, DXLK, KPKH, tef, FBH)
      sbm(tt) = FBM * .39: sbh(tt) = FBH * .39

      CALL tablim(vahkm(), SMALL, DXLK, KPHKH, tef, FBHM)
      CALL tablim(vahkh(), SMALL, DXLK, KPHKH, tef, FBHH)
      sbhm(tt) = FBHM * .39: sbhh(tt) = FBHH * .39

REM ** Ceramic Cookstove Efficiency Estimates **

      CALL tablim(valhm(), SMALL, DXLH, KPLO, tef, FHM)
      CALL tablim(valhh(), SMALL, DXLH, KPLO, tef, FHH)
      efhm(tt) = FHM * .3: efhh(tt) = FHH * .3

      CALL tablim(vallm(), SMALL, DXLL, KPLO, tef, FLM)
      CALL tablim(vallh(), SMALL, DXLL, KPLO, tef, FLH)
      eflm(tt) = FLM * .3: eflh(tt) = FLH * .3

IF tt < 10 THEN
      eflm(tt) = 0: eflh(tt) = 0
      efhm(tt) = 0: efhh(tt) = 0
      sbm(tt) = 0: sbh(tt) = 0
      sbhm(tt) = 0: sbhh(tt) = 0
END IF
IF tt >= 10 THEN tef = tef + 1


REM ** DEMAND EQUATIONS FOR CHARCOAL AND FIREWOOD ********

      TTCHARC(tt) = TCHARC(tt) * (GDPB(tt) / GDPB(tt - 1)) ^ -.2
                  * ((CHARCPR(tt) / CHARCPR(tt - 1)) ^ -.7) - sbh(tt)

      TTFIREW(tt) = TFIREW(tt) * (GDPB(tt) / GDPB(tt - 1)) ^ -.4
                  * (1 - eflh(tt))

      TTTOTAL = TTCHARC(tt) + TTFIREW(tt)
      NETOTAL = TTTOTAL
      IF tt > 20 THEN NETOTAL = TTTOTAL - ENER(tt)
      FDRY = NETOTAL * .52
      FHUMID = NETOTAL * .43
      FPINE = NETOTAL * .05

REM ** PRINT CONSUMPTION ESTIMATES **
      LPRINT USING "     ####      #####.#     #####.#     #####.#
            #####.#"; tt + 1980, NETOTAL, FDRY, FHUMID, FPINE
      NEXT JJ
```

```
REM ** PRINT POPULATION DATA **
       PRINT USING "####    ######    ######    ######"; 1980 + tt,
      TPOPUR(tt), TPOPRU(tt), TPOP(tt)

REM ** PRINT PRODUCTION ESTIMATES **
      PRINT USING "    ####     #######.#    #######.#     #######.#
      ######.#"; tt + 1980, DRYMAT(tt), HUMIDMAT(tt), PINEMAT(tt),
      CHARMAT + FIREWMAT
NEXT II


REM ** END OF MAIN

SUB CONSUMP (TPOPUR(), TPOPRU(), DT, TCHARC(), TFIREW(), tt, numhhdur(),
       numhhdru(), GDPB(), CHARCPR(), housefire, housechar)

      DIM CONCHAUR(65), CONFIWUR(65), CONCHARU(65), CONFIWRU(65)
      AVGPFUR = 5!
      AVGPFRU = 5.1
      POL1 = 1
      POL2 = 1
      PFCFUR = .443   'PERCENT OF FAMILIES THAT USES CHARC OR FIREWOOD
                  IN URBAN AREAS.

      PFCFRU = .8813  ' "              "                  "      "
                  IN RURAL AREAS.
            PCCH = 5.16
      PCFW = 3.64
      PPCHUR = .87: PPFWUR = .13
      PPCHRU = .3: PPFWRU = .7

      numhhdur(tt) = TPOPUR(tt) / AVGPFUR * PFCFUR
      numhhdru(tt) = TPOPRU(tt) / AVGPFRU * PFCFRU

REM ** GDP BASE Data ************
      GDPB(0) = 7079
      FOR JJ = 1 TO 5
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .004
      NEXT JJ
      FOR JJ = 6 TO 10
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .0068
      NEXT JJ
      FOR JJ = 11 TO 15
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .008
      NEXT JJ
      FOR JJ = 16 TO 20
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .012
      NEXT JJ
      FOR JJ = 21 TO 25
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .008
      NEXT JJ
      FOR JJ = 26 TO 30
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .0058
      NEXT JJ
      FOR JJ = 31 TO 35
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .0068
      NEXT JJ
      FOR JJ = 36 TO 40
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .008
      NEXT JJ
      FOR JJ = 41 TO 45
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .012
```

```
      NEXT JJ
      FOR JJ = 46 TO 50
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .008
      NEXT JJ
      FOR JJ = 51 TO 55
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .0058
      NEXT JJ
      FOR JJ = 56 TO 60
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .0068
      NEXT JJ
      FOR JJ = 61 TO 65
      GDPB(JJ) = GDPB(JJ - 1) + GDPB(JJ - 1) * .008
      NEXT JJ

REM ** CHARCOAL PRICE ASSUMPTION **
      IF tt <= 30 THEN
            CHARCPR(tt) = CHARCPR(tt - DT) * 1.006
      END IF
      IF tt > 30 THEN
            CHARCPR(tt) = CHARCPR(tt - DT) * 1.004
      END IF

REM ** Calculation for charcoal and firewood ****

      CONCHARU(tt) = numhhdru(tt) * PPCHRU * PCCH * POL1
      CONFIWRU(tt) = numhhdru(tt) * PPFWRU * PCFW * POL1

      CONCHAUR(tt) = numhhdur(tt) * PPCHUR * PCCH * POL2
      CONFIWUR(tt) = numhhdur(tt) * PPFWUR * PCFW * POL2

