CULTURAL ASSESSMENT OF REFORESTATION PRACTICES IN RURAL EASTERN PARAGUAY

By

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The thesis: “Cultural Assessment of Reforestation Practices in Rural Eastern Paraguay” is hereby approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE IN FORESTRY.

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PREFACE

As an undergraduate student, I studied art, focusing on the relationship of art with people and the natural environment. During this time, I decided that I wanted to learn more about people and their natural environments through hands-on work. I determined that Peace Corps was the best option, but I lacked the strong science background needed to work in Peace Corp's environmental sector. Through a campus visit by Blair Orr, I learned about the Master's International Program in Forestry at Michigan Technological University, which combines the study of forestry with Peace Corps service. I served as an agroforestry extensionist from 1998-2000 working in Paraguay, South America. After learning about the people and the culture, I developed a study looking at people and their interaction with their natural environment.

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ACKNOWLEDGEMENTS

I would especially like to thank my advisor, Blair Orr for his continual support over the last five years, both here and overseas. Additionally, I am grateful for him sharing all he knows about working in the developing world. His commitment to the Master's International program and his many students spread throughout the world is an inspiration to me. Additionally, I would like to thank the additional members of my committee, Margaret Gale, James Pickens, and Josiah Heyman for their suggestions and support during the time I have spent as a student on campus and as a Peace Corps Volunteer.

I would also like to thank Diego Hay, APO and Melissa McDonald, APCD of Peace Corps Paraguay for their encouragement and support in Paraguay. I am appreciative of the input and advice from the Peace Corps Volunteers of A-30 and Paraguayan farm families. Without them, this study would not have been possible. Nande valé!

A special thanks goes out to Mary Ann Beckwith, for teaching me all she knows about teaching and encouraging my creative side. Fly, be free!

I would also like to thank my family and friends for their continual support throughout this experience through letters, phone calls, and long journeys. Especially, I thank Matthew for his unending support and encouragement, every day.

Chapter 1 Introduction

After one year of working in Noviretá, Paraguay with farm families on reforestation and soil conservation projects, the focus of my work changed. I owe this partially to the experience of taking farmers from Noviretá on an excursion to a demonstration farm. This farm, SEPA, started by former Peace Corps Volunteers, is run entirely by skilled Paraguayan farmer extensionists, or *tecnicós* from communities similar to Noviretá. Rural communities in eastern Paraguay are faced with problems adapting to environmental problems associated with deforestation and population growth. The majority of rural Paraguayans are subsistence farmers whose traditional swidden-fallow methods of farming have been replaced, out of necessity, with intensive agricultural systems. Without any technical support from the government, small scale farmers are struggling to grow quality food crops on their severely degraded land.

At SEPA, farmers from Noviretá learned low risk, low cost methods of improving soil quality from fellow rural farmers. A portion of the excursion was devoted to the importance of reforestation and simple examples of established systems. The focus of this segment was a demonstration of transplanting tree seedlings, quickly, free, and with a minimal amount of work. The *tecnicó* dug natural regeneration from a nearby degraded forest, and with two cuts of his machete, leaving a stake, prepared it for transplanting. A few farmers from Noviretá had used natural regeneration in a similar manner when establishing agroforestry systems, and were nodding in agreement. Those participants, who had not yet utilized this resource because of fear, or lack of land, were interested in learning more about it.

During the first year I lived in Noviretá, I had attempted promoting tree nurseries, like most agroforestry extensionists. And, similarly to other development workers, I was unsuccessful. This encouraged me to examine the feasibility of tree nurseries and other options, if any, in reforestation projects.

In chapter 1 I will discuss the study area, Paraguay. First, I discuss the geography and brief political history, followed by the economic and environmental problems in Paraguay. Next, I continue with a discussion on Noviretá, the rural farm community that I lived and worked in for two years. Included are geographical, social, and environmental descriptions of the community as well as current agroforestry practices. Finally, I conclude with a discussion on reforestation programs in rural Paraguay, focusing on the establishment of tree nurseries. Together these topics form the background are needed to understand rural Paraguay and reforestation projects.

Chapter 3 includes the methods for the initial stages of the study. A brief discussion explaining participant observation is followed by the results gathered from the initial stages of the study. I continue to explain my findings and the importance of further studying tree nurseries, their success, and alternatives in reforestation projects in rural Paraguay.

After the initial general observations described in Chapter 3, I explore them further in Chapter 4. I begin by discussing unstructured interviews that were held in Noviretá and the data sheets used in collecting this information. Next, I discuss informal interviews conducted in other rural communities in Paraguay and descriptions of these study areas. Finally, a description of the survey involving Peace Corps volunteers working in the agroforestry extension program is presented.

Chapter 5 begins with the results of the resources and tree species used in specifically Noviretá and also in other rural Paraguayan communities. This is followed by a comparison between tree nurseries and natural regeneration use and practicalities. I conclude with examples of reforestation projects in other parts of the world that have utilized natural regeneration and also examples of reforestation projects that have failed, and why they have failed.

Case studies of three farm families and maps of their fields are found in Chapter 6. A discussion of their family resources and agroforestry systems they established using natural regeneration is included.

The conclusions and recommendations for this study are discussed in Chapter 7. Recommendations for future Peace Corps agroforestry extensionist training are discussed. Also included is a guide for working with specific tree species, in the form of natural regeneration, in rural Paraguay. The appendix with statistical results follows this.

My objectives for this study are to examine reforestation projects in rural eastern Paraguay, especially promoted by Peace Corps agroforesty extensionists. Through studying the reforestation practices of Paraguayans I hope to gain an understanding of how we, as extensionists, can improve our methods of working.

Chapter 2 Background

General Description of Paraguay

The Republic of Paraguay is located in the heart of South America, bordering Bolivia and Brazil to the North and Argentina to the South centered at the coordinates 58 degrees west longitude and 22 degrees south latitude (CIA, 2000) (Figures 1 and 2). The country area totals 406,750 sq. km, roughly the size of California (Harcourt, 1996). In July 2000, total population was estimated to be 5,600,000 (CIA, 2000). Ninety-eight percent of the population lives in the eastern half of the country with a population density of 18.6/ km^2 compared with 0.2 people/ km^2 in the Western half (Glastra, 1999). Approximately 20 indigenous communities still exist throughout Paraguay, making up only 1% of the population (Harcourt, 1996).

In the sixteenth century, colonists from Europe explored central South America, bringing language, markets, and disease. The Spanish remained in control until Paraguay won its independence in 1811. General Alfredo Stroessner overthrew President Federico Chavez in 1954 and began a military dictatorship that relied heavily on massive repression and coercion (Abente, 1989). Under Stroessner, any attempt to organize outside of the Colorado party, peasant unions, or under the Catholic church was treated as armed Communist insurrection with the full weight of the army unleashed against its members (Reed, 1995;65). After 35 years, a military coup overthrew Stroessner in February of 1989, ending the longest dictatorship in the 20^{th} century Latin America (Dibble, 1992). Currently, President Luis Gonzalez Macci leads the Constitutional Republic.

Figure 1: Latin America map
http://www.latinsynergy.org/latinmap.htm

Figure 2: Paraguay map
http://www.latinsynergy.org/paraguaymap.htm

Many people are becoming frustrated by the plummeting economic situation and corruption within the government. "Only a dozen years after democracy arrived, political disillusion in Paraguay is widespread" (The Economist, 2001). People are overwhelmed by feelings of helplessness and pessimism in rural communities. Historically, the Paraguayan peasantry has been powerless, and manipulated by political parties (Bray, 1991; 127). The Colorado Party has dominated the political arena and lost its first election in the 2000 Vice-Presidential election.

Guarani and Spanish are the two official languages of Paraguay. It is the only country in South America recognizing an indigenous language as an official language. Guarani was originally spoken by the Guarani Indians, but is now used by almost everyone inhabiting Paraguay. Spanish is the primary written language and is used in

business and urban areas. Historically, Guarani was an unwritten language until the 20th Century when Jesuit Missionaries translated the Bible into Guarani. As a result, in rural Paraguay, most information is communicated orally, through radio and TV. The public schools teach in both languages; Guarani only recently has been integrated into textbooks.

The economy of Paraguay has been described as a "classic dependency" (White as cited in Reed, 1995; 32). Throughout history, the sale of raw materials has been the primary means of acquiring hard currency and materials from the world market. The majority of these materials were taken from Paraguay's forests. In the 1970s an Agriculture boom shifted exports to agriculture products such as soybeans and cotton (Abente, 1989). Currently, 98% of exports are agricultural (Reed, 1995; 197).

In 1999, the average per capita income was $3, 650 in Paraguay (CIA, 2000), and it is estimated that only 17% of the population earns at least the minimum wage (Abente, 1989). The majority of families are subsistence farmers, farming enough land to support their food needs. Additionally, many plant cash crops, such as cotton or tobacco, for hard currency (Figure 3). Unfortunately, after pesticide and labor fees are subtracted, most families receive little payment and are forced to return to the traditional system of trading agricultural products for material goods. In 1981, the agricultural census determined that 92.1% of cotton farmers owned less than 50 hectares and 48.8 % owned less than 10 hectares (Campos cited in Bray, 1991).

The Rio Paraguay flows southward from the Pantanal region of Brazil, dividing Paraguay into two distinct ecological regions (Figure 2). The western region makes up

Figure 3: Cotton harvest

61% of the country's landmass. It is part of the Chaco desert, an alluvial, flat plain with hot Andean winds, strong southern rains, and savanna and xerophytic vegetation (Harcourt, 1996). Although the Chaco contains more land area than the east, it is inhabited by a smaller percentage of the population. Most Paraguayans reside in the eastern region with low, rolling hills, subtropical climate, and semi deciduous forest, which is more suitable for farming. Eastern Paraguay is drained by dendritic water systems that flow off the Parana Plateau and into the Paraguay or Parana rivers. The subtropical climate of the east can reach average daily highs of 30 degrees C in the summer and average daily lows of 16 degrees C in the winter, with an average rainfall of 1500-1700 mm each year (Reed, 1995; 9).

Foreigners own a large portion of arable land. This is a result of land enactments in 1883 and 1885 know as the Laws of Sale of Public Land. These laws evicted poor peasants who occupied land and put it into private hands. By the end of the 1950's, 1549

landowners controlled 85% of the land (Abente, 1989). The majority of large-scale landholders are foreigners from Germany, Brazil, and Japan. Their land is used primarily for cattle ranching or mechanized farming. Mennonites have established many colonies, migrating from Germany, Canada, and the US. They are well known for their large-scale farms that supply most of the country's dairy products and grains. Internal migration increased in the mid-1960s when the Paraguayan government launched a road-building and colonization campaign to the east as a way of alleviating population and land pressure in the central department of Asuncion (Bray, 1991).

