Evaluation of the *Proyecto de Reforestación Puertorriqueño*

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This report is the product of an educational program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

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ABSTRACT

Starting in 1998, the Forest Service Bureau of the Department of Natural and Environmental Resources (DNER) has sponsored a 50 million dollar reforestation project, the *Proyecto de Reforestación Puertoriqueño*. Our involvement in this project, in collaboration with the International Institute of Tropical Forestry (IITF), was to assess the effectiveness of this program to date. In seven weeks, we collected data from the reforested areas and from project participants, and looked for factors affecting the overall success of the program. Using this information, recommendations were developed to help the DNER and IITF enhance their current efforts and plan future reforestation projects.

Authorship Page

This entire report is a result of equal contribution between all group members.

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EXECUTIVE SUMMARY

The island of Puerto Rico has been experiencing deforestation due to human activity and natural processes throughout the past two hundred years. In response to this, the US Forest Service has aimed to encourage the natural regeneration of these forests and to manage land more effectively in order to improve ecological conditions on the island. However, natural regeneration is a slow process. Increasingly, large-scale tree planting projects are being used to enhance reforestation efforts.

In the wake of the deforestation that has been occurring in Puerto Rico, the Department of Natural and Environmental Resources (DNER), in coordination with other agencies, initiated the project called *Sembrando por Puerto Rico*. The aim was to reforest portions of land throughout the seven different regions of Puerto Rico. This project involved the allocation of ten million dollars per year for five years starting in 1998. These funds went towards tree planting, land acquisition, and educational facilities in the forests of Puerto Rico. Although this project has since changed, these services, now referred to as the *Proyecto de Reforestación Puertorriqueño*, are still offered by the DNER to interested landowners.

The goal of this study was to assess the effectiveness of the *Proyecto de Reforestación Puertorriqueño* and make recommendations in order to better the program. In order to evaluate the success of the project, several important aspects were considered: ecological characteristics of the regions, project planning, tree distribution and planting, maintenance and care issues, and reforestation project promotion.

Five landowners from each of the seven regions of Puerto Rico were selected for our study using a stratified random sampling method. By researching the archives of the DNER, we gathered information about our sample of landowners, including their names and locations, and if incentives were given to them. The approximate number of trees that were planted by each landowner, ranging from about 60 to over 10,000, and the time of year they were planted were also acquired.

Through interviews, we gathered information from the DNER forestry technicians and landowners in each of the seven regions of the island. We sought information about the

interaction between the DNER and the landowners, the type and amount of the maintenance and care performed by each landowner, and views of the program regarding potential improvements and promotional ideas. Fieldwork was also conducted at the sampled planting sites to assess the trees' health. A numerical scale for the health was used, and the approximate heights of trees were also determined.

Several areas in Puerto Rico experienced different precipitation levels and this could have had an effect on the health and growth ratings of the trees. Teak trees showed relatively low health rates in the regions of Aguadilla, Guayama, and Mayagüez. This was due primarily to poor soil conditions caused by drought in these regions. We could see that most of the leaves on the trees in Mayagüez were dry and looked unhealthy. Also, the lack of water seemed to influence the height of the trees since they were relatively small for their age compared to trees in other regions. The low average health rating in the region of Mayagüez can be partly attributed to this factor.

Through our analysis we were able to discover some flaws in tree distribution and planning. Almost all of the landowners received their trees in good health, but they claimed that the height of the trees were, on average, too small. In addition, an important aspect in planning a reforestation project is determining the spacing of the trees. Several of the sites we visited had planted the trees with the proper spacing; however, two of nine living fence projects had improper spacing. In these cases, the landowners either needed to have a property line or living fence established in a short amount of time or they were unaware of their improper spacing.

We have considered maintenance and care issues that may be directly linked to the health and growth rates of the trees we observed. These issues are concerned with clearing the area around the trees, pruning, and watering. In our visits to the sites, we saw 11 of 31 instances in which the landowner did not clear the area around the trees, resulting in vines growing up the trunks restricting the trees' growth. The pruning we observed included trimming branches off the lower parts of the trees. Seven of the 31 sites we visited showed a lack of pruning, three of which were located in Humacao. From our observations we could see that some of these trees were

growing abnormally. While most of the trees we observed at these sites did appear to be healthy, the future health of these trees may be at risk due to this lack of maintenance.

We have discovered through our research that watering is probably one of the most important ways to maintain and care for the newly planted trees. In eastern areas of the island, such as the regions of San Juan, Humacao, and Ponce, sufficient watering was provided through precipitation. Out of 17 sites in the western part of the island where watering was necessary, eight of these areas did not water at all. This could be due to the fact that the importance of watering was not included in the brochures that were given to the landowners.

In all of our sampled locations, the forestry technicians returned to the site after the initial planting. The number of times and frequency of visits varied between technicians. On average, site visits were made up to 6 months after the trees were planted, with one visit approximately every 2 to 3 months. We observed that when the landowners and DNER forestry technicians establish a relationship, the landowners are more enthusiastic about the reforestation project.

At the heart of a reforestation program are the methods of promotion and educating people about the importance of it. Through our interviews with landowners, we found that personal communication with members of the DNER was the most effective way of contacting potential participants, which had reached 20 of 24 sampled landowners. Promoting the project through radio, television, newspapers, and other advertising media was another effective method, reaching the remaining four landowners in our sample.

We have come to several conclusions about the current state of this reforestation program. As of now, the overall health of the trees is very good, suggesting a great success for this program; however, the future health of some trees may be at risk due to lack of knowledge in planting and maintenance techniques. To alleviate negative effects in the future, education and communication between the DNER and landowners should be further developed to ensure the future success of this reforestation program. We have provided our recommendations that, if followed, may improve this program for the future. In each case, we highlight findings that formed the basis for the recommendation.

Allow the trees to grow to 2-3 feet before distribution from the nurseries. Several landowners suggested that because of the small size of the trees, they were more susceptible to death and their growth was much slower. Following this specification, the DNER will provide the landowners with trees more adequate for planting and also decrease the mortality rates of the trees before transplanting them.

Educate the landowners about the importance of and techniques for maintenance and care practices. There were a large number of participants who did not take proper care of their trees in regards to watering, pruning, clearing the land, and other basic procedures. With more education about the importance of these procedures and how to carry them out properly, this may result in an increase of maintenance and care.

Provide participants with informative written information in addition to verbal instructions. The information distributed in brochures to participants contained some basic information about how to plant and care for their trees. We came to the conclusion that the information in the pamphlets and brochures is too general and the information is not targeted at farmers who already know basic agricultural techniques. Watering is one of the most important aspects of maintaining and caring for newly planted trees; however, no form of written information was given to the landowners on the importance of and techniques for watering newly transplanted trees.

Visit the sites frequently to provide assistance and establish a relationship with participating landowners. Site visits of at least once per month by the forestry technicians should be a sufficient amount. Visiting once a month will allow the technicians to assist these landowners with their maintenance and care needs. In addition, these visits will improve the relationships between landowners and technicians and increase the amount of enthusiasm the landowner has for the project. This enthusiasm will increase the amount of maintenance and care the landowners provide to their trees.

Increase promotion for the reforestation project through a variety of methods. Although much more time and human resources are needed, the most effective way to reach people located in rural areas is through personal contacts. In addition, advertising media is

another effective way to reach some landowners. Radio, television, and newspapers are examples of such advertising media that can be used to spread the word of the reforestation program. Community events are a way to promote the project to smaller communities. Some ways that have been effective in the past include holding public seminars on conservation of natural resources, promoting the project through community leaders, and publicizing the celebration of milestones for the project. Education should also be utilized in the promotion of these government projects. More specifically, curriculum should be developed in schools for young students about reforestation and the environment and employees from environmental agencies should visit local schools about these topics. Since promotion of the project is the most important way to continue a reforestation program, these promotional considerations should be taken seriously.

Throughout this report, we have sought to pinpoint the many factors that influenced the effectiveness of the *Proyecto de Reforestación Puertorriqueño.* With knowledge of these factors, conclusions and recommendations have been made to both, the DNER and IITF, to allow these agencies to further enhance their ongoing reforestation efforts that benefit everyone involved. On a more global scale, the recommendations and the implementations of these recommendations by the DNER may provide other deforested areas with a template for a successful reforestation project.

1.0 INTRODUCTION

Deforestation is a worldwide problem that has been occurring since humans began changing the earth's landscape. In recent history, people have cleared large areas of forest for cattle grazing, farming and logging. Natural processes such as hurricanes and landslides also contribute to deforestation. Deforestation can cause a local decrease in wood fuels, soil and water resources and the quality of life in rural areas. Other negative effects resulting from a decline in forest cover include a shift in hydrologic balance, a disturbance of the carbon cycles and other natural processes, widespread erosion in mountainous areas, and even a loss of unique ecosystems.

The island of Puerto Rico has been experiencing deforestation due to human activity and natural processes throughout the past two hundred years. In the late 19th century, due to population growth and the extensive use of the land for agriculture, forest cover continued to decrease. Unregulated timber cutting also contributed to flooding and erosion. In part, because of loss of tropical forests, several animal species, including the Puerto Rican parrot are threatened with extinction. In addition, there may be far-reaching impacts such as the destruction of reefs and marine life.

In more recent years, there has been a gradual increase in forest area due partly to economic changes that caused an abandonment of farmlands and increase in industrial commerce. Critical watersheds -- peaks, ridges, and steep slopes -- are now off-limits to timber harvesting, resulting in water that flows relatively clean and free of sediment. Natural regeneration of forest has occurred in some of these abandoned farm areas; however, construction, cutting, and farming, among other causes of deforestation, still destructively influence these developing forests. In response to this, the U.S. Forest Service has aimed to encourage the natural regeneration of these forests and manage these lands more effectively in order to improve ecological conditions on the island. Natural regeneration is a slow process, however. Increasingly, large-scale tree planting projects are being used to enhance these previous reforestation efforts.

In response to the deforestation that has been occurring in Puerto Rico, the Department of Natural and Environmental Resources (DNER), in coordination with other agencies, initiated the *Sembrando por Puerto Rico*. The aim was to reforest portions of land throughout the seven different regions of Puerto Rico. This project involved the allocation of ten million dollars per year starting in 1998 for tree planting, land acquisition, and educational facilities in the state forests of Puerto Rico. Although the promotion of this project has since ended, these services, now referred to as the *Proyecto de Reforestación Puertorriqueño*, are still offered by the DNER to willing landowners. Not much is known, however, about the results of the program and what factors might have contributed to success or failure at particular planting sites.