REM** Charcoal Consumption over time

      TCHARC(tt) = CONCHAUR(tt) + CONCHARU(tt)

REM** Firewood Consumption over time

      TFIREW(tt) = CONFIWUR(tt) + CONFIWRU(tt)

REM ** -------------------------------------------***
      housefire = numhhdur(tt) * PPFWUR + numhhdru(tt) * PPFWRU
      housechar = numhhdur(tt) * PPCHUR + numhhdru(tt) * PPCHRU
END SUB


REM ** SUBROUTINE FOR LINEAR APPROXIMATIONS **
SUB tablim (VTL(), SMALL, DXL, KP, tef, F) STATIC
      IF tef < DXL THEN POINT2 = DXL
      IF tef >= DXL AND tef < 2 * DXL THEN POINT2 = 2 * DXL
      IF tef >= 2 * DXL AND tef < 3 * DXL THEN POINT2 = 3 * DXL
      IF tef >= 3 * DXL AND tef < 4 * DXL THEN POINT2 = 4 * DXL
      IF tef >= 4 * DXL AND tef < 5 * DXL THEN POINT2 = 5 * DXL
      IF tef >= 5 * DXL AND tef < 6 * DXL THEN POINT2 = 6 * DXL
      IF tef >= 6 * DXL AND tef < 7 * DXL THEN POINT2 = 7 * DXL
      IF tef >= 7 * DXL AND tef < 8 * DXL THEN POINT2 = 8 * DXL
      IF tef >= 8 * DXL AND tef < 9 * DXL THEN POINT2 = 9 * DXL
      IF tef >= 9 * DXL AND tef < 10 * DXL THEN POINT2 = 10 * DXL
      IF tef >= 10 * DXL AND tef < 11 * DXL THEN POINT2 = 11 * DXL

      XTL = tef
      IF tef > KP * DXL THEN
            XTL = KP * DXL
            POINT2 = XTL + DXL
```

```
      END IF
      DUML = XTL - SMALL
      ITL = .5 + DUML / DXL
      IF ITL < 1 THEN ITL = 1 ELSE IF ITL > KP THEN ITL = KP
      F = VTL(ITL) + (VTL(ITL + 1) - VTL(ITL)) * (DXL - (POINT2 - XTL))
         / DXL
      IF tef = 0 OR tef = DXL OR tef = 2 * DXL OR tef = 3 * DXL OR tef =
      4 * DXL OR tef = 5 * DXL OR tef = 6 * DXL OR tef = 7 * DXL
      OR tef = 8 * DXL OR tef = 9 * DLX OR tef = 10 * DXL
      OR tef = 11 * DXL THEN
             F = VTL((tef + DXL) / DXL)
      END IF
      IF tef > KP * DXL THEN F = VTL(KP + 1)

END SUB

SUB DTDTR (VIN, VOUT, R(), DEL, DT, K, AR) STATIC
REM ** DISTRIBUTED DELAY SUBROUTINE WITH IMPROVED CORRECTOR FORMULA

        DM1 = K - 1
        A = DT * K / DEL
        B = 1 / (1 - AR * DEL / K)
        FOR JJ = 1 TO K
        ROLD(JJ) = R(JJ)
        NEXT JJ

REM ** PREDICTING USING EULER's INTEGRATION FORMULA **
        FOR II = 1 TO DM1
        R(II) = R(II) * B + A * (R(II + 1) - R(I) * B)
        NEXT II
        R(K) = R(K) * B + A * (VIN - R(K) * B)

REM ** CORRECTING USING THE TRAPEZOIDAL RULE **
        FOR JJ = 1 TO DM1
        FOLD = ROLD(JJ + 1) - ROLD(JJ) * B
        F2 = R(JJ + 1) - R(JJ) * B
        R(JJ) = ROLD(JJ) * B + A * (FOLD + F2) / 2
        NEXT JJ
        FOLD = VIN - ROLD(K) * B
        F2 = VIN - R(K) * B
        R(K) = ROLD(K) * B + A * (FOLD + F2) / 2
        VOUT = R(1) / B
END SUB


REM EXAMPLE OF FOREST PRODUCTION ROUTINE: THE DRY FOREST CASE
SUB DRYWOOD (VOLUME(), VOLUME2(), VOLHARV(), VOLHARV2(), DT)

      DIM R0(10), R1(10), AUX0(10), AUX1(10), VOLUME(60), growth(60)
      DIM R20(10), R21(10), AUX20(10), AUX21(10), VOLUME2(60)
      DIM VOLHARV(60), VOLHARV2(60)
      land = 219.485
      land2 = 30.515
      store0 = 800 * land: store1 = 900 * land: store2 = 550 * land
      STORE20 = 800 * land2: STORE21 = 900 * land2
      STORE22 = 500 * land2
      DBH1 = 8: DBH2 = 12: DBH3 = 17
REM VOLUME AT t=0: Parameters for the 200,000 has. of natural dry
forest*****
      av = .8295834
      bv = 1.884737
```

```
      VOLUME(0) = store2 * ((av * DBH1 ^ bv) * .76 + (av * DBH2 ^ bv)
                    * .19 + (av * DBH3 ^ bv) * .05) / 1000

REM Volume at t=0: Parameters for existing production areas (30,000 has)
      av2 = .9183795
      bv2 = 1.967279
      VOLUME2(0) = STORE22 * ((av2 * DBH1 ^ bv2) * .76 + (av2 * DBH2 ^
                  bv2) * .19 + (av2 * DBH3 ^ bv2) * .05) / 1000
      VOLHARV(0) = 0: VOLHARV2(0) = 0