The deforestation rate in Paraguay is astounding, the highest in South America. In 1945, Paraguay contained 6.8 million hectares of forested land and in 1985 only 3.5 million hectares remained (Reed, 1995). Currently it is estimated that 6% of the original forest cover remains in eastern Paraguay (ABC Color 1/25/00). The main source of deforestation is illegal logging and land clearing for agriculture and ranching. Large-scale landowners have even cut their own land to keep out peasants and illegal loggers. Most illegally harvested logs are exported to Brazil or other industrialized nations.

Deforestation is especially damaging to tropical soils. Nutrients quickly disappear through leaching and erosion after the protective canopy and the delicate forest ecosystem are removed. In an effort to reduce logging many laws have been passed. In fact, Paraguay has some of the strongest environmental laws in the world, including the Forest Law of 1973, which provides strong protection for forested land. But as stated by Glastra (1999), "Paraguay has had little political will to uphold this law." Only 13,954 km^2 of land are protected, with most of the remaining forest in private hands, unprotected by conservation efforts (Harcourt, 1996).

Deforestation within established rural communities is a direct result of the lack of technical assistance for small farmers. Unable to use the traditional method of farming, swidden-fallow, farmers are forced to intensely farm their fields until the soil can no longer support food crops. Left without any alternatives, the farmers are forced to cut the forest, creating new fields to support their families. The main cash crop of Paraguay, cotton, quickly depletes the soil of its nutrients, making the land unusable without implementing soil conservation practices (Figure 4). For example, after cultivating tobacco for one year and cotton for three years, the soil requires a fallow of ten to fifteen years to recuperate (Kammesheidt, 1998). Traditionally, land was farmed in a swidden-fallow system, leaving an area of land fallow to replenish its nutrients. Population pressure and land scarcity has forced farmers to rework the same fields. Many turn forest into fields in search of fertile soil, but, without integrating soil conservation practices, the cycle of soil destruction continues.

Figure 4: Soil erosion in a field in Paraguay

Unfortunately, the government does not have the resources to send technical experts to rural communities. The Ministry of Agriculture focuses on large-scale cotton production and expensive farming practices such as spraying herbicides. Little work has been done with small-scale farmers in the area of reforestation. Law 294 was passed to encourage reforestation projects and was funded through outside assistance. It compensates landowners who plant tree plantations. Some large-scale landowners have profited from Law 294, receiving exorbitant payments and additional funds to maintain the system. Unfairly, Law 294 was not designed for the small landowner. It contains unreasonable requirements, such as the understanding of complex technical information, an environmental impact analysis, required visits by Ministry extensionists, and the mandatory purchase of project-approved seedlings. Many small landowners attempted reforestation projects, only to become frustrated, and in some instances, lose their land to debt acquired from purchasing tree seedlings. Farmers' organizations have staged forceful demonstrations against the government for the biased treatment of peasants, with few results.

Many organizations from within and outside of Paraguay have developed programs to slow down and possibly reverse the rate of deforestation. A natural reserve, Mbaracayu, located on the eastern border with Brazil, was established with help from the Nature Conservancy. The Moises Bertoni Institute, a Paraguayan NGO (Non-governmental Organization) focuses on community based environmental education in conjunction with the reserve. Additionally, the World Wildlife Foundation has set up an office in Asuncion to work on projects protecting the Atlantic forest, a diverse forest on the eastern border of Paraguay. Grass-root efforts, such as Peace Corps, train and send

environmental education, agriculture, and agroforestry extentionists to work with farm families in rural areas. I was sent as an agroforestry extentionist to work with a farmers' group interested in reforestation in the rural community of Noviretá, San Pedro.

Noviretá

Noviretá is located in the District of San Istanislau, Department of San Pedro in the eastern half of Paraguay (Figure 5). The nearest town, Santani (San Istanislau) lies 23 kilometers south. Route 2, the main road to the Rio Paraguay port city of Puerto Rosario passes through the community. San Pedro was the second Department to be established in the Republic of Paraguay. Noviretá was founded December 27, in approximately 1890. The community celebrates Founder's Day with a parade in honor of the patron saint, a tradition in Paraguay.

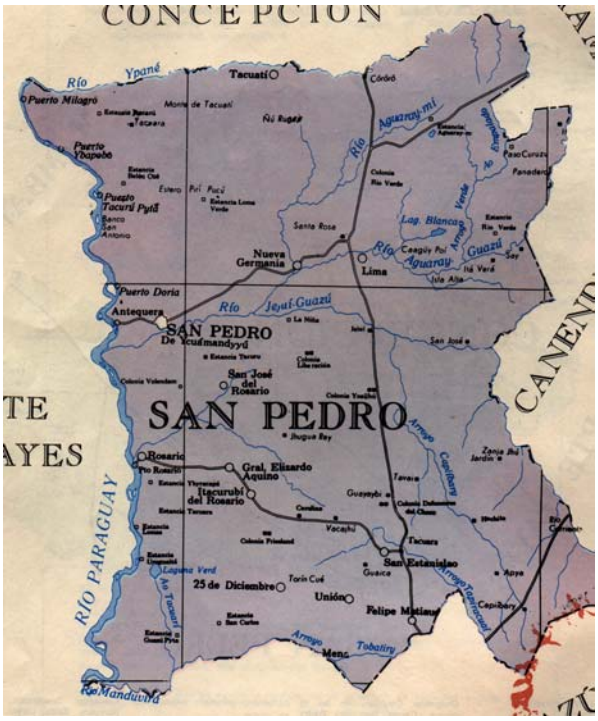

Figure 5: The department of San Pedro map
Atlas del Paraguay, 1989

Most members of the community are descendants of the founders of the area, but a few families have immigrated from crowded areas of Paraguay and Brazil. Noviretá is divided into three separate "barrios," San Blas, San Juan, and Central. Each section has its own school, church, and community organization. San Juan is located on the main dirt road with access to busses into Santani, Asuncion, and Porto Rosario. Central is accessible by a smooth dirt road off from Route 2. San Blas is isolated 2 K off the main road and following the rain, only accessible by horse or foot. Approximately 100 families live in Noviretá with 25 families living near the road in San Juan.

The landscape is generally flat with rolling hills, causing few erosion problems in the fields (Figure 6). Noviretá lies in the Rio Paraguay watershed and a five-hectare wetland area separates San Blas and San Juan. The soil is presently classified as several thermic families within the Utisols (Buol, 1997; 355). It contains 70-80% sand and is quickly degraded with deforestation or intensive farming, without soil conservation practices. Very few farmers leave any ground cover or shade near their crops during the growing season. Nutrients in unprotected soil are quickly washed away with rain or heavy wind. "Whereas swidden agriculture relies on forest nutrients for fertility, intensive agriculture relies on nutrients stored in the soils themselves or on those provided by additives and correctives" (Stewart, 1994). Therefore, when the forest biomass is removed, the soil fertility quickly diminishes until it can no longer support basic food crops. Acidic sandy loams are more extensively leached when exposed than under forest cover (Evans, 1994).

Figure 6: Noviretá, Paraguay

Noviretá does not have communal running water. Families have wells with a manual crank to draw the water. A few wealthier families use a motorized pump and tank with a gravity fed hose and faucet. Wells in Noviretá are hand-dug and deep, averaging 40 meters. Electricity came to the community in 1987, and is used by most households.

Almost all families in the area are subsistence farmers, growing enough food to survive the fallow season. Standard food crops include maize (*Zea mays*), manioc (*Manihot* sp.), beans (*Phaseolus vulgaris*), groundnuts (*Arachis hypogea*), pineapple (*Ananas* sp.), and bananas (*Musa* sp.). It rarely frosts in the winter months of June and July, making the area ideal for growing bananas and pineapple. In addition, some

families grow cash crops as a means of earning currency. Cotton and tobacco are the most common cash crops, followed by pineapple, sesame, and *esencia*.

Esencia is a citrus oil extracted from the leaves and green branches of sour orange trees (*Citrus vulgaris*). A still (*pipón*) made from a steel drum is packed with fresh leaves and water, heated with a wood fire, and the distillates are drawn off and cooled in a tube submerged in water (Reed, 1995; 145). The process uses a significant amount of the forest resources; processing the oil burns one wagonload (approximately 3 cords) of wood per hectare of orange trees.

Cotton farmers receive credit for cotton seeds (in some years they receive them for free) and pesticides at the beginning of the season. Most of this money is usually used immediately to buy necessities, like food or school uniforms. Unfortunately, the boll weevil is an aggressive pest in Paraguay and pesticides are the most efficient method of saving the cotton crops. Constant application using a backpack sprayer is necessary once the cotton has fruited, incurring high costs and creating many health problems due to misuse. Many farmers can not read the pesticide labels, which can be written in Spanish, Portuguese, or English. The Ministry of Agriculture is experimenting with an alternative to directly sprayed pesticides, but is still in development stages. During the harvest period, men, women, and children spend all day hand picking the fiber. Labor fees can be expensive if the threat of rain exists during the harvest period because rain can ruin the cotton's quality. The price of cotton is low (the equivalent of $0.30 per kilo) and has remained the same for the last few years. After the harvest and paying off debts, pesticide costs, and labor fees, the farmers are left with a nominal amount. Many farmers are frustrated with this system, but feel there is no alternative for earning currency.

During the time I spent in Novireta, many farmers experimented with other cash crops, only to return to cotton the next year.

Other means of income include making charcoal and bricks for construction, both substantial consumers of wood. The clay bricks are baked in a wood-burning oven, and charcoal is a product of slowly burning high-density wood, such as kurupa'y ra (*Parapiptadenia rigida*). Women sometimes earn extra income by washing clothes, making and selling clothes, cow's milk, cheese, manioc flour, or gathering medicinal plants. It is common for young adults in the community to join distant relatives in Argentina, working as domestic employees or in factories, sending their money home to support their family. It is estimated that one million Paraguayans work in neighboring Argentina.

Many families participate in a "*minga*" system, a traditional system of working together as a community, rotating their work time within the groups' homes and fields. In Noviretá, most men were descendants or married into one of two main families. It is common for a father to give his sons sections of his land when they marry. The fields are then in close proximity to one another, making it easy for the farmers to divide their time between fields and go home for lunch and siesta. They work together to prepare the soil, usually battling thick weeds that have grown during the fallow months of June through August, using hand tools such as machetes and hoes. If the resources are available, they are assisted by a horse-drawn plow. Generally one member of an extended family owns a horse or ox and a plow, which is then rotated through the members' fields. Another method of controlling winter growth, which is less labor intensive, is burning. Burning causes the release of carbon, nitrogen, and sulfur locked up in organic matter and top

nutrients to turn to ash and blow away. Fields are usually turned to pasture once the burned forest nutrients are exhausted (Stewart, 1994). Nutrients could be available to crop roots, through leaching, but the effect of fire on land clearing is a gradual loss of nutrients from the environment (Osemeobo, 1989). Additionally, fires often get out of control, burning sections of woodlots or neighboring fields. Working together, in a *minga*, is especially beneficial during the labor-intensive initial months of crop growth when the farmers hoe weeds. They also work together, sometimes with children, to thin the cotton crops by hand, picking excess plants. Soil conservation and agroforestry techniques can reduce the workload significantly by using such principles as mulching, ground cover, and shading to out compete the weeds.