The goal of this study was to assess the effectiveness of the *Proyecto de Reforestación Puertorriqueño* and make recommendations in order to better the program. The DNER and the International Institute of Tropical Forestry (IITF) were both interested in learning about the effectiveness of this project. In order to assess the success of the project, two important aspects were considered: the communication between the DNER and the participants of the reforestation program, and the health of the trees due to specific planting methods, care and maintenance, and the ecological factors of the island.

Once all of these factors were evaluated, we sought to determine how these aspects could be addressed to maintain effective and viable projects in the future. Conclusions and recommendations have been made to both the DNER and IITF to allow these agencies to enhance their ongoing reforestation efforts. On a more global scale, the recommendations and the implementation of these recommendations by the DNER may provide other deforested areas with a template for a successful reforestation project.

2.0 BACKGROUND AND LITERATURE REVIEW

It is important to understand the consequences of deforestation and why reforestation is such an important endeavor. The *Proyecto de Reforestación Puertorriqueño* is a program initiated to counteract the effects of the loss of forests in Puerto Rico. The success of this reforestation is likely to depend on several factors, such as participation by the community and the agencies responsible for the program, and the methods used in planting and maintaining the reforested trees. The information in the following chapter addresses these background topics and supported our evaluation of the *Proyecto*.

2.1 Causes and Effects of Global Deforestation

According to Allen and Barnes (1985), deforestation is a loss of primary closed forest area. Studies have shown that almost all developing countries are experiencing a net loss of natural closed forest area and, on average, deforestation is occurring at rates of approximately 1 to 2 percent of forest area per year (Allen & Barnes, 1985). These trends are the basis for the heightened alert about deforestation in recent decades. In order to understand this problem more in depth, the negative effects and related causes will be discussed.

Many people realize that deforestation is a global problem, but they seldom understand the real danger. If the problem is widespread, it can have global repercussions; large-scale loss of forest area has been implicated in changes in wood supply, shifts in the hydrologic balance, a decline of genetic resources, and changes in the global cycles of carbon as well as other elements (Allen & Barnes, 1985). Some short- to mid-term effects from loss of forest cover include a reduction in the supply of wood fuels for energy, flooding in lowlands, degradation of water resources, and a decrease in the quality of rural life. The largest worries that researchers have for forests in the Caribbean Islands are erosion in mountainous regions, desertification in semi-arid tropics, and losses of species and unique ecosystems (Allen & Barnes, 1985; Beller, d'Ayala & Hein, 1990).

It is not only very important to know the negative effects of deforestation, but to learn and understand the causes of it. Globally, deforestation takes place everyday through natural occurrences and continuing human activity. Natural deforestation is attributed to hurricanes, tornados, landslides, and fires. Although natural deforestation can have devastating effects on forest cover, human disturbances are the major contributor to worldwide deforestation (Waide, Zimmerman & Scatena, 1998). These human disturbances, in particular the clearing of forests for agriculture and cattle grazing, have transformed many forest ecosystems and still have an effect on forests today in terms of structure, composition and function.

Although humans are the major contributors to the causes of deforestation, they can also make the largest contribution to reforestation projects. Understanding the way land has been used in the past can be useful information about how to discourage further deforestation.

2.2 History of Forestry in Puerto Rico

Understanding the history of land use in Puerto Rico can explain many reasons for its deforestation problem. This problem has brought about an awareness of the negative consequences of deforestation and the need for reforestation. In recent decades, the Puerto Rican government has initiated the *Proyecto de Reforestación Puertorriqueño*, an island-wide project, to address this problem. In the following sections, information on the important aspects of past land use in Puerto Rico as well as the history of the *Proyecto de Reforestación Puertorriqueño* is provided.

2.2.1 History of Land Use in Puerto Rico

Beginning with the colonization of the island, Spanish land use in Puerto Rico was slight until the 19th century, when government land distribution led to agriculture, forest cutting, and mining (Aide *et al.*, 1996; Foster, Fluet & Boose, 1999). In the early 1900s, pasture covered more than 55% of Puerto Rico as forest clearing and agriculture reached a peak. Extensive nutrient depletion eventually led to widespread abandonment of agricultural lands, especially on steep

hillsides and high elevations (Aide *et al.*, 1996; Foster *et al.*, 1999). Overgrazing and cultivation, combined with heavy precipitation and steep slopes, produced widespread erosion and landslides. During early U.S. ownership of Puerto Rico, forest management practices concentrated on reforesting for timber production. The 20th century decline in the agricultural economy of Puerto Rico, coupled with an industrial migration to San Juan and the United States, resulted in a rural population decline, broad-scale agricultural abandonment, and some natural forest regeneration (Aide *et al.*, 1996; Foster *et al.*, 1999).

Across Puerto Rico, the massive migration from rural areas led to an increase in forest area from less than 10% to about 30% during the late 1900s (Foster *et al.*, 1999). The developing forests continued, however, to be influenced by fuelwood production, silviculture, construction, and recreation. The objectives of the USDA Forest Service have been to reforest and encourage forest growth on all agricultural lands, improve forest production, and manage lands for diverse natural resources. By the mid 1940s, approximately 2800 ha. of land had been planted by the agency at varying densities (Foster *et al.*, 1999). To improve timber growth, the USDA Forest Service thinned approximately 125 ha. annually throughout the 1970s. These thinning activities were highly selective by species, and extensively impacted forest composition and structure (Foster *et al.*, 1999).

By the 1980s and 1990s, new cultural values and enhanced appreciation of tropical forests had greatly altered land use practices. USDA Forest Service silvicultural activity largely decreased, and recreation, scientific research, and educational activities increased. Because of this trend, future decades should see a development of progressively older forests, mediated only by natural disturbances (Foster *et al.*, 1999).

Today, however, deforestation in Puerto Rico continues due to steady population growth, economic, and development pressures. According to the World Resources Institute (1991), with those previous deforestation rates, in tropical areas such as Puerto Rico, all but scattered remnants of tropical forests and many tropical species would be gone before today's high school students retire. With this, the understanding of the need to reforest has been greatly acknowledged, and unlike most tropical areas, the island of Puerto Rico and several other

Caribbean islands have regained much of their original forest area in the last half-century. Of 114 nations for which the Food and Agricultural Organization has data, Puerto Rico far exceeded all other nations in its percentage gain of forest area since 1948 (Caribbean Vegetation Mapping Project, 2002). This progress can be attributed to past reforestation efforts, and more currently, to the *Proyecto de Reforestación Puertorriqueño*.

2.2.2 Origins and Purposes of the *Proyecto*

The deforestation of Puerto Rico caused by its history of land use has given rise to government sponsored reforestation projects. These projects sought to initiate island-wide reforestation efforts in Puerto Rico.

Massive reforestation of the island began during the administration of Governor Pedro Roselló with the initiation of the *Sembrando por Puerto Rico* in 1998. The former secretary of the DNER, Daniel Pagan, used Brazil's large-scale reforestation project as a model for Puerto Rico. Pagan went to Roselló, the former New Progressive Party governor, with a proposal for a large-scale reforestation project to mirror the success found in Brazil. This program would allocate $10 million per year for five years starting in 1998 to reforest throughout the 7 regions in Puerto Rico. Figure 1 shows these different regions.

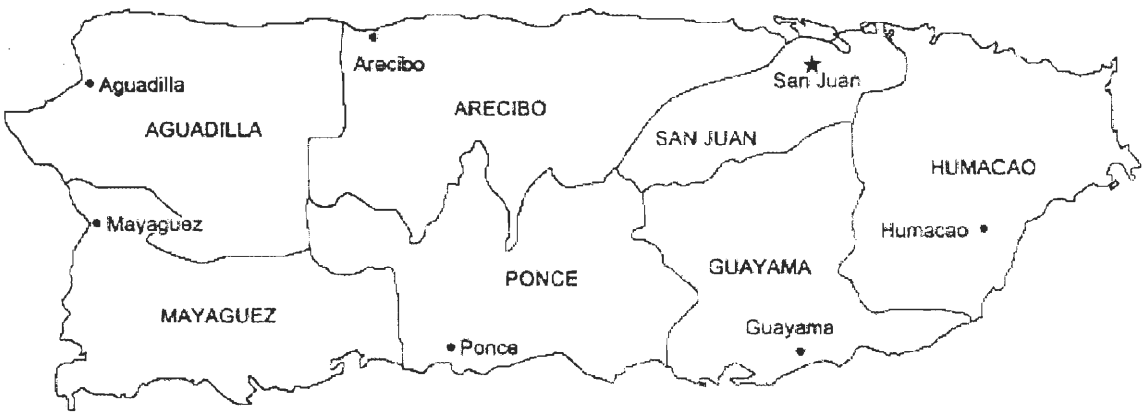

Figure 1: The seven regions of Puerto Rico

Adapted from: http://www.lib.utexas.edu/maps/americas/puerto_rico_1999.jpg

The DNER developed brochures and educational programs in schools to publicize the program. The goal of the project was to plant a total of 3.8 million trees: 600,000 trees in 1998, 1.2 million trees in 1999, and 2 million trees in 2000. The $50 million that was allocated to the program was designated for tree production in nurseries, land acquisition, tree planting, incentives for participants, and DNER salaries, supplies and equipment (Figueroa, personal communication, April 16, 2002). The land acquisition proved to be a benefit, expanding six of the state forests that already existed.

The elections of 2001 brought about a change in the government and the end of Pedro Rosselló's administration. The Democratic Popular Party experienced funding problems and therefore discontinued the *Sembrando*. Media promotion of the project ceased, but some reforestation services are still being offered under the name *Proyecto de Reforestación Puertorriqueño* (Figueroa, personal communication, April 16, 2002).

2.3 Reforestation: Processes and Efforts

The *Proyecto de Reforestación Puertorriqueño* is one of the ways Puerto Rico is trying to address the deforestation problem on the island. Forest regeneration occurs over an extended period of time and is a natural form of reforestation. This ability to reforest naturally is a slow process, however, and human initiated, proactive projects offer the most hope for reforesting faster and more effectively. Past projects have shown that community participation in such reforestation projects can be an important factor toward success (Aide *et al.*, 1996). The practices of reforestation both naturally and by human intervention can provide Puerto Rico with a more sustainable island. In order for reforestation projects to be a success, knowledge of how to plant and care for trees is very important and should be acknowledged (Aide *et al.*, 1996).

2.3.1 Natural Forest Recovery

Under proper environmental conditions, natural reforestation of land can occur without human intervention. After about 50 years of growth, secondary forests cannot be distinguished from undisturbed sites in terms of density, basal area, composition diversity, or species variety, but it will require centuries for these sites to return to an ecosystem similar to true, undisturbed forests (Aide *et al.*, 1996). Rainfall, humidity, wind, light exposure and cloud-cover, soil composition, elevation, and topography have all been identified as major factors influencing natural reforestation in a complex system (Waide *et al.*, 1998).