REM *** Proportional Loss Parameters

            AR0 = .18 + .18 / 1000 * (store0 / land - 500)
            AR1 = .024 + .024 / 1000 * (store1 / land - 500)
            ar2 = .06 + .06 / 1000 * (store2 / land - 500)
            AR20 = .18 + .18 / 1000 * (STORE20 / land2 - 500)
            AR21 = .024 + .024 / 1000 * (STORE21 / land2 - 500)
            AR22 = .06 + .06 / 1000 * (STORE22 / land2 - 500)

REM *** Initial Conditions: Regarding Dry forest**

      KM = 10
      DT = .25
      t = 0
      DEL0 = 3
      DEL1 = 14
      DEL21 = 12
      DUR = 60
      ITPR = CINT(1 / DT)



      FOR I = 1 TO KM
      R0(I) = store0 / DEL0
      R1(I) = store1 / DEL1

      R20(I) = STORE20 / DEL0
      R21(I) = STORE21 / DEL21
      NEXT I

      FOR J = 1 TO KM
      AUX0(J) = R0(J) * AR0 * DEL0 / KM
      AUX1(J) = R1(J) * AR1 * DEL1 / KM
      AUX20(J) = R20(J) * AR20 * DEL0 / KM
      AUX21(J) = R21(J) * AR21 * DEL21 / KM

      R0(J) = R0(J) - AUX0(J)
      R1(J) = R1(J) - AUX1(J)
      R20(J) = R20(J) - AUX20(J)
      R21(J) = R21(J) - AUX21(J)
      NEXT J

      AUX2 = store2 * ar2
      AUX22 = STORE22 * AR22

      TIN0 = 218.73 * land: TIN20 = 218.73 * land2
      TIN1 = R0(KM): TIN21 = R20(KM)
      tin2 = R1(KM): tin22 = R21(KM)
      in210 = tin2 - AUX2: in220 = tin22 - AUX22
```

```
REM *** Execution Phase
      FOR II = 1 TO DUR
      FOR JJ = 1 TO ITPR
      t = t + DT
      store2 = store2 + DT * (tin2 - AUX2)
      STORE22 = STORE22 + DT * (tin22 - AUX22)

      CALL DEL2A(TIN0, VOUT0, R0(), DEL0, DT, KM, AR0)
      CALL DEL2A(TIN1, VOUT1, R1(), DEL1, DT, KM, AR1)
      CALL DEL2A(TIN20, VOUT20, R20(), DEL0, DT, KM, AR20)
      CALL DEL2A(TIN21, VOUT21, R21(), DEL21, DT, KM, AR21)

      SR0 = 0: SR1 = 0: SR20 = 0: SR21 = 0

      FOR J = 1 TO KM
      SR0 = SR0 + R0(J)
      SR1 = SR1 + R1(J)
      SR20 = SR20 + R20(J)
      SR21 = SR21 + R21(J)

      NEXT J

      store0 = SR0 * DEL0 / KM
      store1 = SR1 * DEL1 / KM
      STORE20 = SR20 * DEL0 / KM
      STORE21 = SR21 * DEL21 / KM

      TIN0 = 218.73 * land: TIN20 = 218.73 * land2
      TIN1 = VOUT0: TIN21 = VOUT20
      tin2 = VOUT1: tin22 = VOUT21

      FOR J = 1 TO KM
      AUX0(J) = R0(J) * AR0 * DEL0 / KM
      AUX1(J) = R1(J) * AR1 * DEL1 / KM
      AUX20(J) = R20(J) * AR20 * DEL0 / KM
      AUX21(J) = R21(J) * AR21 * DEL21 / KM

      R0(J) = R0(J) - AUX0(J)
      R1(J) = R1(J) - AUX1(J)
      R20(J) = R20(J) - AUX20(J)
      R21(J) = R21(J) - AUX21(J)
      NEXT J
      AUX2 = store2 * ar2
      AUX22 = STORE22 * AR22

      IF store0 / land < 500 THEN
            AR0 = .18
      END IF
      IF store1 / land < 500 THEN
            AR1 = .024
      END IF
      IF (store2 + harvest) / land < 500 THEN
            ar2 = .06
      END IF
      IF STORE20 / land2 < 500 THEN
            AR20 = .18
      END IF
      IF STORE21 / land2 < 500 THEN
            AR21 = .024
      END IF
      IF (STORE22 + HARVEST2) / land2 < 500 THEN
            AR22 = .06
```

```
END IF
IF store0 / land >= 500 AND store0 / land <= 1500 THEN
      AR0 = .18 + .18 / 1000 * (store0 / land - 500)
END IF
IF store1 / land >= 500 AND store1 / land <= 1500 THEN
      AR1 = .024 + .024 / 1000 * (store1 / land - 500)
END IF
IF (store2 + harvest) / land >= 500 AND (store2 + harvest) / land
<= 1500 THEN
      ar2 = .06 + .06 / 1000 * ((store2 + harvest) / land - 500)
END IF
IF STORE20 / land2 >= 500 AND STORE20 / land2 <= 1500 THEN
      AR20 = .18 + .18 / 1000 * (STORE20 / land2 - 500)
END IF
IF STORE21 / land2 >= 500 AND STORE21 / land2 <= 1500 THEN
      AR21 = .024 + .024 / 1000 * (STORE21 / land2 - 500)
END IF
IF (STORE22 + HARVEST2) / land2 >= 500 AND (STORE22 + HARVEST2) /
land2  <= 1500 THEN
AR22 = .06 + .06 / 1000 * ((STORE22 + HARVEST2) / land2 - 500)
END IF