Agroforestry, the practice of cultivating trees within a farming system, can greatly improve the soil quality. Many native Paraguayan tree species fix nitrogen, making it available to the crops through the decomposition of leaves (Peace Corps, Paraguay, 1997). Additionally, trees play a key role in the nutrient cycle, improving soil fertility. "Tree cover also helps to reduce soil temperature, which decreases evapotranspiration, making more water available for crops" (Bunderson, 1995).

The *minga* system is still practiced in the Noviretá area, unlike other areas of Paraguay. Probably, the older age of the community and shared family roots play a role in its success. In newer settlements, there is less trust and communication between families. This method of working is useful when new farming practices are introduced. The field becomes a model that the *minga* members observe from a distance, with the opportunity to learn by observing and participating in the work. Participatory learning works exceptionally well when the benefits of a new soil conservation practice, such as

planting cover crops or integrating nitrogen-fixing tree species, take a minimum of one crop season to see. A farmer is more likely to adopt a successful farming method if his neighbor has had good results. In subsistence farming systems, the willingness to try new ideas is risky because the livelihood of an entire family for one to two years is at stake (Beets, 1990). When a new method of farming is successful, the experimenting farmer can be empowered to share his experience with the members of the *minga* facilitating an exchange of ideas. This is sometimes referred to as farmer-to-farmer extension methodology.

Farmer-to-farmer extension methodology includes the development and sharing of knowledge among communities, with farmer promoters playing a key role in the process (Selener, 1997). Farmer promoters are usually people with little or no formal education, but through experimentation, practice, and observation become empowered to work as extension agents.

The forests in Noviretá are quickly disappearing. Patches of degraded forest 20 to 30 hectares in size still remain, but most families only have a small woodlot for firewood. The women complain that they now have to walk one kilometer to gather firewood, whereas just five years ago they went as far as their backyard. All families in the community use wood as a primary fuel for cooking and most construction is still done with wood. A few farmers have seen the need for reforestation and have started reforestation projects by creating agroforestry systems. Agroforestry is the integration of trees into farming systems. Other families have felt the need, but do not believe they have the land space to sacrifice for trees, and are hesitant to alter traditional farming methods and experiment with agroforestry. Unfortunately, there are many people who

are ignoring the signs of deforestation and do not want to plan ahead for the future. Women are cooking less nutritious food, such as corn bread, due to the growing scarcity of firewood. Traditionally, corn bread (*sopa* or *chipa guasu*) is cooked in a brick oven (*tatakua*), which requires a large amount of firewood. Despite these alterations, they do not want to admit that their lifestyles are changing. For example, one farmer in Noviretá planted trees in preparation for future fuel needs to harvest *esencia*, his main source of income. His cousin questioned the work, "Why would you plant trees? There is plenty of wood in the forest. It is a waste of your time."

In 1998, a group of 12 farm families in Noviretá San Blas and San Juan formed a reforestation committee in response to Law 294. Law 294 promised to pay Paraguayan farmers who planted trees as an incentive to reforest. All of the members owned a minimum of 10 hectares and had access to a patch of forest. They invited nearby Peace Corps Volunteer Brad Harrison to do a talk on transplanting natural regeneration. No one mentioned procuring nursery seedlings. Brad Harrison did a demonstration of cutting natural regeneration and explained the best weather conditions for planting. Six families started reforestation projects, using a variety of techniques, species, and land size.

Reforestation Programs and Rural Paraguay

A significant portion of Peace Corps technical training was dedicated to developing tree nurseries, both familial and communal. We even built a practice nursery with exotic and native species. A strong emphasis was placed on citrus grafting, which provides better quality fruit in a short time. In truth, many farmers did express interest in citrus grafting when Peace Corps did initial community analysis in potential Peace Corps sites. But, growing the rootstock for grafting is a technical, serious venture that many

farmers are not inclined to undertake. It takes two to three years to produce a grafted citrus tree from a lemon seed.

Only once during training was using natural regeneration as source of tree seedlings practiced. For demonstration purposes, however, we used containerized seedlings for the actual planting segment of the discussion. Emphasis during agroforestry training was on nursery establishment and teaching Paraguayans the technical fundamentals of nurseries.

Traditionally, in rural development reforestation programs the focus has been creating small community tree nurseries. The goal is to produce high volumes of seedlings to out-plant in plantations, creating future woodlots. Using this method of reforestation, a farmer can prepare the area to be planted ahead of time, waiting until optimal weather for transplanting the nursery stock. The seedlings can be transported to the field and the farmer can choose the layout of the species. Working together as a community on a project, such as creating a tree nursery, can be an empowering experience, if it is successful.

Nursery Planning

For a tree nursery to be successful, careful planning and evaluation must take place before the ground is broken. Logistics such as site location, space, seedling species, care taking responsibilities, protection, ownership, and future planting need to be determined. Most importantly, a reliable water source must be available year round. If the nursery is large-scale and managed by a group of people, responsibilities, material contribution, and regular meetings need to be firmly decided in advance. The next step is to decide between a bare root and a containerized nursery. Containers prevent the roots

from becoming intertwined, and are necessary if the seedlings will be out of the ground for a significant time between the nursery and planting. If the seedlings need to travel, the planting site should have a temporary nursery and water to keep the trees healthy until planting time (Weber, 1986).

Nursery Establishment

A tree nursery requires a significant amount of material input in the establishment phase and a continuing amount to keep the nursery functioning. Start up materials for preparing the seedbeds and nursery site include hoes, machetes, fencing material, and a water source. Fencing is necessary to protect the seedlings from theft or damage by people, animals, and weather. Seeds need to be collected from a good source, and treated for planting, if necessary. Some popular reforestation species, such as *Leucaena leucocephela*, require inoculation with rhizobia to enable the plants to fix air nitrogen with their roots (Bunderson, 1995). Fertile soil with a balance of nutrient content and drainage is important if you want to produce quality seedlings. Also, inoculation of the soil with mycorrhizal fungi is necessary for non-native pine species (Davey, 1984). These items are not readily available in rural Paraguay, and transportation of the rhizobia, which needs to stay cold, can be difficult. In fact, during my service I brought rhizobia in a cooler from the capital city on a bus. The farmers in Noviretá, looked at it with disbelief, and used it without understanding the purpose. Materials for a shade structure can include natural items such as bamboo and palm leaves, or commercial shade cloth. Either chemical or natural fungicides and pesticides are necessary. Leaf cutter ants can destroy a nursery, of any size, overnight. Proper chemicals are expensive and not readily available in rural areas.

In a containerized nursery, items such as bamboo, plastic bags, banana leaves, or professional black seedling bags can be used to hold the seedlings. In 2000, in the capital city, fifteen average sized professional seedling bags cost $0.30, the equivalent of two eggs in Noviretá. Neither the nearest town, Santani, or most rural towns sell these bags. Containers should be small enough to easily transport but large enough to allow proper root growth. Another option for containerized nurseries is to plant seeds in a seedbed and transfer them to containers when they become crowded. Nevertheless, containers will need to be procured.

Labor, both skilled and unskilled is another important ingredient in building and maintaining a nursery. Chemical products should only be handled and applied by someone that can read the labels and properly use them. Misuse of pesticides is a common cause of death in rural Paraguay. Also, knowledge of seed treatments and spacing for a range of species will influence successful germination. For example, a reforestation project in Guyabi, Paraguay, explored the direct sowing of tree seeds between crops. The project failed because it "proved too complex for the farmers; the seeds required treatment" (Evans, 1994). Building a nursery also involves work such as soil sterilization, fertilization, bed shaping, seeding, planting, mulching, and irrigation.

Running a Nursery

Once the nursery is established, more materials are necessary. This includes containers to hold mature seedlings, a reliable water source, pesticides, fungicides, and replacement shade and fence structure. In case of disease, funds should be set aside to purchase the necessary items.

Work responsibilities include irrigation, fertilization, weed and pest control, disease management, and root and top pruning. Continual maintenance on the shade structure and fencing is also important. Again, the work crew should include someone skilled in working with pesticides, herbicides, fungicides, and diseases. When the seedlings reach maturity, they need to be moved from the crowded seedbed to containers, or a larger seedbed. Additional work for containerized nurseries involves the preparation of rooting medium, container filling, seedling transplanting, and shading (Davey, 1984).

Out-planting Mature Seedlings

Mature seedlings should be planted during optimal planting season and before the roots push out of the containers. Root pruning temporarily prevents seedlings from establishing themselves in the nursery. Every professional nursery I visited in Paraguay had a patch of overgrown young trees whose roots had torn through the plastic bags into the soil beneath. Before transplanting, time between watering should increase, hardening off the trees.

If the goal is to move a large amount of seedlings, transportation should be procured. Lack of transportation has been the downfall of many reforestation efforts world wide. In an afforestation program in Tanzania, the nurseries were full of seedlings, but they lacked vehicles to deliver them (Skutsch, 1985). Moving seedlings in direct sunlight long distances can dry out and kill them. An ideal vehicle would be a pickup truck with a shade structure (Figure 7). In rural Paraguay, the most common means of transporting such objects include a horse or ox-drawn cart. Not all families can afford this luxury and even fewer own automobiles.

Figure 7: Vehicle transporting plants in Paraguay

In conclusion, to build and maintain a successful tree nursery, many inputs are necessary. For a small rural community, they are an expensive, technical, and risky commitment. Careful planning and organization at every phase is crucial. Most reforestation development projects start with building and working with tree nurseries. It is used to demonstrate to people how to work together in a group towards a common goal. As a development worker working with a community that had expressed a desire to start a reforestation project, I assumed that building a tree nursery would be the logical first step. I was quickly confused when that did not turn out to be true. I determined through my observations that nurseries were not working, so I developed a new approach to working – natural regeneration.

Chapter 3 Methods and Results from Initial Stages: Participant Observation

On the second day of my initial visit to Noviretá, the father of the family I was staying with led me to a field behind his home. Filled with excitement and pride he demonstrated a hectare planted with tree seedlings and maize. Feeding off of my enthusiasm, he proceeded to identify every seedling, educating me of their potential uses. He knew that I was still learning the many native tree species of Paraguay and wanted to share his knowledge. Throughout our walk through the rows of trees, he told me the land's history. His wife is the great granddaughter of one of the original families in the area. In the tradition of rural Paraguay, the land had been divided through generations and she and her husband were permitted to use the ten-hectare plot of land for living and farming. They also had access to the largest plot of forest left in the community, which was shared by her parents, eight siblings, and the families of her aunts and uncles.