Natural reforestation is more favorable in northeastern Puerto Rico than in other areas of the island because of the smaller areas of deforested land, lack of fire and drought, nutrient rich soils, and a lack of past hurricane disturbances (Aide et al., 1996). The extreme differences in climate across the island create varying results with natural forest generation. For example, the severe drought conditions in the southwest region of Puerto Rico prevent the rapid growth of new vegetation (Aide et al., 1996).

Although natural reforestation occurs throughout the island, it is a very slow and gradual process. With Puerto Rico's continuing deforestation problems, the rate of natural reforestation is insufficient to counteract the damage (Aide *et al.*, 1996). To solve this problem there must be additional methods of reforesting the island.

2.3.2 Importance of Participation in Reforestation Projects

Reforestation can occur without human intervention, but this process is enhanced when individuals and communities are involved. Some agencies sponsoring reforestation projects claim that there is a large amount of participation by local communities to make their projects seem more credible, when, in actuality, there is very little direct involvement by local populations. Without support from the local landowners, these projects have not lived up to their full potential in reforesting the land (Groome & Perez, 2000). Sometimes, no matter how many useful participation approaches are implemented, reluctance by established forestry services to adapt

new reforestation tactics limits the success of projects. The promotion of new participatory methods of forestry management is starting to increase with the efforts of non-governmental organizations (NGOs) and government agencies. NGOs continue to insist that there is a great need to "reorientate" forest policy to provide alternative development schemes in order to allow local people to have a more proactive role in reforestation programs (Groome & Perez, 2000).

An important case that illustrates the consequences of lack of participation and a strong opposing public opinion is taken from Palencares, Spain. In Palancares, from the 1970s to the present day, there has been high resentment among land users towards the idea of reforestation. The reasons for this resentment are directly related to the current land use; these landowners have needed to use all their land for cereal production and livestock grazing (Groome & Perez, 2000). The lack of involvement and strong negative public opinion were not considered in the planning stages of the reforestation project resulting in a low number of trees being reforested.

There are some ideas that Groome and Perez (2000) suggest in order to address the importance of local participation. Firstly, they believe that agencies should switch from a method of adopting landowners and other interested groups into an already organized reforestation plan, to a modified plan which first considers the participation factors before the plan is established. A second idea suggested is that the Department of Forestry should add new curricula of study in rural development planning rather than the general forestry engineering programs currently established; Groome and Perez (2000) also believe the curriculum that exists now is inadequate in the social, anthropological, and political sciences aspects. The third technique that they suggest is the idea of a trial run in participation, making use of consultants. This idea would allow ecologists to collaborate with such professionals as economists, geographers, and sociologists in the decision making process.

There have been several noteworthy reforestation efforts to date, and these case studies suggest that participation can increase the chances of success in a project. In the northeast section of Peru lie natural cloud forests that play a significant role in cloud water collection, feeding the major rivers and streams that make up the hydrological system of the province. The cloud forests constitute a unique ecosystem in the country because of the biological diversity that

they support; however, the majority of these lands have been cleared. The International Tropical Timber Organization (ITTO) has been conducting a reforestation project since 1994 called Reforestation, Sustainable Management and Utilization in the Natural Cloud Forests of Jaén-San Ignacio, and participation in the projects proved to be very important (Rebaza, 2002).

In the first phase of the project, studies were conducted and strategies were designed to improve the participation of the local communities. A successful awareness-raising and local involvement campaign was initiated to maintain the participation of local personnel who have become experienced in activities related to the reforestation effort. The ITTO organized workshops to train the public in the establishment and maintenance of nurseries (Rebaza, 2002). Since communication between different settlements was difficult, the ITTO broadcasted daily programs on the local radio stations and published monthly articles in the local newspapers to raise environmental awareness and to educate about technical forestry and other information. In addition, forest committees in the villages have been involved with activities related to plantation establishment, the installation of nurseries, and other areas that aid in reforestation (Rebaza, 2002). As the evidence shows from the success of the ITTO's project, the knowledge of the volunteers along with their participation can be important to the reforestation effort.

Another study was conducted to investigate the participation of people in the Reforestation Campaign in Commemoration of The Royal Golden Jubilee in Phrae, Thailand. The factors that affected the people participating in the project and problems and difficulties in conducting the project were the main focus of the study (Seekeaw, 2002). The results from the study showed that due to the population's social status, education, and economic status, the local participants in the project had little knowledge of the factors important to the success of the reforestation effort (Seekeaw, 2002).

In Samut Songkhram Province, Thailand, there was a reforestation effort that was established to reforest mangrove trees. For the first two years, the project was conducted mostly through community participation. The mangroves were voluntarily planted, but due to the lack of knowledge and technical support from pertinent government sectors, the survival rate was very poor (Derun, 2002). Though it was relatively unsuccessful, the expectations for the project

remained high. In the years to come, the project began to gain more support from the local government and private sectors. During these later years the people were able to gain more experience in planting the mangroves, thus allowing for a more successful reforestation effort (Derun, 2002). These efforts require persistence, courage, and the ability to adapt management practices in a process that is extremely time consuming. This study provides an example of the importance of community and sponsoring agency participation in a reforestation effort (Derun, 2002).

The examples just provided suggest that when evaluating the success of a reforestation effort, participation and partnership of the public and sponsoring agencies are likely to be important factors. Participation is largely based upon the will of the person volunteering, but there are many other outside factors as discussed above. Volunteers can become involved through the efforts of the organizer to either educate or provide assistance to these volunteers directly.

2.3.3 Sustainable Development in Forestry

Sustainable development is one of the philosophies that people can implement to conserve natural resources and aid in reforestation. The most concise and widely used meaning of sustainable development is meeting the needs of the present without compromising the ability of future generations to meet their own needs (Campbell *et al.*, 1997; Hartshorn, 1995; Lesh & Lowrie, 1990). Sustainable forestry implies that forest harvest can be sustained over the long term. It is a continual process of harvest and regeneration. With the loss of most of the world's original forests, people must rely more and more on second-growth or managed forests (Mastrantonio & Francis, 1997). The information that follows demonstrates the importance of sustainability as a response to deforestation issues. More specifically, examples from small islands and countries such as Costa Rica, and Peru are used to explain how this theory has been put into practice in recent years.

Importance of Sustainability in Forestry

Small islands, countries with limited resources, entire continents, and even our world as a whole can all benefit from past experiences of practicing sustainability (Beller *et al.*, 1990). The dangers that arise when islands do not practice sustainable development are becoming clearer with the continual deterioration of our natural resources. The complete destruction of an island's natural resources would ultimately undermine the economic and environmental health of that island for future generations (Beller *et al.*, 1990).

In order to solve these types of problems native to small islands, 32 representatives from 19 different countries attended the 'Interoceanic Workshop on Sustainable Development and Environmental Management of Small Islands' in Puerto Rico on November of 1986 (Beller *et al.*, 1990). The purpose of this workshop was to give recommendations to each small island regarding its core problems in sustainability. Without adopting a management system similar to the ones recommended at the workshop, conditions of soils, wildlife, forests, watersheds, and coastal areas would most likely continue to be degraded on the islands.

Specific to the issue of forestry, the members of the workshop put together some general recommendations for achieving sustainability (Beller *et al.*, 1990), including:

a) Island governments should recognize the importance of forest cover, assign adequate funding to forestry departments, and develop comprehensive land-management planning, which uses principles of sustainable development, multiple use, conservation, and land capability;
b) Fragile forest lands or those with special ecologic value should be completely preserved under a program of rational land-use planning;
c) The introduction of exotic species should be recommended only after extensive adaptability trials and proper experimentation;
d) Adequate training and support for professional forest, land, and resource managers needs to be provided; and

e) The citizens themselves should be well educated about the importance of forests for maintaining adjacent ecosystems and watersheds, and for preventing far-reaching impacts such as the destruction of reefs and marine life.

Table 1: Recommendations for Caribbean Islands on Sustainable Forestry

SECTOR	SITUATION	POSSIBILE SOLUTIONS	RECOMMENDATIONS
High Islands	Slopes covered with secondary growth. Deforestation continues in low lands. Agriculture is encroaching into forest lands. There are few plantations. Charcoal frequently produced from natural forests.	Establish plantations for wood-import and energy substitution. Protect native forests for watershed, tourism and wildlife. Reduce wood imports. Couple food and fiber production through agro-forestry.	Survey and protect public forest lands. Improve forestry agencies. Couple forestry and food production, or forestry and grazing through agro-forestry.
Low Islands	There is no forestry. Islands are wood importers.	Establish plantations and reforest lands for watershed protection and limited production of forest products. With native tree species, protect vital lands for wildlife.	Establish a forestry office, and support the forestry sector. Properly train personnel. Conduct adaptability trials for tree species that can be used for energy and fence posts.

(Source: Sustainable Development and Environmental Management of Small Islands, 1990)

Table 1 shows the approaches to forestry issues experienced by Caribbean Islands such as Puerto Rico. As we can see from this table, these specific recommendations follow the general guidelines set by the members of the workshop. The following section gives some additional examples of how sustainable forestry has been utilized in Costa Rica and Peru.

Industrial and Community-Based Examples of Sustainable Forestry

In more recent years, timber companies have started to realize the long-term benefits of implementing sustainable forestry methods. The Costa Rican company PORTICO S.A. has managed its own forests on a sustainable basis since the mid 1980s (Hartshorn, 1995). The wood called royal mahogany (Carapa guianensis), which is abundant in the northeast section of Costa Rica, is used to make hardwood doors for trade to the U.S. Before PORTICO, tree harvesting was performed by loggers who caused considerable damage to the land using traditionally crude logging techniques. Upon arrival, PORTICO decided to develop a comprehensive forest management plan for each section of land it bought from local farmers.

The company made a major commitment to research and monitoring its production forests. Instead of allowing its employees to damage the forests by using indiscriminate felling and skidding[1], they trained their employees in the field to reduce logging damage of the land. By using very simple sustainability methods, PORTICO worked towards achieving the long-term sustainability of its forests.

An example of how a local community has implemented sustainable forestry can be seen in the efforts of the Yánesha Forestry Cooperative (COFYAL) and the Peruvian Amazon government (Hartshorn, 1995). An environmental assessment of the land concluded that more traditional approaches to a rural forestry development project would undoubtedly fail. COFYAL's goals were to: 1) manage the communities' natural forests for sustained yield of forest products; 2) protect the cultural integrity of the Yánesha people; and 3) provide a source of employment for members of the native communities. New processing technologies were given to the local landowners by COFYAL to improve the use of timber and manage the complex systems of their tropical forests. The method used to cut the timber from the forests, called the strip-cut technique[2], promotes excellent natural regeneration of the native tree species. COFYAL has managed to create a very effective sustainable forestry project that does minimal damage to the land and successfully meets the needs of the economy now and in the future.