IF store0 / land > 1500 THEN
      AR0 = .36
END IF
IF store1 / land > 1500 THEN
      AR1 = .048
END IF
IF (store2 + harvest) / land > 1500 THEN
      ar2 = .12
END IF
IF STORE20 / land2 > 1500 THEN
      AR20 = .36
END IF
IF STORE21 / land2 > 1500 THEN
      AR21 = .048
END IF
IF (STORE22 + HARVEST2) / land2 > 1500 THEN
      AR22 = .12
END IF
NEXT JJ
netin2 = (tin2 - AUX2)
netin22 = (tin22 - AUX22)

harvest = 0: HARVEST2 = 0
IF store2 > 100 THEN
      harvest = 1! * netin2
END IF
IF STORE22 > 100 THEN
      HARVEST2 = 1! * netin22
END IF
store2 = store2 - harvest
STORE22 = STORE22 - HARVEST2

VOLUME(II) = store2 * ((av * DBH1 ^ bv) * .76 + (av * DBH2 ^ bv)
               * .19 + (av * DBH3 ^ bv) * .05) / 1000
VOLHARV(II) = harvest * ((av * DBH1 ^ bv) * .76 + (av * DBH2 ^ bv)
               * .19 + (av * DBH3 ^ bv) * .05) / 1000
VOLUME2(II) = STORE22 * ((av2 * DBH1 ^ bv2) * .76 + (av2 * DBH2 ^
                 bv2) * .19 + (av2 * DBH3 ^ bv2) * .05) / 1000
VOLHARV2(II) = HARVEST2 * ((av2 * DBH1 ^ bv2) * .76 + (av2 * DBH2
            ^ bv2) * .19 + (av2 * DBH3 ^ bv2) * .05) / 1000
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    NEXT II

END SUB

REM ** There are two additional subroutines, not shown here, similar to
SUB DRYWOOD, customized for the cases of HUMID FOREST and PINE FOREST
respectively. **
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APPENDIX C

An Intensive 10-year Cookstove Program

Table C1. Equating projected demand of wood material from Dominican dry forests, with an intensive 10-year cookstove program at 70 percent level of adoption.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.5	5324.9	138.6	1793.3	53.6	10.7
1991	189.5	4927.6	121.2	1841.5	55.0	11.0
1992	178.3	4527.3	113.7	1867.9	55.7	11.1
1993	167.1	4136.3	114.9	1881.8	56.2	11.2
1994	155.9	3751.1	121.5	1864.6	55.7	11.1
1995	144.8	3396.4	129.6	1856.8	55.6	11.1
1996	133.7	3037.4	135.9	1863.0	55.8	11.2
1997	122.4	2669.8	138.5	1886.9	56.6	11.3
1998	110.9	2289.0	136.6	1907.7	57.2	11.4
1999	99.3	1915.1	130.7	1945.9	58.3	11.7
2000	87.4	1533.4	121.5	1976.4	59.2	11.8
2001	75.3	1177.1	110.1	2024.1	60.5	12.1
2002	63.0	869.8	97.2	2058.2	61.5	12.3
2003	50.7	1034.1		1151.9	50.7	10.1

Table C2. Equating projected demand of wood material from humid broadleaf forests, with an intensive 10-year cookstove program at 70 percent level of adoption.

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Clearcut Hectares 1000 has	Hectares Lost 1000 has
1986	330.9	5637.9	246.5	1274.5	34.1	6.8
1987	323.7	5535.2	206.3	1347.7	36.0	7.2
1988	316.3	5425.4	189.8	1389.2	37.0	7.4
1989	308.6	5311.3	174.5	1437.5	38.2	7.6
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.8	5069.0	146.4	1512.6	40.1	8.0
1992	284.7	4941.7	134.0	1539.0	40.7	8.1
1993	276.4	4810.9	123.1	1560.9	41.2	8.2
1994	268.2	4676.9	114.1	1560.9	41.2	8.2
1995	259.9	4541.1	107.6	1565.4	41.3	8.3
1996	251.6	4403.2	103.5	1576.5	41.5	8.3
1997	243.2	4262.3	101.6	1597.4	42.1	8.4
1998	234.7	4117.7	102.0	1608.0	42.4	8.5
1999	226.1	3970.4	104.6	1628.4	43.0	8.6
2000	217.5	3819.6	108.9	1637.1	43.3	8.7
2001	208.7	3666.8	114.6	1656.4	43.9	8.8
2002	199.9	3511.2	120.8	1663.2	44.1	8.8
2003	190.9	3354.5	127.3	1680.7	44.7	8.9
2004	181.9	3196.0	133.0	1689.0	45.0	9.0
2005	172.8	3036.9	137.9	1707.1	45.7	9.1
2006	163.6	2876.6	140.9	1715.1	46.0	9.2
2007	154.3	2716.3	142.3	1733.7	46.6	9.3
2008	144.9	2555.2	141.2	1744.8	47.0	9.4
2009	135.3	2394.1	138.1	1767.9	47.8	9.6
2010	125.7	2232.0	132.1	1782.9	48.3	9.7
2011	115.9	2069.5	124.1	1805.9	49.0	9.8
2012	106.0	1905.8	113.6	1819.4	49.4	9.9
2013	96.0	1741.8	101.5	1842.5	50.1	10.0
2014	85.9	1576.5	87.4	1858.6	50.5	10.1
2015	75.6	1410.3	72.1	1884.9	51.2	10.2
2016	65.3	1242.2	55.3	1900.7	51.7	10.3
2017	54.8	1072.9	38.2	1923.8	52.3	10.5
2018	44.3	901.8	20.5	1941.5	52.7	10.5
2019	33.8	729.1		1238.9	33.8	6.8

Table C3. Equating projected demand of wood material from the Baoruco's pine forest, with an intensive 10-year cookstove program at 70 percent level of adoption.