The field we visited had been severely degraded after five years of intensive cotton farming. He decided to utilize the area and transplanted native tree seedlings from the bordering forest, in hopes of receiving payment from Law 294. A quarter of the trees had died due to poor transplanting procedure and many were in need of management. I made the assumption that he lacked the technical skills to successfully plant and manage the plantation, but was ready to learn. Judging by his eagerness to talk, it seemed that he did not have many people with which he could share ideas. I took the opportunity to ask him more about his plans for the trees, currently and in the future. Uncommon for the community, he was well educated and had traveled extensively throughout Paraguay, working. He had seen large-scale intensive farms which operate significantly differently

from small farms in Noviretá. Apart from the technological differences of the machinery, he observed their sustainable method of farming. He learned about the benefits of fertilizers and herbicides, both chemical and natural, and ground cover. Most importantly, he saw the way they planned for the future, thinking about fuel consumption and establishing tree plantations.

After he moved to Noviretá, he continued to farm the way he had learned as a child, but had greater visions in the back of his head. He had been given the opportunity to attend organic gardening training through a Swiss NGO, and had attended tree planting demonstrations given by a nearby Peace Corps agroforestry extentionist, Brad. So when he heard about Law 294, he organized a group of farmers and started the reforestation committee. I knew that Brad had discussed with them the possibility that they may never see the money, and encouraged them to focus on the future value of the trees. With this in mind, I asked him what he would do if Law 294 did not go through. He told me that he was planning on selling the mature trees to help pay for his two children's education. As we walked back to his home he expressed his gratitude towards Peace Corps for sending an extentionist to work with the community.

This early experience helped me understand what farmers do with what resources they have. I was impressed by the simple process of transplanting nearby seedlings to a field and the eagerness of this farmer to learn how to improve his skills and family's livelihood.

As I learned more about Noviretá, it became evident that I needed to develop a method to learn more about how farm families have been working with trees, and what technical skills they were lacking. During the initial stages of the project, I used

participant observation and informal interviews to collect information. Participant observation allows the researcher to become familiar with the study area and topic through living and participating in the people's daily lives. It involves joining a community, allowing "business to go on as usual when you show up" (Bernard, 1995). Most importantly, the researcher combines observation, discussion, and informal interviews, tapping a continuous flow of information (Nichols, 2000).

I lived in Noviretá from January of 1999 to December of 2000. During this time, I became a member of the community. In the beginning, I lived with a family until the members of the reforestation committee built my house (Figure 8). My daily ritual included drinking maté, a hot tea served in a communal manner, with the mother of the family next door where we were periodically joined by neighbors passing through to purchase basic food goods at her small store (Figure 9). I would eat at least one meal a day at their home and a few sessions of drinking tereré. Tereré is the cold water version of maté and is drank with refreshing medicinal plants. It was here that people began to get to know me, trust me, and befriend me. During the second year I was even left in charge of the store for a few hours while the family went to the health post in Santani. Their home was the community-gathering place, between women and children buying goods during the day and men drinking cane liquor and playing cards at night. The family was related in one way or another to most of the community and the father ran the local Catholic Church. I was the first Peace Corps volunteer to live in Noviretá, so I spent a lot of time answering questions and explaining the purpose of my work.

As I learned Guarani, I learned about life in the campo. During tereré sessions I heard the farmers talk about their fields, complain about low cotton prices, and debate the economic benefits and risks of new cash crops. While I cooked with the women, I

Figure 8: Members of the community building my house

Figure 9: Community Store

listened to them plan where to get the next load of firewood, which wood burned the hottest, and I learned how to fit in as a foreign woman in Latin America. The children taught me the names of the trees and what they saw as their uses. Every Sunday I attended the reforestation committee meetings and began to understand their goals, needs, and frustrations. Through these meetings I received invitations to have lunch and meet their families, which led to further plans of activities such as teaching bread making to the mothers, and eventually visits to the fields.

In Paraguay, women usually do not do more in the fields than harvest crops or spend private time with their husbands, so I had to spend time gaining the trust of the families in order to be invited to the fields. Women whose husbands work outside of the home had more responsibilities in the fields and working with them was a great way to familiarize myself with the agricultural system in Noviretá. The only female member of the reforestation committee quickly befriended me and proudly marched me out to see the five hectares of trees she and her family had planted. Through visiting and talking with her, I learned the history of the reforestation committee, how they were formed, and the opinions of the members after they did not receive any money from the government from Law 294. This information was crucial in assessing the committee's needs and knowledge. Due to gender differences in Paraguay, a male member would have not felt comfortable talking to me that soon after meeting me.

As I became a familiar face in the community, I was asked to visit more and more families. People became comfortable enough to ask me to work with them in their fields, gardens, and kitchens. At this point I could share my ideas about trees and agroforestry and the farmers could share their experiences, background, and ideas. I

realized that, although they may not have a planted woodlot, Paraguayan farmers know a lot about trees and the concept of agroforestry. In fact, many families already had forms of natural woodlots and agroforestry systems.

I shared with them the basics of my technical knowledge, in hopes of developing a forestry project with families in Noviretá. I based all of my technical and cultural knowledge of Paraguay on my experiences in Peace Corps training. As I learned more about the people of Noviretá, I realized that there were many differences between my perception in training and what I saw in Noviretá. I then decided that what I had learned or what was written in manuals might not apply to the people living in my community.

I had previously learned that farmers do not like planting trees in their fields because they fear change, lack the technical skills, or are opposed to new innovations. But in reality, it has been found that the adoption of new technology is largely dependent on the degree of risk in rural populations (Biggs as quoted in Evans, 1994). So, I decided to look at "old" technology, and I began observing the ways trees are used in Novireta. I noticed that people transplanted tree seedlings to their patio area for shade or fruit, some left trees standing when they cleared their fields for spring planting, and, in the case of the six families in the reforestation committee, some transplanted natural regeneration from the forest into their field.

To get a better idea of the uses of natural regeneration in Noviretá, I held conversations with various farm families, talking with men and women separately. Women seem to be more aware of the home patio area, which they are responsible for cleaning. The patio area consists of the land surrounding the home, which usually has

shade trees, fruit trees, and various plants. Paraguayan women sweep the dirt surrounding the home for both presentation and the practical purpose of controlling ant invasion. Men are responsible for the field portion of the homestead.

During the first year of the reforestation committee meetings, I mentioned a tree nursery as a potential group project. The members looked at me, matter-of-factly stated that we had plenty of seedlings in the forest, and quickly changed the subject. No one was interested in planting exotic species, which could have only been achieved in a nursery. I continued to talk with members of the community about nurseries and starting citrus grafting rootstock. Many claimed to be interested but nothing beyond conversation was realized.

During the first year, I worked with the local school to set up a seedbed for rootstock in the school garden. Each child brought seeds of the common lemon, we dug a deep seedbed, applied fungicide, and they agreed to water the seedbed every day, except weekends. They determined that a shade structure was not necessary because of the hardiness of lemon. A few weeks later the school well dried up because of a drought period, which lasted for nearly a year. The children had to bring water from home to drink with and watering the seedbed became a low priority. As a result, the nursery failed, and the rootstock was never produced.

While observing the community and reforestation committee, I noticed that people were using trees, but not tree nurseries. I concluded that I needed to research further and came up with the question: In rural Paraguay, is developing tree nurseries a successful method for producing tree seedlings and promoting agroforestry?

Chapter 4 Further Exploration

This section describes further research, studying why people I observed used trees but not tree nurseries. I devised a plan to answer the question: In rural Paraguay, is developing tree nurseries a successful method for producing tree seedlings and promoting agroforestry, or is there a better method? First, I conducted unstructured interviews with members of the community of Noviretá who had transplanted trees. I noticed many similarities in their responses and decided to investigate whether or not this common way of thinking was universal in rural Paraguay. Second, I conducted informal interviews with farmers in other rural villages where an agroforestry extension Peace Corps volunteer lived. Next, I developed a survey for all agroforestry extension volunteers that had been living in their sites for at least one year. Agroforestry extension volunteers act as *técnicos* (technical people), which can provide a valuable perspective, through comparison with farmer and scientific knowledge (Boa *et. al*., 2001). Finally, I held formal interviews with the participants of the survey.

Unstructured interviews: Noviretá

Unstructured interviews were held with fourteen families in the community and reforestation committee with whom I had gained mutual respect. People in Noviretá are untrusting of strangers, believing them to be spies. This probably is a result of the Stroessner era when military spies watched and reported the people's every move, sometimes leading to a death to a family member. When an unfamiliar Peace Corps Volunteer came to my village to visit, my neighbors told him I was not home.

Meanwhile, their daughter came to tell me of his arrival and a brief character description. My friends in the community protected me like an extended family member.

Unstructured interviews are held with a specific plan, but are characterized by minimum of control of the informant's responses (Bernard, 1995). I began the interviews in June of 2000, after living in Noviretá for eighteen months. At this point I had held many informal interviews with them and had substantial records of their technical knowledge, work experiences, and attitudes. They trusted me and I felt confident that they would tell me accurate information. Unstructured interviews are usually held in a formal setting, but I conducted these interviews in various locations. They were held in fields, after meetings, while drinking maté around a fire or tereré on a porch. I wanted to be considerate of their work time and comfort. All interviews were held in Guarani, the language of rural Paraguay. From June until December, the data was supplemented after holding additional unstructured and informal interviews. A list of the information collected is shown in Table 1 and 2. Data sheet A (Table 1) contains general family information. Specific information regarding work with trees is collected in Data sheet B (Table 2). This non-random, purposive sample helped me to make informal judgments about what is "typical" in rural Paraguay (Nichols, 2000).

Informal Interviews: Rural Paraguay

The next phase of the research involved comparing the results from Noviretá with other rural communities. This was accomplished by visiting other communities working with Peace Corps volunteers. I chose one community with more accessible forest than

Table 1: Data Sheet A: General Family Information

Family: Date:	
Person interviewed:	
Number of hectares: Field: Home/Patio: Forest	
Location of land:	Access to forest:
Land owner:	Method of cooking:
Time living in the community:	Medicinal plant use?:
Family income source:	
Annual crops:	
Members of household & work:	
Hired help:	
Animals Cows Pigs Chickens Ducks Goats Sheep Horses Oxen	
Water source:	
Home garden? Winter Summer	
Work with Peace Corps volunteers	
Technical education (Peace Corps excursion, Dia de Campo, ect.)	
Experience with trees? If yes, complete Data Sheet B	

Table 2: Data Sheet B: Tree information

Family:		
Work with tree nurseries:		
Natural regeneration classification	YES	NO
Patio/ home area		
Left in working field		
Transplanted to field		
Transplanted to patio/home area		
Field left fallow		
For every yes, complete the following:		
Classification of natural regeneration:		
History:		
When established:		
Who initially decided to use natural regeneration?:		
Motivation:		
Technical background:		
Who did the work?:		
Time:	Sacrifices:	
Future vision:	Changes in vision:	
How:	Spacing:	
Species & placement:		
Maintenance:		
Established as a result of excursion, demonstration field, volunteer influence, etc.?:		

Noviretá and one with very little forest. This allowed me to study the feasibility of using natural regeneration as opposed to nursery seedlings as a main source of tree seedlings.