2.3.4 Practices of Planting Trees for Reforestation

Many of the reforestation case studies previously described illustrate the importance of educating participants about proper planting and care methods. This section will provide an overview of the considerations that should go into a reforestation effort with respect to planning,

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[1] The term felling and skidding is used to describe when a tree is cut and falls on a standing tree causing bark abrasion. This removes a layer of growth tissue (cambium) and exposes the underlying wood (xylem) to further invasion of fungi (Ontario Woodlot Association, 2001).

[2] A strip cut is a narrow clearcut offering more protection from sun and wind than larger clearcuts. A clearcut is a harvest where all trees are removed from a given block or forest area (Macphail Woods Ecological Forestry Products, 2000).

planting, and caring for the trees. It is important to gain a better understanding of what is actually involved in the entire planting process.

Selection of Location and Species

Selecting the proper planting location is one of the most critical steps of the planting process. For example, if the plant has to be removed in the future because the site proves to be unsuitable, then the planting effort will have been a failure. There are several factors that can be considered at each site including soil conditions, exposure to environmental elements, past human activity, drainage, space constraints, and hardiness[3] (International Society of Arboriculture, 2000).

Soil quality is a very important aspect for the survival of reforested trees. The ability of landowners to recognize potential problems and how to deal with them will allow the growth of healthier trees. For example, in urban sites, the topsoil has often been altered and is frequently shallow, compacted, and subject to drought. With these conditions, the trees will be placed under much stress (International Society of Arboriculture, 2000). For species that are not able to deal with these types of stress and soil flaws, the landowner must perform regular maintenance procedures or the tree may not survive. Another important aspect of soil is its composition, which can be determined by having the soil tested and analyzed in a forestry lab. Technicians can then make recommendations on either what type of species should be planted, or what can be done to improve the soil using fertilizer or soil amendments such as sand, peat moss, and manure (International Society of Arboriculture, 2000).

The exposure of the trees to the environmental conditions around them must also be considered when selecting trees to plant. The amount of sunlight available in a certain location is important to the health and survival of the trees and should always be considered (International Society of Arboiculture, 2000). Most species of trees require full sunlight for proper growth. Though some trees may be able to survive in light shading, very few are able to grow well in

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[3] Hardiness is a term used to describe how a plant reacts to different temperatures.

densely shaded areas. If a tree is going to be planted in a shady location, a species that is able to survive with less sunlight should be considered.

In addition to variations in sunlight, exposure to wind drastically affects trees' growth. Wind has the ability to dry out soils and create drought conditions, cause damage to branches and leaves during strong storms, and can also uproot newly planted trees that have not yet been able to establish an extensive root system. In windy locations, simple maintenance procedures should be used frequently to ensure a tree's healthy growth, including staking the tree for support and watering it for up to three years (International Society of Arboriculture, 2000).

The influence of human activities, including soil compaction, underwatering, overwatering, vandalism, and planting the wrong type of tree, are sometimes overlooked in deciding where to plant a tree (International Society of Arboriculture, 2000). In light of this fact, landowners should evaluate their land and their physical limitations prior to selecting specific trees. For example, if landowners cannot feasibly care for a large plot of trees because of time or economical limitations, they should not select a tree that needs extensive care for successful growth.

In order for a plant to obtain the necessary amount of oxygen from the available water and soil, the drainage system at the location should match the requirements of the plants. If there is poor drainage, the ability of the tree to obtain oxygen will be depleted (International Society of Arboriculture, 2000).

When planting trees, there can be many factors such as underground utilities, buildings, surrounding trees, and other obstacles present that will limit the ability to properly space the trees. The landowner should provide adequate room for the tree to grow to full maturity, both above and below the ground. Keeping this in mind, enough room must also be available for the landowner to plant the desired number of trees with the necessary spacing for the trees (International Society of Arboriculture, 2000).

Hardiness is the tree's ability to survive in the extreme climatic temperatures of a particular geographic region. Plants are either cold hardy and/or heat tolerant (International Society of Arboriculture, 2000). Before planting, landowners should consult local forestry

agencies to check geoclimatic maps and evaluate the type of climate they will be planting in. It is important that landowners realize that their climate may drastically affect the survival of their trees. All of these preliminary checks can add to the development of a successful reforestation program. The next step is to prepare a site chosen for planting.

Site Preparation

Proper site preparation is important to any planting process and will vary with all the elements that were previously mentioned. One aspect of site preparation may include clearing the land. Using heavy machinery is very effective, but costly. Collecting debris by hand and allowing decomposition is the least costly. Both of these methods, though different in cost, are effective ways to prepare a site for planting (Purdue, 2000).

Once the area has been cleared for planting, there are further steps to prepare the site. Breaking up sod to allow it to dry before discing[4] may be useful. Also, undercutting the sod with a blade cuts the sod from its roots and accelerates drying. Leveling the site without breaking up the sod may cause young trees to be harmed, due to the methane gas produced as large pockets of sod decompose. If leveling is used, ripping[5] the surface should be done as soon as possible so that the sealing of the soil does not occur (Dave Wilson Nursery, 2001). Irrigation is another aspect to consider after clearing the land. Irrigation is used to settle the planting site and provide adequate moisture for fumigation. This process should be done with a sufficient amount of water so that the soil will be able to settle most effectively (Dave Wilson Nursery, 2001). After the site is cleared and irrigated, chemicals such as fertilizers and pesticides may be used. In all cases, it is recommended that the use of any chemicals should follow strict directions to avoid creating more problems (International Society of Arboriculture, 2000).

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[4] Discing is a farming practice used to help break up the soil and bury crop refuse.

[5] Ripping occurs when crop roots create soil pores and then promote the formation of cracks in cracking soil.

Care of Trees before Planting

Along with preparing the site, the trees must be cared for prior to planting. Preventative measures should be taken to make sure tree roots do not dry out and are kept away from sun and wind. The trees should be moved to the site in vehicles that are covered, should be watered at least once a day prior to planting, and their health should be checked regularly. If a tree has to be held longer than a couple days, these trees should be "heeled in" -- temporarily planted in loose moist soil (Dave Wilson Nursery, 2001). Once all of the preparation steps have been addressed, the actual steps of planting the trees remain.

Spacing Requirements

The spacing between the trees must be properly planned before planting the trees. The tree's size when fully matured must be considered. Planting too close can result in unhealthy growth when the trees compete for limited resources. Unless pruning or the removal of dying trees is correctly performed, these trees will deform one another and create other potential growth problems as they mature (Harris, Clark & Matheny, 1999).

The distance between the trees to be planted is determined by their landscape purpose, their expected mature size, leaf retention, costs of installation, necessary room for maintenance, and type of climate (Harris *et al.*, 1999). If it is anticipated that the trees will be moved in the future and sold to professional landscapers or that they are part of an urban reforestation project, these trees must be spaced wider to allow for more growth. A common spacing method is planting two rows 8 feet apart and a drive row of 10 to 14 feet on each side of the two rows. This pattern should be repeated over the entire area to be planted. This spacing, if planned correctly, allows greater room for digging and results in fewer injuries to trees during harvesting. Smaller flowering trees can be planted in rows 6 feet apart, while larger shading trees should be spaced 10 feet apart in each row (North Carolina, 1999). The ability to move equipment for maintenance purposes such as fertilizing and mowing must also be considered when spacing the trees (North Carolina, 1999).

Post-Planting Practices

Once the trees have been planted, continuous care is needed to ensure their health. Mulching, watering, and pruning are all practices that should all be conducted regularly.

Mulching is one post-planting practice that can be used to maintain the health of the newly planted trees. Past studies have shown that wood chip mulch can tremendously increase the growth rate of trees in the first few years after planting (Lovett & Bolander, 2001). This is due to the fact that mulch placed around the base of a tree conserves moisture, reduces competition from weeds, and insulates roots from extreme temperature. Organic mulch is ideal because it helps aerate the soil and replenish soil nutrients as it decomposes. On the other hand, excess mulch may provide a habitat for small rodents and lead to considerable damage. The excess mulch may also retain excessively high levels of moisture for long periods of time and cause root damage (Lovett & Bolander, 2001). Thus, people need to be educated about proper mulching techniques.

Another important aspect in caring for a tree is watering. All newly planted trees should be thoroughly watered to the point of soil saturation at the time of planting. This will provide the tree with the essential moisture for the plant and will also settle the soil in the planting hole for contact between the roots and soil. Overwatering, however, can cause serious problems for the trees by drowning their roots. The consequences of underwatering the trees, including burning at the edges of the leaves, must also be taken into account. It may be beneficial to group specific trees in relation to their watering requirements to avoid these problems (Lovett & Bolander, 2001).

Pruning is a very effective technique to care for newly planted trees. At planting time, trees and shrubs should be pruned only to remove branches damaged during handling and transplanting. The main branch on some single-stemmed trees should not be pruned unless there is a significant amount of damage. In addition, lower branches should not be removed completely because they help gather a large portion of the nutrients necessary for the tree's health (Lovett & Bolander, 2001).

Fertilizers can also be used to help in growth, although most base soils contain sufficient levels of available nutrients to supply to the newly planted trees. Fertilizer should not be applied

during the early stages of growth when new roots are being established (Lovett & Bolander, 2001). After this period, fertilizer can be used in moderation to enhance the nutrients in the soil.

3.0 METHODOLOGY

The goal of this project was to assess the effectiveness of the *Proyecto de Reforestación Puertorriqueño* and make recommendations for the future of the program. To complete this task, we sought information and feedback from the key stakeholders in this reforestation project: the DNER, local forestry technicians, and participating landowners. This was done through archival research and interviews. We also visited planting sites in all regions of the island to assess both the health and growth rates of the trees. All of our objectives and methods for interviews and fieldwork are discussed in this chapter.

3.1 Collecting Information and Feedback from DNER Forestry Technicians

DNER forestry technicians played a very important role in the *Proyecto de Reforestación Puertorriqueño.* They were responsible for carrying out the duties, such as giving the landowners information on planting and maintaining their trees. They also followed up with each of the reforestation sites and provided assistance to the landowners when needed. To find out more in depth about their involvement in the reforestation project, we sought to interview the seven technicians responsible for their particular region of the island. Meeting the DNER forestry technicians served two main purposes. The first purpose was to gain information and insight into the *Proyecto de Reforestación Puertorriqueño* based on their experiences and personal viewpoints. The second purpose was to have their assistance in contacting the landowners and finding the reforested locations. These two purposes will now be addressed in further detail.