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1986	35.9	1997.8	166.4	10.568	0.190	0.038
1987	35.9	1978.7	161.3	19.724	0.355	0.071
1988	35.8	1965.3	142.4	41.594	0.749	0.150
1989	35.7	1913.0	141.5	45.452	0.828	0.166
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	60.197	1.110	0.222
1992	35.1	1829.8	138.6	55.364	1.027	0.205
1993	34.9	1820.1	129.5	66.469	1.235	0.247
1994	34.7	1785.1	123.8	71.233	1.332	0.266
1995	34.4	1753.6	113.8	80.191	1.511	0.302
1996	34.1	1709.2	106.1	88.869	1.694	0.339
1997	33.8	1670.3	87.0	111.017	2.132	0.426
1998	33.3	1603.1	83.7	115.280	2.246	0.449
1999	32.9	1555.6	75.2	126.751	2.500	0.500
2000	32.4	1494.3	72.0	130.996	2.627	0.525
2001	31.9	1447.7	59.8	146.247	2.964	0.593
2002	31.3	1386.4	56.6	151.384	3.108	0.622
2003	30.6	1334.1	54.0	156.022	3.244	0.649
2004	30.0	1281.2	52.8	159.165	3.357	0.671
2005	29.3	1227.4	54.9	160.149	3.434	0.687
2006	28.6	1177.5	55.2	160.797	3.499	0.700
2007	27.9	1130.4	53.9	164.149	3.622	0.724
2008	27.2	1081.2	52.5	166.548	3.726	0.745
2009	26.5	1038.5	44.4	177.600	3.996	0.799
2010	25.7	986.5	43.4	179.623	4.074	0.815
2011	24.9	946.8	42.0	182.001	4.142	0.828
2012	24.0	906.9	40.6	184.401	4.211	0.842
2013	23.2	866.2	39.2	186.823	4.284	0.857
2014	22.3	828.4	33.5	192.516	4.415	0.883
2015	21.4	786.8	32.2	195.840	4.494	0.899
2016	20.5	746.6	30.8	196.189	4.506	0.901
2017	19.6	705.5	33.7	194.346	4.482	0.896
2018	18.8	666.1	32.2	195.843	4.535	0.907
2019	17.8	623.6	30.6	198.361	4.613	0.923
2020	16.9	579.9	29.1	199.906	4.669	0.934
2021	16.0	537.1	27.5	201.472	4.726	0.945
2022	15.0	494.3	25.9	203.059	4.784	0.957
2023	14.1	451.5	24.3	205.667	4.866	0.973
2024	13.1	407.6	22.7	207.305	4.926	0.985
2025	12.1	364.7	21.0	209.965	5.011	1.002
2026	11.1	320.8	19.3	212.655	5.097	1.019
2027	10.1	277.1	17.6	215.375	5.183	1.037
2028	9.1	233.6	15.9	217.127	5.247	1.049
2029	8.0	191.9	14.1	219.902	5.336	1.067
2030	7.0	150.9	12.3	222.709	5.427	1.085
2031	4.8	113.5		122.478	4.782	0.956

APPENDIX D

An Intensive 30-year Brick-kiln Program

Table D1. Equeting projected demand of wood material from Dominican dry forests, with an intensive 30-year brick-kiln program (1500 kilns at end of program).

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectare Lost 1000 has
1990	200.0	5324.2	137.1	1791.5	54.1	10.8
1991	188.9	4926.9	119.5	1844.2	55.6	11.1
1992	177.6	4521.2	111.6	1875.8	56.5	11.3
1993	166.1	4122.9	112.2	1907.8	57.5	11.5
1994	154.5	3715.6	117.9	1924.9	58.1	11.6
1995	142.7	3318.3	124.7	1952.0	59.0	11.8
1996	130.9	2909.9	129.3	1942.4	58.8	11.8
1997	119.1	2538.4	130.1	1950.8	59.0	11.8
1998	107.3	2154.6	126.5	1953.2	59.1	11.8
1999	95.4	1780.2	119.1	1970.7	59.6	11.9
2000	83.4	1395.7	108.7	1980.4	59.9	12.0
2001	71.2	1022.3	96.3	2015.0	60.9	12.2
2002	58.9	633.1	82.6	2035.8	61.4	12.3
2003	46.7	265.2		1888.8	46.7	9.3

Table D2. Equating projected demand of wood material from humid broadleaf forests, with an intensive 30-year brick-kiln program (1500 kilns at end of program).

Year	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Clearcut Hectares 100 has	Hectares Lost 1000 has
1986	330.9	5637.9	246.5	1274.5	34.1	6.8
1987	323.7	5535.2	206.3	1347.7	36.0	7.2
1988	316.3	5425.4	189.8	1389.2	37.0	7.4
1989	308.6	5311.3	174.5	1437.5	38.2	7.6
1990	300.8	5192.2	160.0	1477.0	39.2	7.8
1991	292.8	5069.0	146.4	1516.6	40.2	8.0
1992	284.6	4941.3	133.9	1548.1	40.9	8.2
1993	276.2	4809.8	123.0	1586.0	41.9	8.4
1994	267.7	4673.4	113.7	1614.3	42.6	8.5
1995	259.0	4532.9	106.8	1649.2	43.5	8.7
1996	250.3	4387.5	102.0	1648.0	43.4	8.7
1997	241.6	4240.3	100.1	1654.9	43.6	8.7
1998	232.9	4090.6	100.5	1649.5	43.5	8.7
1999	224.2	3939.5	103.1	1652.9	43.6	8.7
2000	215.5	3786.6	107.4	1644.6	43.5	8.7
2001	206.7	3633.2	113.2	1652.8	43.8	8.8
2002	198.0	3478.0	119.4	1649.6	43.8	8.8
2003	189.2	3322.6	126.0	1655.0	44.0	8.8
2004	180.3	3166.5	132.0	1652.0	44.1	8.8
2005	171.5	3010.8	137.2	1659.8	44.4	8.9
2006	162.5	2854.8	140.7	1663.3	44.6	8.9
2007	153.5	2699.1	142.6	1677.4	45.1	9.0
2008	144.5	2543.1	142.0	1683.0	45.4	9.1
2009	135.3	2387.5	139.6	1701.4	46.0	9.2
2010	126.0	2231.3	134.3	1712.7	46.4	9.3
2011	116.7	2075.0	127.1	1720.9	46.6	9.3
2012	107.3	1919.0	118.0	1730.0	47.0	9.4
2013	97.8	1763.0	107.0	1750.0	47.5	9.5
2014	88.2	1605.9	93.9	1763.1	47.9	9.6
2015	78.4	1448.2	79.7	1797.3	48.9	9.8
2016	68.6	1287.9	63.4	1800.6	48.9	9.8
2017	58.7	1127.6	47.6	1822.4	49.5	9.9
2018	48.8	965.6	965.6	902.4	48.8	9.8