Other Study areas

La Morena

The community of La Morena (Figure 10) is located in the department of Canediyu, near the Paraguay – Brazilian border (Figure 2). La Morena has been established for eight years, and continues to expand. Population pressure forced families to migrate to the area, resulting in deforestation to create fields and a homestead. The community is very isolated and accessible by a rough dirt road, or the river Jejui; the nearest hospital and large town is approximately 60 Km away. A small store selling basic food goods, a local school, and a church are located in the center of the community. Neither running water nor electricity exists in La Morena.

Figure 10: La Morena

Dave Cobb is the first development worker and foreigner to live in La Morena. Large patches of original forest remain in the community, which borders on the buffer zone of the Mbaracayu Forest Reserve. The Mbaracayu Forest Reserve is managed by a Paraguayan NGO (non-governmental organization), the Moises Bertoni Institute. The Moises Bertoni Institute promotes tree nurseries in the areas surrounding the buffer zone, as an effort to reduce deforestation. Foreign organizations and governments have donated money to NGOs in hopes of reducing environmental problems in eastern rural Paraguay. La Morena received aid in the form of a modern tree nursery, equipped with a motorized running water system, and some technical support.

Natalio 25

Natalio 25 is located in the department of Itapua, near the border of Argentina (Figure 11). Natalio 25 is approximately 30 years old and has had a long history of development organizations working in the area. Alec Jarvis is the fifth Peace Corps volunteer to live in the community. Additionally, the World Bank, Helvetis (a Swiss development organization), and CERI have been involved with large-scale development projects in the area, all of which have failed.

The community has running water and electricity. A bus frequently makes trips from Natalio 25 to two nearby towns. Large scale farming by foreign landowners is prevalent in the community. As a result, few trees remain. Patches of severely degraded forest smaller than one hectare stand out in the horizon.

Figure 11: Natalió 25

Informal interviews

In both communities, I visited farm families who have worked a significant amount with trees. The volunteers living in the area had identified them as key informants and had been working with them for a year and a half. The families were already comfortable working with Peace Corps volunteers, so I was welcomed from the beginning. I felt that the best method for collecting data was informal interviewing. First, I was a stranger in the community, and did not feel that such a formal structure of interviewing was appropriate. Next, I was not as familiar with the communities as I was Noviretá, and wanted to learn from an observation standpoint. Finally, I wanted flexibility in what questions I asked, forming them around the situation.

I observed nurseries, both communal and private, established agroforestry systems, and woodlots. Discussions focused on tree nurseries, natural regeneration, and tree species. I asked some of the same questions I asked in Noviretá, expanding into more detail on the subject of tree nurseries.

Due to time restraints and practicality, I could not visit all agroforestry extension volunteers in their communities. I created a survey to gather more intensive information regarding the uses of trees, natural regeneration, and tree nurseries where they work. This would further allow me to research the role of tree nurseries and natural regeneration, if any, in reforestation projects and agroforestry systems.

Survey

I designed a survey applicable to all rural communities in the eastern regions of Paraguay. Peace Corps agroforestry volunteers are placed in different regions throughout the country in areas with diverse environmental situations (Personal communication, APCD Melissa McDonald). I wanted to know if the uses of natural regeneration and the interest in starting tree nurseries had a correlation with the amount of forest cover in the community.

The survey contained questions pertaining to general information about the community, previous development work in the community, local resources, natural regeneration uses and species, and tree nurseries. Questions are shown in Table 3 and Table 4.

Table 3: General Survey Questions

1. Age of community.
2. Brief description of community.
3. Are you the first Peace Corps volunteer? If not, how many have lived in the community before you?
4. Have there been any outside organizations working in your site? If yes, who and how long. Did they promote tree nurseries?
5. Closest town name. What is the distance and transportation available?
6. Closest DEAG office (The Ministry of Agriculture). What is the distance and transportation available?
7. Does the community have running water? How long?
8. Percentage of people with home gardens: Winter Summer
9. Forest within the community: High Medium Low None
10. Is there a forest reserve or National Park nearby?
11. Are there tree nurseries in your community?
    committee/organization community school
    personal (%) commercial
12. Can anyone use seedlings from these nurseries for free? Which ones?
    If not, what is the cost?
13. Closest publicly or privately run tree nursery.
14. General species list of seedlings in tree nurseries.
15. Have you, as a Peace Corps volunteer, promoted tree nurseries? With whom? What have been the results?
16. Any additional information.

Table 4: Detailed Natural Regeneration Information

NATURAL REGENERATION

	SPECIES (greatest to least used)	SPECIFIC USE
Left in the field		
Left in home area		
Transplanted to field		
Transplanted to home patio area		
Other		

Any additional information related to the use of natural regeneration, tree nurseries, etc. in your community.

I ran SAS correlation coefficients for six sets of correlation coefficients based upon the two surveys conducted. The Pearson correlation coefficient r is an unbiased estimate ranging from –1 to +1; r-squared can be interpreted as the proportion of variance in one of the variables that can be explained by variation in the other variable. A positive correlation means that as values of one variable increases, values of the other variable also tend to increase. A small or zero correlation tells us that the two variables are not closely related (Cody and Smith, 1997; Steel and Torrie, 1960). I chose a significance value of .10 in order to be at least 90% confident in the correlations. Due to the size of the study and the subject matter, a significance value of .10 was sufficient. Variables used in the correlation calculations are shown in Table 5. Results are shown in Appendix I and where appropriate are presented in Chapter 5, Results and Discussions.

Table 5: Variables Used in Correlation Calculations

Age of Community
Majority of land holders (1=Large, 0=Small)
Previous Peace Corps volunteers
Outside Organizations
Outside Organization promotion of nursery
Outside Organization; years in community
Distance to nearest town
Distance to nearest DEAG (Department of Agriculture)
Communal running water
Winter gardens
Summer gardens
High % forest cover
Medium % forest cover
Low % forest cover
No forest cover
National Park or Reserve in the area
Access to natural regeneration
Trees left in the field
Trees left in the home area
Trees transplanted to the field
Trees transplanted to the home
PCV promotion of tree nurseries
Success
Group nursery
Success
School nursery
Success
Personal nursery (% of community)
Public nursery

Chapter 5 Results and Discussions

Through interviewing, surveying and living in rural Paraguay I have assessed the question: Is developing tree nurseries a successful method for producing tree seedlings and promoting agroforestry, or is there a better method? First, I evaluated the resources of Noviretá and communities surveyed in rural Paraguay. Next, a report of the uses and production of preferred tree species was conducted to study what people are capable of doing with their resources. Following, as an extension of the report, natural regeneration and its role in agroforestry was studied. Lastly, an examination of unsuccessful reforestation projects and methodology was conducted as comparison.

I examined the decision making process of rural farmers, looking at their willingness and ability to try new things. "Within the environment the farmer is viewed as an active decision-maker with a limited freedom of choice, depending on available resources" (Van der Glas, 1996). If a farmer does not have the available resources necessary to try new farming practices, he can not take the risk.

When I brought new ideas to the community such as planting green manures with crops to improve soil quality, few farmers were willing to experiment. They feared that the crops would out-compete their food crops and would require too much extra time and work. Also, the concepts were new and they were unsure of the results; they did not want to jeopardize their family's stability. The most successful method of working with farmers was starting out small; planting one line of green manures within their food crops (Figure 12). This was low risk and free, with a minimal amount of work. We would

Figure 12: Green manure with food crops (small scale)

plant after the farmer cleaned the crop free of weeds, with me walking behind the farmer, planting seeds along the way. The first time I tried this method, I immediately understood the value of supporting people experimenting for the first time. He was "scared to plant the seeds wrong," potentially ruining his crops and becoming the laughing stock that believed the foreign (female) development worker. Once the farmer saw success, he was apt to plant half of a field the following year. Most likely, he will share his success with his neighbor. If a new idea or way of working is low risk, small scale, and requires little monetary or work input, farmers are much more willing to try it. Few people are willing to sacrifice the well being of their family for experimenting with an idea that may not be successful.

The process of working as a development worker involves assessing the needs of the community, learning about the available resources, and developing a project with farm families that will be sustainable. Peace Corps volunteers work with few or no monetary inputs. Since smallholder farmers have few external sources of income, their farming system has to be sustainable. Beets (1990: 16) defines sustainable development as follows:

> Development which meets the present needs of the farm family for food, fuel-wood, etc. without damaging the resource base, thereby compromising the ability of future generations to produce their needs on the same land, using the same resource base.

Families in Noviretá expressed the need to preserve the forests, and were worried about the environmental damage that has come as a result of deforestation. Animals such as monkeys were abundant, but are now rare. At the reforestation committee meetings, the members are always telling me how important the forest is. "*Inamportanteteriri*" (very, very, important). It provides them with medicinal plants, fuelwood, fruits, building material, and it protects them from wind and heat. They see the difference between the soil quality in their forests and their fields. Paraguayan farmers understand the nutrient cycle. For example, the word for tree, *yvyramata*, in Guarani means wood from the earth. The members of the committee care enough about reforestation to meet on a biweekly basis. Although they are frustrated about not receiving payment from Law 294, they continue to meet and talk about reforestation. The need to preserve the forest and to create reforestation projects was brought to my attention continuously.

Although the need was there, I felt that people needed assistance in determining a feasible, low-risk, low input system. Few people knew what to do. The traditional

swidden-fallow method was no longer feasible with increasing population, and less land was available to farm. Most families are not at a position to sacrifice the land that they intensely farmed for woodlots. Agroforestry is an efficient land-use system that is prevalent in traditional farming areas with increasing population pressure (Raintree, 1986). Landowners with vast amounts of forest and fields confirm Raintree's hypothesis. They have other options. One family has a fifteen-hectare forest with large standing trees, a stream, and a vast array of plants and animals. They have decided not to cut any trees from the forest and instead started woodlots and agroforestry systems for future wood needs.

Results of Informal Interviews, Resources: Noviretá

To determine the resources of the people in Noviretá, I studied the results of Data Sheet A: General Family Information (Table 6) and my personal observations. I focused on the most valuable resources of a small farm family - work inputs, materials, skills, and land area.

Work

Seventy-nine percent of the families receive their income from farming, supplementing it with outside work. Only twenty-one percent of the families did not depend on agriculture for income. A majority of all farm families' time is spent working in agriculture preparing fields, planting, weeding, and harvesting. Additionally, over half of the families had animals to care for, such as cows, pigs, chickens, and horses. Only fifty-seven percent had horses and none had oxen, which implies that many farmers do not use a plow in their fields, relying only on physical labor. Half of the families hire outside help to work in the fields, especially during the cotton harvest. Hired labor is not

Table 6: General Family Information (Results from Data Sheet A)

Resources	**Totals / 14 Families**	**Percentages**
Land: Total (hectares)	Avg.11	
Field (hectares)	Avg. 6	
Income: Agriculture/ Only source	11 / 1	79% / 7%
Other/ Only source	11 / 3	79% / 21%
Household members	Avg. 5	
Under 16 years old	Avg. 2.4	
Hired help	7 yes	50%
Animals Cows	7	50%
Pigs	8	57%
Chickens	13	93%
Ducks	4	29%
Goats	3	21%
Sheep	2	14%
Horses	8	57%
Ox	0	0%
Running water with a motorized pump	6	43%
Garden: Summer	2	14%
Winter	9	64%
Technical education	8	43%
Access to forest	14	100%
Method of cooking (F=Fire; G=Gas stove; B=Both)	F=9, G=0, B=5	F= 64%, G=0%, B=36%
Medicinal plant use	14	100%

common throughout the remainder of the year due to the cost. Most people work in a *minga* during intensive work seasons.