3.1.1 Data Collection Methods

In order to gain more knowledge on the *Proyecto de Reforestación Puertorriqueño* from the forestry technicians' perspective, we collected data on the planting sites and participants in each region, as well as the communication and interaction between the DNER forestry technicians and the participating landowners. During each meeting with the DNER forestry technicians, we

requested site planning information from their archives. These records contain information such as:

- Names and other demographic information on participating landowners
- Total area of reforested land
- Total number of trees
- Amount of money incentives given to landowners
- Names and number of specific species of planted trees
- The date and time of year the trees were distributed to landowners

In addition to the data collected through the archives in each regional office, we sought information concerning the following main topics:

- The type of information distributed to the participants by the DNER
- How the DNER forestry technicians helped the landowners with planning and maintenance
- How often the DNER forestry technicians followed up with landowners after planting
- The opinions of the DNER on how to improve the program and promote reforestation

After defining what qualitative information was needed from the DNER forestry technicians, interviewing was chosen as our method to gather this data. Since we communicated directly with the participants, interviewing allowed us to collect all the answers to our questions without the delays associated with other methods. It was important to meet with technicians in person because of their individual circumstances and for their convenience. In addition, we were able to understand more accurately how our questions were perceived, and it was much easier to clarify any misinterpretations they may have. A copy of the questions asked to the DNER forestry technicians can be found in Appendix B.

3.1.2 Contact Methods

Our method of contacting the forestry technicians was given careful consideration so that we would receive the information we desired. It was important for them to understand our project, and that it was for educational purposes and not an assessment of them as individuals. Our next task was to develop specific methods and guidelines for making these initial contacts. Lastly, overcoming the language barrier was a challenging part of communicating with the interviewees.

A phone call from a familiar person is much more likely to be well-received than a cold call from a stranger. In a conference call, a member of the IITF was able to help us contact the

DNER forestry technicians responsible for the reforestation project in each region. When calling the DNER forestry agents, we abided by the following guidelines suggested by Frey and Oishi (1995). Within the first week of our arrival to the island, the IITF employee and our team tried calling at several different times of the day and on different days of the week until contact was made. If we received a busy signal or no answer, we called back a half hour later. When an answering machine was reached, we left a brief message on the machine stating who we are, what our project involves, and that we would like them to participate in our study by agreeing to a short interview and a field survey of the reforested trees. Then we stated that we would try to call again at another time. If there was an answer, but the technician was unavailable, we asked when the most convenient time would be to talk to him.

When we were able to reach the DNER forestry technicians, the representative from the IITF first introduced himself as an employee from the USDA Forest Service. He was careful in introducing everyone and explaining our need to evaluate the *Proyecto de Reforestación Puertorriqueño*, not the landowners or the technicians involved with the project. He continued to explain that he was working with three students from Worcester Polytechnic Institute, an engineering school from the United States. The purpose of the project was explained using the goal and objectives we established. We asked for copies of their records on the landowners in their district and requested that they contact the sample of landowners to arrange a short visit. We also made it clear that we wanted to speak with several landowners throughout the island simply to gain an understanding of the general attitude toward the program for our educational purposes. Since these technicians personally know each landowner in their region, we felt the best way to contact the landowners was for them to receive a call from their local forestry agents. Next, we established a date on which we could visit the region. We then explained to the technicians our need to perform an interview with the landowner and perform field research on the reforested trees and assess their health. We made a follow-up contact with the technicians several days before the scheduled visit to confirm and remind them of our arrival.

Although interviewing was selected as the best method for collecting data, the language barrier between interviewers and interviewees was a problem that needed to be addressed. Poor

communication over the phone or in person can cause some people to become frustrated and hesitant to help. Our method to deal with this problem involved utilizing the human resources available at the IITF and the DNER. A member of the IITF was available to translate when we spoke to individuals in person as well as on the phone.

3.2 Collecting Information and Feedback from Participating Landowners

Data on the landowners' involvement in the reforestation project was gathered by talking to the landowners while visiting the sites. The interviews were designed to gain an understanding of the communication strengths and weaknesses between the DNER forestry technicians and the landowners, to learn what care and maintenance methods were used, to observe the level of excitement and various attitudes of the landowners toward the program, as well as to learn about the most effective ways to advertise reforestation projects.

3.2.1 Selecting a Sample of Landowners

Given the large number of subjects in the population of landowners and the time constraints for this project, we chose to use a sample of the total population of landowners. Our sample was chosen from the total population using a stratified random sampling method described in more detail below. A randomly generated sample of adequate size should create the desired representative population needed to study all landowners participating in the program. To achieve this accurate representation of the total population, the landowners in our population were selected by the forestry technicians. The technicians assured us that their selections were indeed random. Since the selection of five landowners was not a statistically sound sample given the large total population of landowners participating in the reforestation program, we cannot generalize our results to all planting sites; however, this sample will give us a sufficient overview of the program.

In a stratified random sample, the population is divided into different subgroups (or strata) that share the same characteristics, and a random sample is then drawn from each stratum

(Triola, 2001). This method was chosen over the standard random sampling method, which is a simple random sample of the whole population, due to the fact that we wanted to compare the success of reforestation in each of the seven regions on the island. If the population were not divided into each of the seven regions, we would have a list of landowners that may not accurately reflect each region as a separate zone being studied. A normal random sample of the participants across the entire island could have been chosen, but the samples within each region would need to be sufficiently large to compare them with each other. For example, in order to differentiate the success between a region of the island that was not successfully reforested to another area that was much more successful, we would most likely spend more time visiting additional sites to make sure the sample was large enough.

It is important to consider the response rate for the chosen landowners since it could affect the sampling error depending on the circumstances. Since all of these people had volunteered for the reforestation program by the DNER, it was likely that they would participate in an evaluation study sponsored by the IITF. Although they agreed to, there were several instances in which the landowners could not be reached when we were conducting surveys of their land. In these cases, in order to increase the response rate, we followed up the visits with phone calls to conduct a short interview. After establishing rapport, we conducted the interviews with the same questions as the on-site interviews. Although it is possible that conducting the interview by phone might have yielded somewhat different responses than an interview conducted in person, we could not detect any obvious signs that that was the case.

3.2.2 Information Gathered from Landowner Interviews

The data that we sought from landowners can be divided into three areas: their techniques for planting and caring for the trees, their interaction with the DNER forestry technicians, and their perception of the reforestation project. This data was retrieved through the interview questions included in Appendix C.

There were several specifics that we wanted to determine in regard to communication and how the trees were cared for. As these volunteer landowners started to receive and begin to

plant the seedlings, we wanted to know whether or not they were given any instruction by outside sources, written or verbal, on how to plant and care for the trees. If they did receive instructions, we wanted to know how helpful they were and if they followed the guidelines. If no instruction was provided, we assessed if the landowners planted and cared for the trees based solely on their knowledge. Another major question was whether or not any follow-up work was done to the plantings by the landowners to improve the seedling survival. We sought to know if such things as watering, fertilizing, pruning, and fencing were used and the amount given of this care.

Whether or not the landowners placed value in the program is an important factor in the success of the reforestation project. The level of importance they placed on the reforestation effort can affect whether or not there is potential for long term improvement of their land. We sought to learn what areas of the reforestation project the landowners thought could be improved or modified. In addition, we wanted their opinion on the best ways to promote the project so that more landowners may have the opportunity to reforest their land. This information is very important to the IITF in deciding whether or not this project was a success in the eyes of the landowners.

3.3 Performing Field Work

In order to gather data on the growth and health of the trees, we visited a sample of reforested areas in each of the seven regions. The first task in performing this fieldwork was to determine our sample of trees at each site; only a fraction of the trees were selected from the whole population depending on species and layout of the land. For each tree we measured the height and assessed the health of the tree by using a method adopted from forestry technicians.

3.3.1 Selection of Tree Samples

We selected a sample of trees from the total population in each reforested area due to the large number of trees and the extensive areas of land to be surveyed. The number of trees located at each particular site ranged from about 60 to over 10,000 and they were planted in

areas as large as 200 acres. The information on the exact number of trees in each reforested site was unavailable to us, however we were able to obtain an approximate number from the landowners.

With such an extensive number of trees and limited amount of time available to us to gather our data, we chose to sample approximately fifty trees from each site. Although this sample is not statistically sound, it gave us a sufficient overview of the condition of all of the trees in the particular area. General observations were also made on all trees and the conditions of the surrounding area to gather as much information as possible. These conditions gave us enough confidence to test hypotheses that various factors contributed to the success of reforestation between different areas across the island.

The reforested areas that we studied were determined by the locations of the landowners who were randomly selected to be interviewed. Within the 50 trees sampled, comparable samples were taken of the different species that had been planted in that area. The trees were selected according to the layout of the planting. In cases of planting for agro-forestry, for example, where the trees were planted among the other crops, a cluster of reforested trees was chosen and 50 trees were selected randomly from this cluster. In soil conservation and property line planting, the trees were planted in rows or a grid pattern. Trees were alternately selected from the rows until the desired number was reached.

Once a sample had been established we collected the desired information about the trees. We sought to determine the survival rate for the trees that were distributed to the landowners throughout the island. With this sample of reforested trees, we could investigate whether any specific species might have been more successful in survival and growth.

3.3.2 Measurement Techniques

We desired to know the health of each species of tree that was used in the reforestation project. The information needed for analysis was gathered through observations of the trees. A copy of the data sheet used to record fieldwork information is attached as Appendix D. The fieldwork conducted was a very important aspect in this project for our data collection.

First, the species of each tree was determined by examining the tree's leaves and recognizing their basic characteristics, such as how the lobes of the leaves are shaped, how many lobes there are, how the veins branched out from the midrib, and the color of the leaves. The forestry technicians at the IITF and DNER instructed us on how to make this determination. Once the identity of the species was recorded, we observed the leaves of the tree to assess its health. Aspects of the leaves that we looked for include discoloration, presence of dead tissue, drying up of leaves, and distortions at tips or bases of leaves. All of these characteristics were examined in relation to a healthy tree of the same species.