Table D3. Equating projected demand of wood material from the Baoruco's pine forest, with an intensive 30-year brick-kiln program (1500 kilns at end of program).

YEAR	Land Under Forest 1000 has	Available Volume 1000 m3	Allowable Harvest 1000 m3	Deficit in Production 1000 m3	Hectares Clearcut 1000 has	Hectares Lost 1000 has
1986	35.9	1997.8	166.4	10.568	0.190	0.038
1987	35.9	1978.7	161.3	19.724	0.355	0.071
1988	35.8	1965.3	142.4	41.594	0.749	0.150
1989	35.7	1913.0	141.5	45.452	0.828	0.166
1990	35.5	1882.5	141.8	48.250	0.887	0.177
1991	35.3	1864.2	132.8	61.197	1.129	0.226
1992	35.1	1828.6	138.6	57.379	1.064	0.213
1993	34.9	1817.5	129.5	69.510	1.292	0.258
1994	34.6	1780.9	123.7	77.313	1.446	0.289
1995	34.4	1745.3	113.7	90.340	1.702	0.340
1996	34.0	1694.9	105.9	97.129	1.852	0.370
1997	33.6	1656.3	86.7	117.313	2.253	0.451
1998	33.2	1589.9	83.4	120.630	2.350	0.470
1999	32.7	1542.3	74.9	129.118	2.547	0.509
2000	32.2	1483.6	71.6	132.373	2.654	0.531
2001	31.7	1437.7	59.4	145.575	2.950	0.590
2002	31.1	1378.6	56.3	149.695	3.073	0.615
2003	30.5	1327.7	53.7	153.312	3.188	0.638
2004	29.8	1276.4	52.6	154.436	3.257	0.651
2005	29.2	1225.5	54.6	154.398	3.311	0.662
2006	28.5	1177.8	55.0	155.006	3.373	0.675
2007	27.9	1132.0	53.7	158.309	3.493	0.699
2008	27.2	1083.9	52.3	159.659	3.571	0.714
2009	26.4	1043.7	44.4	169.647	3.817	0.763
2010	25.7	994.1	43.4	171.607	3.893	0.779
2011	24.9	956.2	42.1	172.924	3.935	0.787
2012	24.1	919.0	40.7	174.254	3.980	0.796
2013	23.3	881.3	39.4	176.598	4.049	0.810
2014	22.5	845.6	33.8	182.244	4.180	0.836
2015	21.7	806.1	32.5	185.498	4.257	0.851
2016	20.8	767.9	31.2	185.775	4.267	0.853
2017	20.0	728.7	34.2	182.808	4.216	0.843
2018	19.1	692.6	32.8	184.216	4.266	0.853
2019	18.3	652.3	31.4	186.644	4.341	0.868
2020	17.4	610.9	29.9	188.098	4.393	0.879
2021	16.5	570.3	28.4	189.571	4.447	0.889
2022	15.6	529.7	26.9	191.064	4.501	0.900
2023	14.7	489.0	25.4	193.577	4.580	0.916
2024	13.8	447.3	23.9	195.119	4.637	0.927
2025	12.9	406.4	22.3	197.681	4.718	0.944
2026	11.9	364.6	20.7	199.272	4.776	0.955
2027	11.0	323.7	19.1	201.885	4.859	0.972
2028	10.0	282.0	17.5	204.527	4.943	0.989
2029	9.0	240.5	15.8	207.199	5.028	1.006
2030	8.0	199.6	14.1	208.901	5.090	1.018
2031	7.0	161.0	12.4	212.627	5.202	1.040
2032	4.9	123.8		101.202	4.930	0.986

LIST OF REFERENCES

Abakab, E. M. 1990. Real Incomes and the Consumption of Woodfuels in Ghana. An Analysis of Recent Trends. Energy Economics. July 1990. pp. 227-231.

Abking, M. H. and C. Wolf. 1976. Distributed Delay Routines. CLASS Document No.8. Department of Agricultural Economics, Michigan State University. East Lansing. 10 pp.

Adams, D. M., and R. W. Haynes. 1986. A Spatial Equilibrium Model of U.S. Forest Products Markets for Long-Range Projection and Policy Analysis. in Systems Analysis in Forestry and Forest Industries. Kallio, Andersson, Seppala, and Morgan editors. North-Holland. pp. 73-87.

Andersson, A., M. Kallio, and R. Seppala. 1986. Systems Analysis for the Forest Sector. in Systems Analysis in Forestry and Forest Industries. Kallio, Andersson, Seppala, and Morgan editors. North-Holland. pp. 1-23.