The average household has five members, with an average of two children under sixteen. Children go to school for only half of a day in order to help with the work at home. During cotton harvest it is common for children to miss school and work in the fields, earning valuable money for their family.

All families in Noviretá wash clothes by hand, an incredibly labor and time consuming practice. Sixty-four percent of families depend primarily on fuelwood for cooking, an additional thirty-six percent supplement fire with a gas oven; no one depends solely on gas. The mother of the family will rise as early as 5:30 AM to start the fire for the day. Evening time is dedicated to gathering wood for the following days. Fortunately, for now, everyone has access to degraded forest for wood. Few families own forested land and the degraded areas are becoming over harvested. Everyone depends on medicinal plants for their wellness. Plants are usually gathered by women throughout the day in the home patio area and by men in the fields. If plants from the forest are needed, the father or a woman and child will go to collect them.

Material Resources

Cows and pigs are valuable commodities in rural Paraguay. They act as stored wealth and can be sold at any time to pay for emergency expenses, such as prescription medicine for a sick family member. Cows can also produce milk, providing extra nutrients to the family as well as additional income if sold. However, these animals require a significant amount of food, water, and care. Other animals such as chickens and ducks provide eggs and meat throughout the year.

Forty-three percent of the families have a motorized pump, which provides running water for them and their animals. The electricity costs to keep them functioning are expensive so many families use water sparingly. Running water is a luxury that is enjoyed by the more financially secure members of the community. For everyone else, the traditional bucket and rope are the only means of gathering water.

Skills

Over half of the families have had some form of technical education in agriculture or forestry (57%). This includes a technical excursion to an experimental farm, a Peace Corps training event, or a demonstration put on in the community by progressive farmers. Only fourteen percent of the families have a summer garden, which requires copious amount of skills and resources. A shade structure, watering, and knowledge about pest management are necessary. A majority (64%) cared for a winter garden, which has fewer demands than a summer garden, but still requires work and skills to be successful.

Land

Families surveyed in Noviretá have an average of 11 hectares of land, and an average of 6 hectares of field space. The largest landowner has thirty hectares and the smallest owns two hectares. Some farmers with less land rent space from larger landowners. Currently, the average family owns a reasonable amount of land to eat well, if the soil quality is maintained, and they continue to have access to a forest. However, farmers in Noviretá are becoming concerned with the increasing degradation of their fields, especially since there is not any new land to move to. "Soil degradation damages the resource base of the farmers' households" (Van der Glas, 1996). The majority of people do not have other land.

Farm families living in Noviretá work hard to uphold their quality of life. Their systems are delicate and the smallest financial upset, such as a major illness, or a destructive crop pest, has the potential to destroy their livelihood. They struggle with a government system that does little to assist them in adapting to environmental and social changes, such as deforestation and population increase. Working with what small

resources they have, they do not have much flexibility, or extra time and money to spend outside of sustaining their livelihood. New ideas and projects cannot compromise their security.

Results from Informal Interviews and Survey, Resources: Rural Paraguay

After determining the available resources in Noviretá, I evaluated the resources in areas of rural eastern Paraguay for comparison. I expanded the resources to include any technical agriculture and forestry assistance from the government or other organizations. Results are found in Table 7.

None of the surveyed communities have community running water, a basic resource. Acquiring communal running water is an expensive process that involves a significant level of community participation and years of working with the bureaucratic Department of Health. Winter gardens are more common than summer gardens, most likely due to the work input of summer gardens. Maria Auxiliadora has a low number of winter gardens. This community is located next to an international highway that brings fruits and vegetables from Brazil. They have vegetables readily accessible and may choose not to spend time and energy on gardening. Despite a range of forest cover, most communities still have access to natural regeneration. Sources range from untouched parks and buffer zones of forest reserves to degraded forests within the community.

Table 7: Resources, Rural Paraguay

PC Volunteer/ Community	Age of Comm. (years)	Maj. of land holders	No. of PCVs	Outside Organizations			Distance (Km) to		Running Water (Comm.)	Families with gardens (%)		Amount of forest cover in community				National Park or Reserve	Access to natural regen.
					Nursery Work	Years	Town	DEAG		Winter	Summer	High	Med.	Low	None		
Alec / Natalio 25	25	Large	4	Helvetas, World Bank, CERI	Yes	10+	15	11	No	85	40			X	X	No	No
Andrea/ Misiones'I	27	Large	0	CECTEC (Occ.)	No	5	50	50	No	80	15			X		Yes	Yes
Aaron / Pereira Cue	130	Small	1	Plan Int./ Co-op	No	5 / 4 mo.	30	30	No	80	10			X		Yes	Yes
Holly / Kaundy que'I	40	Small	1	GTZ/ DEAG, JICA	No	1	16	16	No	50	10		X			Yes	Yes
Deb / Yvytu Cora	5	Small	0	None	No	N/A	2	2	No	80	5		X			Yes	Yes
Cara / Maria Auxiliadora	36	Small	2	Helvetas, OCDE	Yes	10 / 12	1.5	12	No	25	5			X		No	Yes
Kristen / Noviretá	100	Small	0	None	No	N/A	23	3	No	60	5		X			No	Yes
Dave/ La Morena	8 (still growing)	Small	0	Moises Bertoni	Yes	3	25	45	No	90	50	X				Yes	Yes

X = yes

Outside organizations have worked in over half of the surveyed areas. The Swiss development agency, Helvetas, works primarily with soil conservation and citrus production. CECTEC is a Paraguayan agriculture school with a community work component: students must return to their home and share what they have learned. Two families are participating in the community of Missiones i. OCDE, a peasant farmer's organization, has been successful at developing farmer-to-farmer educational programs.

GTZ is an agricultural development agency from Germany, and JICA is Japan's equivalent of the Peace Corps. Plan International, an international organization, brings equipment and running water to public schools. The Moises Bertoni Foundation works with communities surrounding the Mbaracyu Reserve, focusing on preservation of the Reserve's buffer zone and reforestation projects. DEAG, the Department of Agriculture, works in only one community, despite having offices within close proximity of other rural areas. In Kaundey que' i they have been working on a cooperative project with GTZ. Natalio 25 has been the focus of many development agencies, including working with four previous Peace Corps volunteers. Helvetas, the World Bank, and CERI have, in the past, developed large-scale, high-priced projects in the community. Currently, these agencies and their unsuccessful projects are absent from Natalio 25.

Almost all of the communities are isolated and located over 15 Km from the nearest town. The communities of Kaundey que'i and La Morena are only accessible by foot or horseback. Only one community, Maria Auxiliadora is located next to asphalt. Rain prohibits travel from any of the other sites by bus during parts of the year.

There is a strong connection between large landowners and a lack of forest cover in the community. Natalio 25 and Misiones'i have a low amount of remaining forest cover and the majority of the farmers are large landowners (owning more than 50 hectares). These large landowners practice mechanized farming in fields barren of trees.

Peace Corps agroforestry extension volunteers live and work in communities with a wide range of forest cover. Half of the communities are becoming dangerously deforested, or will be in a few years. Two of the eight areas are critically deforested. Only La Morena, a recently developed area, has a significant amount of forest cover remaining. The community continues to grow as families emigrate in hopes of fertile land, cutting their portion of the forest. The average rural eastern Paraguayan family is a small landholder, without communal running water, isolated from urban areas, and lacking a permanent source of agricultural and forestry technical support. They live in an environment that is not secure enough to take great risks. The majority of their time is spent on the cultivation of food. The forests they depend on for a healthy life are quickly disappearing. The need to reforest is very real. What can be done with the resources and situations they have to work with?

Results, Trees in Noviretá

The second component of the surveys studied the current uses of natural regeneration and nurseries. In Noviretá, La Morena, Natalio 25, and Maria Auxiliadora, I was able to walk with farmers in their fields and patio area, observing and talking about their work. This helped me understand the value of farmers participating in reforestation work, from the decision-making steps to presenting their results. They were proud of

their accomplishments and abilities. The second section of the survey conducted in Noviretá looks at the uses of natural regeneration and tree nurseries; the species preferred, specific tree uses, land area, work involved, and cost inputs. The results are found on Table 8.

Natural Regeneration

Fourteen families were surveyed. All families used some form of natural regeneration. Land area limited the size and availability of fallow areas. Natural regeneration is abundant, growing anywhere with soil. Some families consciously utilize it as a valuable resource, while others recognize it as part of their environment. This is not to say that they are not aware of the seedlings. People are quick to tell me that there are many seedlings in the community. The word for tree seedling in Guarani is *yvyramata ra'y*, meaning the offspring of a tree. Mature trees are referred to as *yvyramata su*, or mother tree. In Noviretá, the people are concerned with leaving trees as a seed source. The species urunde'y mi (*Astronium urundeuva*) is a valuable species used to make posts that can last one hundred years without rotting. There are no longer standing urunde'y mi trees in Noviretá, which bothers many farmers. People use or choose to let natural regeneration grow for a variety of reasons.

Table 8: Trees in Noviretá: Uses, work, and space

Uses of natural regeneration	**# of families (out of 14)**	**Success**	**Time input (est.)**	**Avg. land area (Ha.)**	**Sacrifices**	**Cost**	**Avg. No. of people involved**	**Motivation (# of families)**	**Maintenance (# of families)**
Left in patio/ home area	11	Yes	None	.5	None	0	None	None (6); seed source (3); shade (4)	None (10); protecting (1)
Left in working field	7	Yes	None	Random placing, 2 families (3)	Can not burn field or use plow	0	1	Food; wood; shade; soil nutrients (3)	Weeding; thinning (2); pruning (4)
Transplanted to field (Small and large scale)	6	Yes – some problems with mortality	Avg. 8 hrs. / Ha.	2	Time, 1 family can not use a tractor	0	2	Reforestation Act $ (4); firewood; building material	Weeding; pruning (4); replacing of dead trees (2)
Transplanted to home area	3	Yes	Avg. 6 hrs. / Ha	1/8	None	0	2	To learn how to transplant (3); shade (3); fruit (1)	Watering; protecting from cows (1)
Field left fallow	3	Yes	None	1	Land area	0	1	Future trees; soil rehab.	None
Forest enrichment	1	No – high mortality due to lack of technical skills	3 hrs / Ha.	1.5	Less land for cows until it becomes establishe d (approx. 2 yrs)	0	1	Future trees to sell; forest improvement	None [Many died because they were not properly transplanted or cared for]
Nurseries / Nursery stock									
Transplanting to home area	3	Yes	10 min. / tree	Avg. 5 trees	None	0	2	Shade	Watering; protecting
Large nursery	3	Yes (2) No (1)	8 hrs.	50 ft^2	Time; money (1)	20 US$	2	Citrus seedlings for *esencia* (2); reintroduce endangered spp. (1)	Watering (2), weeding (2), fungicide application (2), shade structure (1)
Small containerized nursery	4	Yes	< ½ hr.	Avg. 2, 2 gallon size containers	Time	0	1	Produce trees not available; prepare for grafting	Watering; weeding

The most common method of utilizing tree seedlings is to leave natural regeneration to grow in the patio / home area (11 families) (Figure 13). Most often, it is a small patch, less than a half of a hectare, between the family patio and field area. This system requires no time, sacrifices, or work input. Only one family dedicated time to protecting a fruit tree that they wanted to grow for future use. All families successfully protected and encouraged tree growth. Motivation varied, three families consciously left the area as a seedling source and everyone welcomed shaded areas. Many families, when asked why they chose to leave the area to regenerate, shrugged their shoulders, with no explanation. It is common for chickens to run free-range in Paraguay, scavenging for bugs, staying cool in the shade of these areas. Small firewood is also gathered here.