A metric with which to assign a health value to each tree was used in order to quantify the data and compare the health of the trees between different species and regions. A rubric was adopted from the forestry experts at IITF to analyze the recently planted trees in the reforestation project. A scale of 0 to 3 was used when assigning a health value to a tree:

0) Dead

1) Poor – plant is still alive, but dying

2) Fair – healthy, but evidence of lack of care and maintenance

3) Good – excellent condition or only minor health problems

Prior to making the recorded assessments, we went to a sample area to be trained by a forestry technician from the IITF. At this time, we practiced assigning health values to various trees until our group was consistent in assigning the same ratings to the same trees. An example of a teak tree with a health rating of 3 can be seen in Figure 2. Figure 3 and 4 illustrate trees with health ratings of 2 for the reasons described in the captions. Figure 5 shows a picture of a cedar tree with a rating of 0.

Figure 2: Example of a tree that received a health rating of 3

Figure 3: Example of a tree that received a health rating of 2; insect infestation

Figure 4: Example of a tree that received a health rating of 2; leaves burned due to drought

Figure 5: Example of a tree that received a health rating of 0; result of a worm infestation

In addition, any health problems evident on the trees were recorded. Relatively common problems included infestation of insects, which caused portions of the leaves to be eaten away, and drought that caused the leaves to burn around the edges and wither. These two conditions can be seen in Figures 3 and 4. We also noted aspects of the land where the trees were planted. In some areas the soil was dry or rocky, which may impair the growth of a tree.

In order to be able to compare growth rates of the reforested trees, we approximated the height of each tree and then calculated a growth rate in feet per month; however, we were unable to obtain all dates of planting in order to calculate growth rates for all of the trees in each site. Photos were taken at all the sites to visually record the planting success or failure.

3.4 Data Analysis Methods

Our analysis strategy was to look for relationships between the tree health data and the information we gathered from interviews of landowners and forestry technicians. In order to review the effectiveness of this program, we considered a variety of variables that might have been influential. Following is a list of research questions that we have explored:

- Was there a significant difference in the average tree health between the seven political regions of the island?
- Did ecological factors played a role in the health of the trees and how did these vary between regions?
- Was the distribution of the trees to landowners affecting their health?
- Were there any differences with planning and planting in the individual projects between regions?
- Did the use of different maintenance and care techniques by the landowners affect the health of the trees?
- How did the promotion of the project to landowners in each region affect the program overall?

The first step in performing our data analysis was numerically evaluating the health of the trees. To do this, the mean health of each species was calculated for all farms in a region. This data provided us with an idea of the average health in each reforested location and allowed us to compare the results by the seven regions and by species. Then we investigated whether differences in the means could be explained by variables such as ecological aspects of the regions, project planning and planting, tree distribution practices, care and maintenance, and project promotion.

Our first consideration was the effects of the ecological aspects of each region. Every region of Puerto Rico is different with respect to temperature, precipitation, and soil conditions. We desired to know whether some or all species were affected by these factors and if this could be directly related to the health of the trees.

The distribution of these trees was also looked at. There was a need to see if these trees were distributed at the proper heights and if these trees were healthy when the landowner received them. Knowing the conditions of the trees at planting may allow us to understand the health and growth of the trees when we observed them.

The post-planting care and maintenance of the trees by each landowner was evaluated as well. We sought to understand whether proper or improper care was directly linked to tree health. Specifically, the care techniques we examined include clearing the land, pruning, watering, using pesticides and fertilizers, guiding, and spacing. For this analysis, we depended on our notes and observations of the reforested trees we sampled. Also, the maintenance and care practices that landowners used were taken into consideration. Looking at our field work and interview results, we then compared the health of the trees and the techniques used at each

particular site when analyzing which practices are most important in maintaining the health of the trees.

The amount of project orientation provided to the landowners, the planning and planting process, and the post-planting involvement of the forestry technicians were other areas examined. It was known that brochures and verbal instructions were given to some landowners to make recommendations on the proper way to plant and care for the trees; however, it was unknown whether these instructions were followed by the landowners. The forestry technicians also performed follow up visits with varying frequencies, but we needed to understand if and how these visits were beneficial to the landowners.

The final aspect of the reforestation project we investigated was the promotion of the reforestation project to the landowners and how it affected the overall program. To look into this, we relied a great deal on the information we received from both the landowner and technician interviews. We were able to analyze the most effective ways of reaching possible candidates for the program.

4.0 FINDINGS

Any reforestation project that establishes forest cover, no matter how modest this may be, can be considered successful. The current health of the trees planted in the *Proyecto de Reforestación Puertorriqueño* is satisfactory, and therefore this project can be considered successful in reaching its goal of increasing forest cover on the island. Throughout the course of our evaluation, however, we have found that the overall success of a reforestation project cannot simply be defined by one variable. Throughout this chapter, we will discuss how these variables can affect the project and the long-term efficacy of the trees. Climate and other ecological considerations is one of these elements that we will discuss in this chapter. In addition to the environmental factors, we address how humans can influence the program through project planning, tree distribution, and tree planting. The amount of maintenance and care provided to these reforested trees is another element discussed in more detail. Lastly, we address our findings with regards to the promotion of the program and how it affects the overall reforestation effort.

4.1 Overview of Tree Health by Species and by Region

The most concrete indicator of success that can be determined from our data is the health ratings of the trees we sampled. This information was used to compare the regional differences in how well reforested trees had established themselves since they were planted. Because of the relatively small number of sites we visited and trees we assessed, we are not able to extend our findings to all sites and the millions of trees that were planted in the reforestation project. Nevertheless, it is reasonable to assume that the observations we made at the wide variety of sites we visited across all regions of the island – large and small, successful and unsuccessful – are representative of the issues that influenced the entire project.

In addition to the health ratings of the trees we sampled, data collected on the average growth rates of species for each region would provide some useful information about how the

growth of these trees is affected by various human and ecological factors. When performing our data collection and analysis, however, we were limited because of a lack of records available to us as well as time constraints that did not allow us to gather and process the necessary information about planting dates. Although we have no numerical information on the growth rates of the trees, we have taken our notes and qualitative observations of the growth into consideration throughout our analysis.

After analyzing the health of trees in each farm and region, we compared this information by region and by species of tree. The scale of 0 (dead) to 3 (healthy) was assigned to each sampled tree, as was discussed in Section 3.3.2. Table 2 shows the average health of each species of tree for each region as well as the number of trees sampled placed in parentheses.

Table 2: Average Health of Trees by Region and Species*

	Aguadilla	Arecibo	Guayama	Humacao	Mayagüez	Ponce	San Juan	All Regions
Caoba ***Swietenia mahogoni Swietenia macrophylla***		3.00 (13)	2.91 (57)	3.00 (50)	2.80 (81)	3.00 (16)	3.00 (63)	2.96 (280)
Capa Prieto ***Cordia alliodora***	2.79 (58)			3.00 (12)		3.00 (26)	3.00 (9)	2.95 (105)
Cedar ***Cedrela odorata* L.**	3.00 (53)	1.64 (55)		2.91 (46)			3.00 (16)	2.64 (170)
Eucalyptus ***Eucaluptus robusta***		3.00 (16)	2.96 (27)	3.00 (11)	2.80 (10)	3.00 (26)	3.00 (27)	2.96 (117)
Maho ***Hibiscus elatus***		3.00 (36)		3.00 (12)		3.00 (12)		3.00 (60)
Roble ***Tabebuia heterophylla***	2.74 (50)	3.00 (11)		2.89 (19)	2.80 (10)	3.00 (22)	3.00 (10)	2.92 (122)
Teak ***Tectona grandis* L.f.**	0.75 (8)	3.00 (26)	2.66 (37)	2.98 (84)	2.17 (60)	2.86 (88)	2.90 (181)	2.47 (484)
All Species	2.46 (169)	2.77 (157)	2.88 (121)	2.97 (234)	2.64 ** (161)	2.98 (190)	2.98 (306)	2.81 (1,338)

* The numbers in parentheses display the number of trees sampled.

** This figure does not take into account two of the five sites in this region's sample selection that were completely destroyed by fires.

As shown in the table, the average health of the trees was determined to be very healthy (2.81); however, there are several numbers on the table that stand out and need further explanation. This rating is a good indicator of success for the trees that have already been planted and established in the soil. It does not, however, take into account the trees that have died before we were able to observe them. The reason for this is there was no data available to us about the number of trees that have died before being planted or those that died and were replaced. If this information was available to us, we would know the survival rate of the species and it may have given us a better indicator of the program's success.

Although cedar trees seemed to be fairly well established where they were planted in most of the areas, Arecibo was an area that cedar trees were, on average, in very poor health and many had died. To understand the reason that cedar trees did not seem to establish well in the region of Arecibo, we looked at our notes and written observations from this region. The sample of farms in Arecibo only contained two farms that had planted cedar trees from the project. At one of these farms, the owner stated in an interview that he had a serious worm infestation that affected only his cedar plantations, and almost all of those trees had died. A picture of one of these trees can be seen in Figure 5 located in Section 3.

Teak trees also showed relatively low health rates in the regions of Aguadilla, Guayama, and Mayagüez. In the case of Aguadilla, the small number of teak samples reflects the fact that only one of the locations we visited had planted teak trees. At this location, the landowner stated that teak trees do not establish well in this area due to the dry soil and therefore their health was extremely poor. In the region of Guayama, the low health rating for teak trees can be attributed in part to a local problem of fungus and insect infestation at one particular site, and very poor maintenance at another. Two sites in Mayagüez had planted teak trees and both locations received only a moderate health rating for this species. This was due primarily to poor soil conditions caused by the drought in the region. In addition, an insect infestation in the teak trees was noticeable in one of these sampled sites. In these same two locations, the health ratings of the other species planted there seemed to be relatively unaffected by these problems.

There are several differences in the ecological aspects between the regions of Puerto Rico, and these likely had an effect on the health and growth rates of the trees. While visiting the various sites, we were able to observe the variations between climate and soil conditions. These two factors are solely based on our qualitative observations rather than actual climate and soil data. In addition, natural disasters, hurricanes in particular, were also observed to play a part in the health and growth of the trees.

Several areas in Puerto Rico have different precipitation levels and this could have had an effect on the health and growth rates of the trees. For example, the region of Mayagüez was experiencing its drought season during our visit. From our observations we could see that most of the leaves were dry and looked unhealthy. Also, the lack of water seemed to influence the height of the trees since they were relatively small for their age compared to trees in other regions. The relatively low average health rating (2.64) in the region of Mayagüez can be partly attributed to this factor. In one case in Mayagüez, the reforested area was poorly maintained and infested with insects. At another site, there was evidence that the teak trees were affected by the drought.

In contrast to the presence of these negative climatic aspects, San Juan, Humacao, and Ponce have the most rainfall of all regions in Puerto Rico according to the forestry technicians and several landowners. These eastern regions of the island had healthier trees overall and they appeared to be growing at much higher rates than those in the drier regions of western Puerto Rico.