Antonini, G., C. C., Ewel and H. M. Dupper. 1975. Population and Energy: A Systems Analysis of Resource Utilization in the Dominican Republic. The University Presses of Florida. Gainesville, Florida. pp. 20-130.

Barros O., and A. Weintraub. 1979. Planning for the Vertically Integrated Forest Industry. Proceedings. Tenth International Symposium on Mathematical Programming, Montreal. pp. 100-125.

Benson, N. A. 1984. Examination of the Feasibility of Low Cost, Rapid Implementation Energy Farm Programs for the Frontier Regions of the Dominican Republic. University of Maryland. Center for International Extension Development. pp. 30-50.

Cicero, J., s.j. 1988. IV Encuentro Nacional de los Grupos Conservacionistas de la República Dominicana. Santo Domingo, Dom. Rep. Unpublished. 10 pp.

Christiansen, P. 1987. Reforestación Industrial, Manejo de Bosques Productivos y Extración. Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO). Plan de Acción Forestal en los Trópicos. Documento de Campo No.2. Santo Domingo. Rep. Dom. 50pp.

________________. 1987. Plantaciones Energéticas y Producción de Leña y Carbón. Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO). Plan de Acción Forestal en los Trópicos. Documento de Campo No.3. Santo Domingo. Rep. Dom. 55pp.

Comisión Nacional de Políticas Energéticas (COENER). 1987. Producción, Transporte, Comercialización, del Consumo de Leña y Carbón en la Republica Dominicana. Santo Domingo. Rep. Dom. Unpublished. 60 pp.

Consejo de Estado. 1989. Documentos Gubernamentales. Santo Domingo. Rep. Dom. 3 pp.

_________________. 1962. Documentos Gubernamentales. Santo Domingo. Rep. Dom. 5 pp.

Dantzig G. 1974. Determining Optimal Policies for Ecosystems. Technical Report 74-11. Department of Operations Research, Stanford University. Stanford, California. pp. 5-15; 45-60.

_________. 1963. Linear Programming and Extensions. Princeton University Press, Princeton, New Jersey. pp. 60-90.

Dysktra, D. P. and M. Kallio. 1987. Introduction to the IIASA Forestry Sector Model. pp. 459-472 in The Global Forest Sector: An Analytical Perspective, M. Kallio, D.P. Dykstra and C.S. Binkley eds. John Wiley and Sons, Chichester. 703p.

Economic Comission for Latin America (CEPAL). 1989. Dominican Republic: Country Study. U.N. Washington, D.C. 50 pp.

FAO. 1973. Inventario y fomento de los recursos forestales, República Dominicana. Inventario Forestal. OF:SF/DOM 8, Informe Técnico 3. Rome. 470 pp.

____. 1981. Los Recursos Naturales de America Tropical, UN 32/6.1301 78 04, Informe técnico 1, Rome. pp. 45-94.

Fatunde, A. 1986. A Forestry Program for Nigeria. Ph.D. Dissertation. Michigan State University. Forestry Department. East Lansing, Michigan. pp. 110-139.

Ferrer, P. A. 1987. Rendimineto gravimétrico y de carbono fijo en dos tipos de hornos. ISA, Santiago, Dominican Republic. Nota Técnica No. 38. 12 pp.

Fundación para el Mejoramiento Humano (PROGRESSIO).1986. Situación Forestal en República Dominicana. Serie PROGRESSIO No.1 y 2. Editora Amigo del Hogar. Santo Domingo, Rep. Dom. 15 pp.

____. 1987. El Desarrollo Forestal en Números. Serie PROGRESSIO No. 4, 5, 6. Editora Amigo del Hogar. Santo Domingo, Rep. Dom. 20 pp.

Holland E. P. and R. W. Gillespie. 1963. Experiments on a Simulated Underdeveloped Economy: Development Plans and Balance-of-Payments Policies. The M.I.T. Press. Cambridge, Massachusetts. pp. 18-72.

Instituto de Estudios de Población y Desarrollo (IEPD). 1985. Población y Energía en la República Dominicana, 1990-2000. Santo Domingo. Rep. Dom. pp. 5-57.

Jerger K. 1978. PAPRISIM 1 - A Dynamic Model of the Canadian Pulp and Paper Industry. Pulp and Paper Research Institute of Canada. Pointe-Claire. pp. 35-59.

Jiménez, R. and I. Ceballos. 1986. Proyecto de Inversión sobre una plantación de eucalipto para leña y carbón. Undergraduate thesis. Unpublished. Univ. Católica Madre y Maestra, Santiago. Dominican Republic. 157p.

Johnston, G. M. 1988. What is a Policy Analysis? in Natural Resources and Environmental Policy Analysis. G. M. Johnston, D. Freshwater, and P. Favaro editors. Westview Press, Inc.

Jones, D. W. 1988. Some Simple Economics of Improved Cookstove Programs in Developing Countries. Resources and Energy 10 (1988). North-Holland. pp. 247-264.

Kallio, M., A. Propoi and R. Seppala. 1986. A Model for The Forest Sector. in Systems Analysis in Forestry and Forest Industries. Kallio, Andersson, Seppala, and Morgan editors. North-Holland. pp.89-112.

Kemph, G. S. 1985. NARMA Project Pre-evaluation. December 13, 1985. Agency for International Development. Santo Domingo, Dominican Republic unpublished. pp. 10-35.

Kilkki, P., J. Lappi and M. Siitonen. 1986. Long-Term Timber Production Planning Via Utility Maximization. in Systems Analysis in Forestry and Forest Industries. Kallio, Andersson, Seppala, and Morgan editors. North-Holland. pp.285-295.

Knudson D. M., W.R. Chaney, and F.A. Reynoso. 1988. Fuelwood and Charcoal Research in the Dominican Republic. Department of Forestry and Natural Resources. Purdue University. Indiana. 181 pp.