Natural regeneration is commonly left in working fields (Figure 14). Seven families had trees that had propagated naturally in their fields. A few trees escaped the yearly field burning, and others were left because of their value. In most cases, the placement is random and the area is highly variable. Two families have left most seedlings in three-hectare areas. When families consciously choose to let the seedlings develop they can no longer burn their fields, which can increase their work time. Experienced farmers feel the improvement of their soil quality outweighs the extra effort.

One farmer initially had to battle his brother who shares the family field with him, but did not share his ideas. He would cut seedlings with a machete when he was weeding crops. Trees that are randomly spaced render the field impassible by horse and plow. To change this, one farmer thinned all seedlings that were in the alley area. In all cases, the

Figure 13: Natural regeneration left in a home / patio area

Figure 14: Natural regeneration left in a farm field (two years later)

systems were successful, with little to no mortality, no time commitment at the establishment phase, and free. Common motivations were a free and easy future source of wood. One species, *mbokaya*, produces a fruit that is extremely nutritious. Three families liked to keep trees in their field for shade and to improve soil nutrients. All families kept the trees free of weeds. This requires no additional work since the food crops need to be weeded. This combined weeding is common in other agroforestry systems (Bergert, 2000; Schnobrich, 2001). Four families pruned taller regeneration and two families thinned lower quality seedlings to promote healthy growth and free the area for a plow.

Natural regeneration is also used as a source of seedlings and transplanted on a small and large-scale. Six families' trees took after transplanting. Due to the lack of

technical knowledge of the farmers, some delicate species did not transplant successfully. Time inputs varied, depending upon how close the seedlings were located in relation to the field. The average time required for establishment was eight hours per hectare. Systems were developed on a small scale, averaging a quarter hectare, to a large scale, averaging two hectares. There was no cost involved in establishing these fields, and the major sacrifice was the work and time it took to establish the system. One family that usually hires a tractor to plow their fields now has to weed the field by hand or plow. Four families established these plots to participate in the Reforestation Act, Law 294. The reforestation committee was encouraged to plant trees by a private forestry technician, who was confident of the government program. Maintenance involved weeding, pruning, and replacing deceased trees for two families. Natural regeneration can be transplanted when it is convenient for the farmer, throughout the rainy season.

Wildlings are also transplanted to the home area. Three families successfully transplanted tree seedlings, with no cost, no sacrifices, and limited work. It took an average of six hours per hectare working on an average of 1/8 of hectare of land. All families were interested in learning how to successfully transplant trees. These families approached me for technical support after they had poor results on their own. Other motivations were for shade and fruit. The home and patio area of a home is used more than the interior of the home. Sitting in the shade during the noon heat, or relaxing throughout the day with community members, drinking tereré is an important aspect of Paraguayan culture. One family reported watering and building protective shelters from cows were the only maintenance.

A traditional land use method, fallowing a degraded field to regenerate and recuperate, was practiced by three families (Figure 15). They had the extra land space to sacrifice, without compromising their food crops. All areas had successful growth and regeneration without any extra cost, time, or maintenance.

Figure 15: Fallow field

Lastly, natural regeneration was used in a forest enrichment project. This was also a free, low time (3 hours per hectare) system that would have been successful if the trees were planted properly. The farmer chose the species, tajy hu (*Tebebuia heptaphylla*), which needs to be transplanted in a delicate manner. No parts of the taproot and few shallow roots can be damaged in the digging, moving, and planting process. Most native tree species, like yvyra pyta, are hardy and can be planted, as the Assistant Peace Corps Director Melissa McDonald says, "upside-down" and still grow.

The farmer's main motivation for enriching the forest was future money to send his baby to school. This is a good example of indigenous knowledge that was applied, but lacked a few technical steps. He chose the species because of its current market value, not its ability to transplant.

Nursery Stock

Less than half of the surveyed families in Noviretá work with nurseries, at any level. Three families successfully transplanted nursery stock from small containerized nurseries to their home areas, with no sacrifices and little time input (ten minutes per tree) and maintenance (watering and protecting). The main motivation was shade and to experiment with non-native trees.

Three families designed nurseries that were an average of $50ft^2$ in order to propagate non-native species, produce citrus seedlings for *esencia,* or to reintroduce a native endangered species. The citrus nurseries were successful because the farmers were able to spend time and money maintaining the systems, watering, weeding, and applying fungicides. One tree nursery was unsuccessful, producing only three seedlings, because no maintenance work was done. These small scale nurseries were close to home, sometimes within their gardens, making them easy to care for.

Four families established a containerized nursery to produce seedlings that were not available as natural regeneration. They did not require monetary input, but seeds needed to be procured. It is common for families to plant herbs or decorative plants in broken pots or other containers around their home, so planting tree seeds was a natural extension for them.

A minority of families in Noviretá works with small scale nurseries. More choose to use the natural tree seedlings abundant and free throughout the community as a resource. For some systems, little to no work is involved in the establishment phase. The process of transplanting involves less work and material inputs than setting up a nursery, maintaining it, and waiting until the seedlings are ready to out-plant. Work involved with a small scale nursery is similar to a summer garden. There is a 0.75 correlation ($p = 0.03$) between Peace Corps volunteer success in the promotion of tree nurseries and number of summer gardens in a community.

During my first year living in Noviretá, I promoted tree nurseries with members of the committee, farmers who had already shown interest in reforestation, and the community school, where a garden space was already in place. The farmers listened to me talk about what needed to be done to start a nursery and a few of the tools needed. I explained free alternatives to using plastic bags, such as bamboo, cardboard, and deep seedbeds. A few of the members had seen professional nurseries, and visions of metal fencing, plastic shade structures, an irrigation system, and rows of plastic bags stuck in their minds. Unfortunately, little interest in developing a space with banana leaves, coco trunks, and bamboo was shown. After evaluating the costs, and realizing that a large donation of money would not be possible, the members told me that nurseries were not necessary anyways because the forests are filled with *yvyramata' ra' u*, or directly translated, offspring of the trees. Farmers would say to me, "we have many quality tree seedlings here" when I asked them why they were not interested in starting a tree nursery.

A legitimate concern for using natural regeneration is the potential lack of diversity and quality species. If seed-producing trees of desired species are standing

within close proximity of the community, then previously logged forests and burned field lands can produce quality seedlings of high diversity.

Table 9 lists the most common tree species used in Noviretá. Native species that are fast growing, good for building, and have a high market value are the most commonly used and protected. Kurupa'y kuru (*Anadenthera macrocarpa*) is the preferred firewood species. Paraguayan women will go to great lengths, passing up other species, to acquire this for firewood. Kurupa'y kuru is believed, but not scientifically examined, to have allelopathic properties, which discourages farmers from leaving it in their fields. Paraguayan farmers say it is "hot" and plants grow poorly under its crown. Most farmers prefer native species to the introduced species, Pairiso gigante. My neighbor claimed that native trees grew faster and were readily available in the woods.

The results demonstrate that desired species are available as natural regeneration. When asked about a lack of quality species, only urunde'y mi was mentioned. "*Heta la yvyramatakuera pora* (There are many good trees available)" was always the response I received. Only three desired species (two exotic and one native) needed to be artificially propagated. Although peach and mango are introduced species, they have naturalized in Paraguay and produce natural regeneration. These species are preferred for their strength in building, burning capabilities, ease of transplanting, self-pruning characteristics, and market price. Their fruit is largely valued for food and medicinal purposes.

Table 9: Tree species and their uses, Noviretá

Species, common name	Scientific Name	Origin	Uses	Species characteristics	Number of systems containing each species						
					Patio / home area	Left in field	Transplanted to field	Transplanted to home area	Fallow field	Forest enrichment	Nursery raised
Yvyra Pyta	*Peltophorum debium*	N	Building, furniture, shade, to sell	Dense, fast growing	1	7	5	2	3	0	0
Petereyvu	*Cordia trichotoma*	N	Building, high market value, to sell	Self – pruning, strong wood	4	4	4	2	3	0	0
Guatambu	*Balfourodendron riedelianum*	N	Building, high market value, tool handles	Self- pruning	1	2	4	0	3	0	0
Kurupa'y kuru	*Anadenthera macrocarpa*	N	Firewood	Believed to be alleliopathic	3	2	3 (few)	0	2	0	0
Cedro	*Cedrela fissilis*	N	Buiding, high market value	Attacked by moth	3	3	3	2	3	0	0
Yvyra' ro	*Pterogyne nitens*	N	Building		0	2	5	0	3	0	0
Tajy hu (Lepacho)	*Tebebuia heptaphylla*	N	Building, high market value, furniture	Does not grow well in open areas	1	2 (few)	3 (low success rate)	1	0	1	0
Yvyra ju	*Albizia hassleri*	N			1	2	0	0	2	0	0
Timbo	*Enterolobium contortisiliquum*	N	Building, shade		1	0	0	0	0	0	0
Urunde'y mi	*Astronium urundeuva*	N	Posts	Rare; endangered species	0	0	1	0	0	0	4
Sombrilla de Playa	*Terminalia catappa*	N	Shade		0	0	0	2	0	0	1

Table 9 (Continued): Tree species and their uses, Noviretá

Species, common name	Scientific Name	Origin	Uses	Species characteristics	Number of systems containing each species						
					Patio / home area	Left in field	Transplanted to field	Transplanted to home area	Fallow field	Forest enrichment	Nursery raised
Pairiso Gigante	*Melia azedarach* var. *"Gigante"*	I	Building		0	0	0	3	0	0	2
Mbokaja	*Acrocomia totai*	N	Food		0	7	0	0	3	0	0
Durasno (peach)	*Prunus persica*	I	Fruit		1	0	0	1	0	0	0
Mango	*Mangifera sp.*	I	Shade, fruit		1	0	0	1	0	0	0

Results, Trees; Rural Paraguay

Peace Corps agroforestry extension volunteers working in eight communities were surveyed to examine the similarities and differences in the way the people were working with trees. The different methods of working with natural regeneration and tree nurseries were recorded. Results are found in Table 10: Natural Regeneration and Tree Nurseries, Rural Paraguay.