Fires, hurricanes, and everyday winds were also discovered, through our interviews and observations, to have effects on the trees. Some landowners told us that Hurricane George had damaged the trees they planted early in the project in 1998. The effects we observed from the hurricane were an increase in rocks and fallen trees surrounding the newly planted ones. The poor soil conditions could prevent the trees from establishing themselves in the ground and growing to full maturity. We also observed the destruction of many trees by fires in the southwest area of Puerto Rico, Mayagüez in particular. In areas where only small fires were present, many of the trees were destroyed, but some were able to survive and are beginning to return to their

healthy state. A picture of a small area affected by fire can be seen in Figure 6. Wind was also a factor we observed to affect the growth of the trees. In Mayagüez, due to strong winds, some trees were growing abnormally to the side rather than straight up.

Figure 6: Destruction by fire in Mayagüez

As can be seen from Table 2, most of the trees sampled were fairly healthy with a few exceptions. As an example of this, we encountered at least one site in almost all of the regions that planted trees along property lines or roadways too closely together; however, most of these were in near perfect condition. The reason that these trees should not be considered completely successful is because most of them will have a difficult time reaching full maturity due to competition for growing space and important nutrients. From our observations, it is possible that the problem lies in a lack of knowledge about planting the trees, lack of communication with the landowners, or a lack of value placed in the trees due to the desire for quick results in tree density.

4.2 Issues Related to Project Planning, Tree Distribution, and Planting

The interviews that have been conducted throughout our data collection have provided us with some insight into factors of this program that would otherwise be very difficult to discover. One of the things that we look at is the assistance provided to landowners in the planning of each

project. Another factor we consider is how these trees were distributed to landowners. A last factor is the actual planting carried out by the landowners and how spacing may affect the health and growth rates of the trees.

Through our interviews and research, we discovered that all the landowners received at least some assistance in planning their reforestation project. The types of information provided by the forestry technicians in this project orientation generally included species selection, appropriate spacing, simple methods that they could use to care for the trees, and how they would be assigned funds, if any, to help them cover the costs of planting the trees. Most of this information was given to landowners by verbal communication in person or over the phone. Brochures, which contained information about general planting, maintenance, and care procedures, were distributed to landowners in all regions but this depended on the prior knowledge of each participant; the technicians used their own judgment on how useful these brochures would have been for each individual case. Nine of the twenty-four landowners interviewed stated that this information was not very useful. The reasons they provided were that the information was outdated, too general to be used for their specific practices of reforestation, or not targeted at farmers who already know the basic planting and care procedures contained in the brochures.

A very important aspect in the planting process is the tree's condition when it is received from the nursery. The goals that were initially set by the *Sembrando* reforestation project changed the production in the Cambalache nursery in Arecibo dramatically. The large amount of new funding improved equipment and processes, but with the increasing pressure to get the trees distributed quickly, Gonsalez (personal communication, April 16, 2002) believes the employees were more concerned with distribution numbers rather than the quality and effectiveness of the project.

These trees were often under-matured and many had died before they could even be transplanted. Almost all of the landowners interviewed stated that the trees were in good health when they received them, but they were only 6 inches to 1 foot tall. Of the landowners who gave a response to the question, nine of twenty-three from across the island specifically suggested that

this was too small for planting. In talking to professionals, we were able to find that trees should not be removed from the nursery until they are at least 2-3 feet tall. Although it is not completely clear whether planting small seedlings had a harmful effect on the health of the reforested trees, the information received through our interviews suggests that it is generally not viewed as a good practice.

An important aspect in planning a reforestation project is determining the spacing of the trees. We know that the DNER suggested the proper spacing to each of the landowners, which was 8 ft. by 8 ft. or 10 ft. by 10 ft. Several of the sites we visited had planted the trees with the proper spacing; however, two of the nine living fence establishments had improper spacing, with the trees only about 5 ft. apart. In these cases, the landowner either needed to have a property line or living fence established in a short amount of time or they were just not aware of the spacing need. Examples of spacing techniques can be seen in Figures 7 and 8. Although spacing of the trees does not have an effect on the health and growth rates of the trees in the early stages, it will have an effect as the tree matures when there will be competition for soil and water resources necessary for survival. Since most of the trees we observed were relatively young, we cannot note the actual effects the spacing may have in the future.

Figure 7: Example of improper fence line spacing of 5 ft.

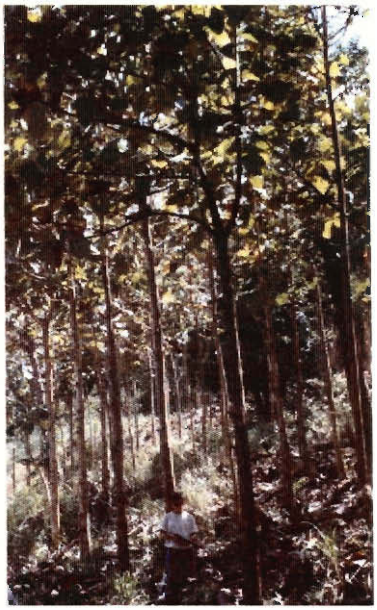

Figure 8: Example of proper spacing of trees

4.3 Maintenance and Care Issues

Through our fieldwork at each site, we observed the effects of the different maintenance and care techniques used by the landowners. These techniques include clearing the area around the trees, pruning, watering, using pesticides, fertilizing, guiding, and spacing. We cannot say whether these methods definitely had direct influence on the health of the trees; however, the use of at least some of these care methods was observed to assist the trees in growing healthy.

A very important aspect that we observed in maintaining and caring for trees was clearing the area around the planted trees. Our background research indicated that clearing the area around a tree is important for healthy growing trees. In our visits to the sites, however, we saw 11 of 31 instances in which the landowner did not clear the area around the trees, resulting in vines growing up the trunks and branches of the trees. These 11 sites were not concentrated in any particular region; they were scattered around the island. Vines are harmful to trees because they attach themselves to the trees and inhibit the growing process. While most of the trees we observed at these sites did appear to be healthy, the future health of these trees may be negatively affected since the surrounding areas will continue to grow.

The maintenance problem was particularly evident at a reforested site in Humacao. During our visit, we had to walk through weeds and brush that reached 6 feet tall in order to observe the trees. The condition of the land made it difficult to locate the trees. The landowner stated that he could not afford to hire people to maintain his 40 acres of land, and even if he could, finding people to actually clear the difficult terrain would be another challenge. These time and financial restrictions seemed to be the reason for the lack of maintenance for most of the 11 landowners.

We also were able to examine several sites that did clear the land around the trees. A good example of this maintenance practice is a 20-acre property in Humacao, shown in Figure 9. The landowner clears around the trees on a regular basis and has access to machinery for this maintenance. The trees on this property were healthy and taller than most of the trees we observed elsewhere on the island.

Figure 9: Example of proper clearing of land

The practice of pruning the trees was also observed during our fieldwork. The pruning we observed included trimming branches off the lower parts of the trees to ensure only one main trunk would grow. In many cases the trees had been pruned and were growing fairly well. In other instances, we observed that the landowners did not prune; there were several lower branches, and in some cases four separate trunks. Seven of the 31 sites we visited showed a lack of pruning, three of which were located in Humacao. From our observations we could see

that some of these trees were growing abnormally. Though the health of the trees was still good, the numerous trunks may affect the health and growth rates in the future.

We have discovered through our research that watering is probably one of the most important ways to maintain and care for the newly planted trees. In eastern areas of the island, such as the regions of San Juan, Humacao, and Ponce, sufficient watering was provided solely through precipitation. In some cases we observed various watering techniques that provided for healthy trees. In Ponce, for example, we encountered a landowner that had developed a very elaborate watering system that collected rainwater and distributed it throughout the property. The trees observed on this farm were very healthy and growing extremely well. Another technique that we observed at a location in Mayagüez was placing buckets with holes in the bottom around the site along irrigation trenches. The buckets would collect rainwater and this would leak through the holes and seep along the irrigation trenches. This technique proved to be very effective for the trees in the driest region on the island.

Aside from the three eastern regions, from the 17 sites where watering data was received, 8 of these areas were not watered at all. Though irrigation systems are not needed, it is still important to provide the trees with water. In many cases, the leaves of the trees were dry and some were falling off. The importance of watering was not included in the brochures that were given to the landowners, and as a result, the landowners that performed this care technique learned it through previous knowledge or verbal instructions.

One maintenance and care practice that was not highly used among the landowners was the use of pesticides. As a result, several of the trees we observed had leaves that were eaten by bugs. An example of this can be seen in Figure 3 in the previous chapter. The worst case we have seen of insect infestation was on a plantain farm in Arecibo. The landowner's cedar trees had been infested by worms and most of these trees were dead. A picture of one of these inflicted cedar trees can be seen in Figure 5. This could account for the low average health of cedar trees in Arecibo. There was one case, however, in Ponce in which the landowner, from his own experience as a farmer, used a soap and water mixture as a pesticide. At this site there were much fewer instances of bug infestation on the trees, and the trees were healthy overall.

Like pesticides, the use of fertilizers was very rare. In a few agro-forestry projects in which the landowner fertilized his crops, the reforested trees also got fertilized. It is uncertain how fertilizers may have affected the trees since there were limited instances in which fertilizers were used. Our research suggests that fertilizers are a good way to help the tree grow and remain healthy.

Several regions in Puerto Rico experience high winds, and this was observed to have an effect on the growth patterns of the trees. Constant winds seemed to cause the trees to grow awkwardly but appeared to have no effect on the health of the trees. Guiding can be used to overcome the effects of strong winds. At a couple sites we visited, stakes and ropes were used in order to aid the tree in growing correctly. Another technique we observed was the use of windbreaks placed around the trees to limit the exposure of the trees to the wind, which allows them to grow upright. The use of these techniques may have an important role in the growth of trees in windy areas.

In all of our sampled locations, the forestry technicians returned to the site after the initial planting was done. The number of times and frequency of visits varied between technicians, but through our interviews, we found a couple of instances in Aguadilla and Arecibo where the landowners would have liked more frequent visits by the technicians. On average, site visits were made up to 6 months after the trees were planted, with one visit approximately every 2 to 3 months. We observed that when the relationship between the landowners and forestry technicians develops into more of a friendship, the landowners are more enthusiastic about the reforestation project. In the region of San Juan, for example, the technicians visited the sites approximately once a month, and we noticed that these projects seemed to have some of the healthiest reforested areas throughout the island. Frequent visit may be hard to come by, though. The technician we interviewed in Guayama stated that he was unable to visit more frequently than every three months because of the large number of participants in the program. Our observations indicate that the health of the reforested trees could be positively affected by a high frequency of visits; however, more research on this topic would be needed to support this idea further.