Lonnstedt, L. 1983. A Forest Sector Prototype Model-The Simplified Model Structure. WP-83-68. International Institute for Applied Systems Analysis. Laxenburg, Austria. 23 pp.

_______________ 1983. Mathematical Formulation of A Forest Sector Prototype Model. WP-83-69. International Institute for Applied Systems Analysis. Laxenburg, Austria. 39 pp.

Manetsch, T. 1991. Improved Simulation of Time-Varying Distributed Delays with Losses. Michigan State University. East Lansing, Michigan. Unpublished. 6 pp.

_______________ 1976. Time-Varying Distributed Delays and Their Use in Aggregative Models of Large Systems. IEEE Transactions on Systems, Man, and Cybernetics. 6(8):547-553.

Manetsch, T. 1971. A Generalized Simulation Approach to Agricultural Sector Analysis: With Special Reference to Nigeria. Michigan State University. East Lansing, Michigan. pp. 10-45; 150-250.

_______________ 1968. Computer Simulation Analysis of a Program for Cotton Production in Northeast Brazil. Working Paper No.3. College of Engineering. Michigan State University. East Lansing, Michigan. 84pp.

Marose, R., R. Tuazon, and L. Davis. 1988. Implementing an Ownership-Behavior Simulation of Private Sector Timber Supplies. in The 1988 Symposium on System Analysis in Forest Resources. Pacific Grove, California. pp. 154-162.

Munasinghe, M. 1988. Integrated National Energy Planning and Management: Methodology and Application to Sri Lanka. World Bank. Technical Paper No. 86. Washington, DC. pp. 15-40; 60-95.

Newham R. 1975. LOGPLAN, A Model for Planning Logging Operations. Information Report FMR-77. Forest Management Institute, Canadian Forest Service. Ottawa. pp. 26-42.

Nweke F. I. 1975. A Systems Analysis and Simulation Study of Nigeria Forestry Sector: Wood Consumption Component. Ph.D. Dissertation. Department of Agricultural Economics. Michigan State University. East Lansing, Michigan. pp. 100-200.

Oficina Nacional de Estadísticas (ONE). 1988. Anuario de Comercio Exterior. Santo Domingo. Dominican Republic. pp. 10-15.

Olson (Potter), K., et al. 1984. A National Forest Management Plan for The Dominican Republic. CRIES-AID. Michigan State University, East Lansing, Michigan. 95pp.

Organization of American States (OAS). 1967. Estudio de Evaluación y Reconocimiento de los Recursos Naturales de la República Dominicana. Washington, DC. pp.250-350.

Potter, K. L., et. al. 1986. Prefeasibility Analysis for the Development of Forest Management Activities in the Dominican Republic. CRIES-USAID. Michigan State University, East Lansing, Michigan. 97 p.

Ramírez, N. 1988. República Dominicana, Población y Desarrollo: 1950-1985. Centro Latinoamericano de Demografía. Serie OI No.1002. Imprenta Nacional. San José, Costa Rica. pp. 30-45.

Ramm, C. W. 1985. The 1985 Inventory of the Sierra de Baoruco and the Sabana de San Juan Timber Production Units. Dominican Republic. Department of Forestry. Michigan State University. East Lansing, Michigan. 48 p.

Randers, J. 1976. A System Dynamic Study of the Transition from Ample to Scarce Wood Resources. Internal Publication of the Resource Policy Center, Darmouth College, Hanover, New Hampshire. pp. 25-65.

Rees, J. 1985. Natural Resources: Allocation, Economics and Policy. Methuen. New York, N.Y. pp.50-100.

Rodríguez, V. 1987. Costo de Producción de carbón vegetal. Instituto Superior de Agricultura (ISA). Nota técnica No.37. Santiago, Dominican Republlic. 12pp.

Rogers, E. M. and F. Shoemaker. 1971. Communication of Innovations. Second Edition. The Free Press. New York, New York. pp. 184-202.

Rosado, J. 1986. Análisis químico del carbón vegetal: evaluación de hornos. Instituto Superior de Agricultura (ISA). Nota Técnica No.21. Santiago, Dominican Republic. 11pp.

Russo, I. 1989. Diagnóstico Sub-Sector Foresta. Junta Agroempresarial de Coinversión y Consultoría, Inc. JACC/RD. Santo Domingo, Dominican Republic. pp. 2-20; 50-95.

Sedjo, R. 1986. Forest Plantations of the Tropics and Souther Hemiphere and Their Implications for the Economic of Templerate Climate Forestry. in Systems Analysis in Forestry and Forest Industries. M. Kallio, A.E. Andersson, R. Seppala and A. Morgan, editors. North-Holland. pp. 55-69

Solgerg, B. 1986. Macro-Economic Model for Long-Term Forest Sector Analysis in Norway. in Systems Analysis in Forestry and Forest Industries. M. Kallio, A.E. Andersson, R. Seppala and A. Morgan, editors. North-Holland. pp. 113-121.

U.S. Forest Service. 1983. Charcoal Production: An Opportunity for the Caribbean. Forestry Bulletin R8-FB/U 1. Atlanta, Georgia. pp. 2-10.

Ware G., and J. Clutter. 1977. A Mathematical Programming System for the Management of Industrial Forests. Forest Science. No.17.

Weintraub, A., and D. Navon. Mathematical Programming in Large Scale Forestry Modeling and Applications. in Systems Analysis in Forestry and Forest Industries. M. Kallio A.E. Andersson, R. Seppala and A. Morgan, editors. North-Holland. pp. 337-351.

Williams D. 1986. Integrating Stand and Forest Models for Decision Analysis. PhD thesis. Department of Forestry, University of British Columbia. pp. 80-140.