4.4 Reforestation Project Promotion

At the heart of a reforestation program are the methods of promotion and educating people about the importance of it. One efficient method that reached some individuals in the region of San Juan was seminars for the community about environmental concerns. Through our interviews with landowners we found that personal contacts by members of the DNER were the most effective way of reaching potential participants. In our sample, 20 of the 24 landowners we interviewed learned about the program through direct contact with an employee of the DNER or other government agencies. Promoting the project through radio, television, newspapers and other advertising media was another effective method, reaching the remaining four landowners in our sample.

The campaign for the project *Sembrando por Puerto Rico* was well supported by government funding, but through our interviews and observations we have noticed that there could have been some additional ways to promote the project to participants in rural settings. Several people involved with this project believe that there are many more people who could benefit from this project, but are either unknowledgeable about how to start with the program or don't know that the opportunity exists in the first place. We sought to discover new approaches to find harder to reach targets in rural areas. For this target audience, a more personal approach is needed; many people have suggested that door-to-door visits by a forestry technician to individual farms would be the most effective way to spread the word about this project to rural residents. We also found that community leaders can be very effective people to talk to about the benefits of a project such as this.

Our findings suggest that the goals of some the participating landowners do not coincide with that of the reforestation project due, in part, to the incentives program offered through the *Sembrando por Puerto Rico*. Although no study was conducted to show a correlation between the reforestation goals of the participants and the type and amount of incentives given, it was suggested through interview responses that some landowners took advantage of the financial

incentives of the program without holding reforestation as their top priority. In several cases, the landowners interviewed thought that more incentives would be helpful to cover the costs of planting and maintaining their reforested trees. The problem with this is that it may not actually help promote the program or improve the focus on reforestation.

Another problem observed with the financial incentives distributed to landowners is that in a few instances the absence of an organized archival system prevented these landowners from receiving the incentives they were promised. There is not enough concrete evidence provided by our research to report any findings about this aspect of the program, but future research in this area could take this factor into account.

5.0 CONCLUSIONS AND RECOMMENDATIONS

In this chapter, we have come to several conclusions about the current state of this reforestation program. As of now, the overall health of the trees is good, thus suggesting a great success for this program; however, the future health of some trees may be at risk due to lack of knowledge in planting and maintenance techniques. To alleviate these effects, education and communication between the DNER and landowners should be further instituted to ensure the future success of this reforestation program. In the remainder of this chapter we provide our recommendations that may better this program for the future. In each case, we highlight findings that formed the basis for the recommendation.

Allow the trees to grow to 2-3 feet before distribution from the nurseries. Several landowners suggested that because of the small size of the trees, they were more susceptible to death and their growth was much slower. Following this specification, the DNER will provide the landowners with trees more adequate for planting and also decrease the mortality rates of the trees before transplanting them.

Educate the landowners about the importance of and techniques for maintenance and care practices. There were a large number of participants who did not take proper care of their trees in regards to watering, pruning, clearing the land, and other basic procedures. With more education about the importance of these procedures and how to carry them out properly, this may result in an increase of maintenance and care.

Provide participants with informative written information in addition to verbal instructions. The information distributed in brochures to participants contained some basic information about how to plant and care for their trees. We came to the conclusion that the information in the pamphlets and brochures is too general and the information is not targeted at farmers who already know basic agricultural techniques. Watering is one of the most important aspects of maintaining and caring for newly planted trees; however, no form of written information was given to the landowners on the importance of and techniques for watering newly transplanted trees.

Visit the sites frequently to provide assistance and establish a relationship with participating landowners. Site visits of at least once per month by the forestry technicians should be a sufficient amount. Visiting once a month will allow the technicians to assist these landowners with their maintenance and care needs. In addition, these visits will improve the relationships between landowners and technicians and increase the amount of enthusiasm the landowner has for the project. This enthusiasm will increase the amount of maintenance and care the landowners provide to their trees.

Increase promotion for the reforestation project through a variety of methods. Although much more time and human resources are needed, the most effective way to reach people located in rural areas is through personal contacts. In addition, advertising media is another effective way to reach some landowners. Radio, television, and newspapers are examples of such advertising media that can be used to spread the word of the reforestation program. Community events are a way to promote the project to smaller communities. Some ways that have been effective in the past include holding public seminars on conservation of natural resources, promoting the project through community leaders, and publicizing the celebration of milestones for the project. Education should also be utilized in the promotion of these government projects. More specifically, curriculum should be developed in schools for young students about reforestation and the environment and employees from environmental agencies should visit local schools about these topics. Since promotion of the project is the most important way to continue a reforestation program, these promotional considerations should be taken seriously.

Throughout this report, we have sought to pinpoint the many factors that influenced the effectiveness of the *Proyecto de Reforestación Puertorriqueño.* With knowledge of these factors, conclusions and recommendations have been made to both, the DNER and IITF, to allow these agencies to further enhance their ongoing reforestation efforts that benefit everyone involved. On a more global scale, the recommendations and the implementations of these recommendations by the DNER may provide other deforested areas with a template for a successful reforestation project.

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APPENDIX A: INTERNATIONAL INSTITUTE OF TROPICAL FORESTRY

USDA Forest Service IITF

PO Box 25000, San Juan, PR 00928-5000;

UPR Experimental Station Grounds

Botanical Garden, Río Piedras, PR 00928

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The International Institute of Tropical Forestry (IITF), directed under the United States Department of Agriculture (USDA) Forest Service, was created in 1939 in Río Piedras, Puerto Rico. As a scientific institution, the IITF is committed to research in tropical forestry and the transfer of technologies. To address aspects of physical, social, and economic issues in managing tropical forests, the IITF has more than sixty years of experience in interdisciplinary research. The IITF is also involved in partnerships for policy and program coordination with many local government agencies as well as with non-government conservation organizations. A recent and expanding effort provides guidance and financial incentives to local authorities for projects in urban forestry. Research partnerships exist with over fifty institutions, including Worcester Polytechnic Institute's International Global Studies Division. Internationally, staff consultancies and research have occurred in virtually all of the Caribbean Island, Mexico, Central America, South America, and parts of tropical Asia.

The focus of the research program at the IITF is tropical American forests. The program is enhanced by laboratory facilities for chemical analysis of soils and water, a library that features technical information, books and journals on tropical forestry, and the area of land known as the Luquillo Experimental Forest (LEF) along with a network of some of the oldest tree growth plots in the hemisphere.

The USDA Forest Service and the US Agency for International Development fund the IITF program. International cooperation specialists provide information in areas such as ecosystem management, silviculture, forest utilization, management of parks and protected areas and other fields of renewable resource management. These programs contribute directly to the international cooperation mission of the IITF that is to exchange knowledge critical to sustainability of tropical ecosystems and their contribution to humankind through demonstration, training, science exchange, and technology transfer.

Throughout the program's existence, the IITF has helped many rural landowners to reforest parts of their land. A total of nine multiple resource forest management plans, covering a total of 1,743 acres were certified in Puerto Rico. Landowner objectives included soil protection, erosion control, water quality, wildlife habitat, timber production, recreation, general forestry conservation and land aesthetics. An additional 311 management plans were written specifically for timber production. 1057 landowners received assistance and over 236 acres were planted with tree seedlings. Over 160,000 tree seedlings were produced in the PR Department of Natural and Environmental Resources (PR DNER) nursery.

Reference:
http://www.fs.fed.us/global/iitf/welcome.html

APPENDIX B: Interview Questions for DNER Forestry Technicians

1. Did you provide assistance the landowners?
   Ustedes le proveyeron assistencía a los dueños de fincas o proyectos?

   If so, what specifically did you help them with?
   Comó los ayudaste?

2. What information was distributed to the landowners in regards to planting and caring for the trees?
   Cuál fue la información que les dió a los dueños de fincas sobre siembra y cuido de árboles?

3. What methods did you suggest to the landowners to use for the planting?
   Que maneras de siembra les dijo?

4. Was any post-planting care given to the trees?
   Las personas le dieron mantenimiento a los árboles después de las sombrarlos?

5. Were any follow up visits done to check up on the landowners and the trees?
   Después que las personas sombraron los árboles, ustedes volvieron a las fincas para ver los árboles?

6. Was there anything the DNER could have done to make this program more helpful and beneficial to you?
   Qué otras cosas ustedes pudieron hacer para mejorar este programa de reforestación de Recursos Naturales?

7. What do you think is the best way to spread the word about participating in reforestation?
   En su opinion, cual sería la major manera de llevar al público en general sobre cómo participr en la reforestación?

APPENDIX C: Interview Questions for the Landowners

1. How did you hear about the opportunity to participate in this program?
   Cómo ud. oyó sobre la oportunidad para participar en este programa?

2. What information was given to you in regards to how to plant and care for the trees?
   Qué información le dieron a ud. sobre cómo sembrar y cuidar los árboles?

3. Why did you volunteer for the reforestation program?
   Por qué ud. participó en este programa de reforestación?

4. What condition were the trees in when you received them?
   Usted recibió los arboles en buen estado?

5. What care did you give the trees after they were planted (water, fertilizer, mulch, pesticide)?
   Qué mantenimiento les dio a los árboles despues de sembrado?

6. Did any DNER employees help you plant and maintain the trees?
   Le ayudaron las personas de Recursos Naturales a ud. para sembrar y mantenimiento de los árboles?

   How did neighbors, family or other people help you?
   Como vecinos, familía o otras personas le ayudaron?

7. Was there anything the DNER could have done to make this program more helpful and beneficial to you?
   Qué otras cosas ustedes pudieron hacer para mejorar este programa de reforestación de Recursos Naturales?

8. Would you recommend other landowners to take part in a reforestation program? Why?
   Ud. recomendaría a otras personas a participar en este programa reforestación? Por qué?

9. What do you think is the best way to spread the word about participating in reforestation?
   Qué ud. creé cual sería la mejor manera de promover este programa?

APPENDIX D: Field Work Tree Health Assessment Form

Date: Location:

	SPECIES	DATE OF PLANTING	HEIGHT	HEALTH (0-3)*	COMMENTS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					

* 3 = Good, 2 = Fair, 1 = Poor, 0 = Dead

	SPECIES	DATE OF PLANTING	HEIGHT	HEALTH (0-3)*	COMMENTS
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					

* 3 = Good, 2 = Fair, 1 = Poor, 0 = Dead

	SPECIES	DATE OF PLANTING	HEIGHT	HEALTH (0-3)*	COMMENTS
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					

* 3 = Good, 2 = Fair, 1 = Poor, 0 = Dead