Natural regeneration was utilized or protected in every community. It was most commonly protected in the home area and fields. Farmers transplanted "wildlings" to fields and home areas in over half of the communities. Natalio 25 and Missiones' i do not have enough quality seedlings to transplant. In the case of La Morena, the NGO Moises Bertoni brings free seedlings to the community and also promotes tree nurseries. It involves less work to transplant these seedlings, so there is little interest in going into the woods to uproot seedlings.

Agroforestry extension workers surveyed had discouraging experiences working with tree nurseries. No one had success with developing a large-scale nursery. A large-scale nursery, in rural Paraguay, ranges in size from 100 m^2 to 400 m^2. Some found working with farmers on a small scale the only successful way of promoting tree nurseries. These farmers wanted to plant species, both native and exotic, that were not available as natural regeneration. Like my experience in Noviretá, in many cases, once the seeds were planted, all work ceased. Maintaining the nurseries was not a priority for most farmers. The only exception is Natalio 25. The critical need for wood has made

Table 10: Natural Regeneration and Tree Nurseries, Rural Eastern Paraguay

PC Volunteer/ Community	Left in field	Home / patio area	Transplant to field	Transplant to home	Nursery / Success				
					PC promoted	Group	Personal	Public	Comments
Alec / Natalio 25		X		X	Yes	Yes – farmers org.	45%	Yes	Few natural tree seedling sources; wanted Eucalyptis
Andrea/ Misiones I	X	X			Yes – no success	No	2%	No	No one wanted to do the work
Aaron / Pereira Cue	X	X	X	X	Yes – no success; lack of care	Yes – school	No	No	Farmers wanted exotic species / spp. no longer available
Holly / Kaundy que' I	X	X	X	X	Yes – container nurseries	No	20% - container	No	Small scale
Deb / Yvytu Cora	X	X	X		Yes- no success	Yes – school	No	No	No one wanted to do the work; wanted free trees
Cara / Maria Auxiliadora	X	X	X	X	Yes – partial success	Yes – farmers org. Organizational problems	No	No	Large scale nursery funded by Helvetas,; the people believe that tree nurseries are the best way; no longer protecting mother trees
Kristen / Noviretá	X	X	X	X	Yes – no success	Yes – school – no success	No	No	No one wants to do maintenance; little interest
Dave / La Morena	X	X			Yes	Yes – farmers org.	No	No	Large scale funded nursery project through NGO; exotic species

X = yes

cultivating trees a top priority. There is a 0.91 correlation ($p = .01$) between the number of personal nurseries and no forest cover. Also, there is a 0.65 correlation ($p = .08$) between group nursery success and no forest cover. Community nurseries developed in the past have failed, due to difficulties associated with working as a group in Paraguay. This hesitancy to form groups is a result of the Stroessner era, when groups were forbidden to exist.

In all communities without large-scale tree nurseries, using natural regeneration as a seedling source was preferred over cultivation. Group nursery success and access to natural regeneration are inversely correlated because there is a –0.65 correlation ($p = .08$). Most farmers would rather use familiar native species that are free and ready to use when they found time to out-plant. They were more interested in technical assistance with transplanting than developing tree nurseries. In the five communities where natural regeneration is used as a first source of seedlings, volunteers had stopped promoting large-scale nurseries by their second year of work. The general consensus was that the focus of their work should meet the needs and feasibility of the farm families and promoting projects that require time and inputs that stress the families' resources are not sustainable.

On the other hand, needs were different for the two communities with established large-scale nurseries. Extension workers were called upon for technical assistance, especially with grafting, and logistical support. Farmers' organizations in Maria Auxiliadora and La Morena were recipients of large aid packages from development organizations to build large-scale nurseries with running water. Success of nurseries is

dependant upon the resources available. There is a 0.75 correlation ($p = .04$) between group nursery success and the presence of outside organizations working in the communtiy. Maria Auxiliadora's nursery has been established for a few years, but closes periodically due to lack of maintenance. The nursery in La Morena has successfully produced seedlings, but it is questionable whether or not they will all be utilized. Dave and Cara, Peace Corps agroforestry extensionists both believe that the people in the communities are becoming more and more dependent on nursery stock and have placed less value on natural regeneration and native species. They fear that this will have an effect on forest conservation. In Maria Auxiliadora all large, quality mother trees have been cut, without concern for their seed value.

School nurseries exist in three communities but are only successful in two. The small tree nurseries are located in the school garden. This is becoming a requirement for all public schools as a part of the Educational Reform, which plans to integrate environmental education into the curriculum over the next few years. Students maintain the nursery as part of a class and are given time during school hours to do the work.

Different communities have different needs and resources. In communities with an abundance of natural regeneration, farmers choose to use it instead of starting nurseries or traveling to buy seedlings from nurseries in large towns. The number of personal nurseries and access to natural regeneration are inversely correlated with a (-0.91 correlation) ($p = .01$). Families in communities with large-scale nurseries that are currently successful still choose to utilize natural regeneration. Most farmers will choose to use native species available as natural regeneration, over introduced species

propagated in a nursery. The popular introduced species (Eucalyptus and Gravilea) have not proven to improve soil quality, unlike many native trees of Paraguay.

Species, Rural Paraguay

Tree species used in the eight communities surveyed in rural Paraguay were recorded. Results are found in Table 11. The most popular species are fast growing, used for building and firewood, and are easily accessible. Guatambu (*Balfourodendron riedelianum*) and peteryvu (*Cordia trichotoma*) are self-pruning, providing a low-maintenance source of straight clear boards for building homes and furniture. Some communities have access to a market to sell logs. For example, farmers sell logs to Brazilian loggers in one community. They usually do not get the full market price, but for them it is an easy way to make money. In places where farmers are interested in grafting citrus, lemon trees for root stock are commonly raised in a nursery.

Three farmers in Noviretá transplanted at least one hectare of natural regeneration. This is a significant amount for a small farmer in rural Paraguay, especially without any formal training. I developed case studies of the three families to better understand why they chose using natural regeneration as a method of reforestation, instead of other options. These case studies are found in Chapter 6

Table 11: Tree species and their uses, Rural Paraguay

Species, common name	Scientific Name	Origin	Uses	Species characteristics	Total number of communities with systems involving each species				
					Patio / home area	Left in field	Transplanted to field	Transplanted to home area	Nursery raised
Yvyra Pyta	*Peltophorum debium*	N	Building, furniture, shade	Dense, fast growing	2	6	2	2	2
Petereyvu	*Cordia trichotoma*	N	Building, high market value	Self – pruning, strong wood	3	4	2	2	0
Guatambu	*Balfourodendron riedelianum*	N	Building, high market value, tool handles	Self- pruning	1	2	1	0	0
Kurupa'y kuru	*Anadenthera macrocarpa*	N	Firewood	Believed to be alleliopathic	2	2	2	0	2
Cedro	*Cedrela fissilis*	N	Buiding, high market value	Attacked by moth	3	5	3	0	0
Yvyra' ro	*Pterogyne nitens*	N	Building		1	2	1	0	0
Tajy hu (Lepacho)	*Tebebuia heptaphylla*	N	Building, high market value	Does not grow well in open areas	4	5	4	2	3
Yvyra ju	*Albizia hassleri*	N			1	2	0	0	0
Timbo	*Enterolobium contortisiliquum*	N	Building		2	0	2	1	1
Urunde'y mi	*Astronium urundeuva*	N	Posts	Rare; endangered species	0	0	1	0	0
Sombrilla de Playa	*Terminalia catappa*	N	Shade		0	0	0	1	0

Table 11 (Continued): Tree species and their uses, Rural Paraguay

Species, common name	Scientific Name	Origin	Uses	Species characteristics	Total number of communities with systems involving each species				
					Patio / home area	Left in field	Transplanted to field	Transplanted to home area	Nursery raised
Pairiso Gigante	*Melia azedarach* var. *"Gigante"*	I	Building		0	0	0	0	3
Mbokaja	*Acrocomia totai*	N	Food		0	8	0	0	0
Durasno	*Prunus persica*	I	Fruit		2	0	0	0	2
Mango	*Mangifera sp.*	I	Shade, fruit		2	0	0	0	2
Kurupa ' y ra	*Parapiptadenia rigida*	N			0	0	0	0	1
Inga guasu	*Inga uruguensis*	N	Shade		1	0	0	0	0
Lemon	*Citrus sp.*	I	Fruit, medicinal, grafting root stock		2	0	0	0	3
Mandarine	*Citrus sp.*	I	Food		1	0	0	1	0
Yerba maté	*Ilex paraguarensis*	N	Maté, tereré	Difficult to artificially germinate	0	0	0	1	1
Hovenia	*Hovenia dulcis*	I	Shade, firewood		0	1	1	2	2
Eucalyptis	*Eucalyptus sp.*	I			0	0	0	1	2
Pindo	*Syagrus romanzoffiana*	N	Food		0	1	0	0	0
Nispero	*Symplocos lanata*	I	Food		1	0	2	0	0

Table 11 (Continued): Tree species and their uses, Rural Paraguay

Species, common name	Scientific Name	Origin	Uses	Species characteristics	Total number of communities with systems involving each species				
					Patio / home area	Left in field	Transplanted to field	Transplanted to home area	Nursery raised
Sour Orange	*Citrus aurantium*	N	Food, forage		1	0	0	0	1
Alecrin		I	Posts, firewood		0	0	1	0	0
Gravilea	*Grevillea robusta*	I	Shade		0	0	0	1	0
Guyaba (Guava)	*Psidium guajava*	N	Food		0	0	0	2	1

Examples of Reforestation Projects Utilizing Natural Regeneration

Previous development projects in Paraguay have utilized natural regeneration instead of nursery stock as seedling sources. William Graul (1994), a former Peace Corps volunteer, worked with farmers who obtained wildings from nearby forest parcels. The farmers chose to plant similar tree species to other communities surveyed in rural Paraguay. Yvyra pyta, tajy hu, kurupa' y kuru, guatambu, and timbo were preferred species in the project. Graul wrote a forestry guide for Paraguayan farmers, which includes a section on clearing vines and bamboo from the forest to release natural regeneration. Similarly, a Paraguayan-run reforestation project focusing on improving degraded forest recommended using and preserving the following species: yvyra pyta, peterevy, guatambu, and tajy (Pastrana, 2000).

In Malaysia, the forestry department devised three strategies to slow down the predicted log deficit that had the potential to end the logging industry (Hamzah, 1983). Two of the three strategies called for regeneration of natural forests through enrichment planting and thinning to release valuable tree species. Over 2 million hectares were severely logged in 1980, and were the targets of these restoration strategies. The third strategy planned to plant forest plantations with fast-growing species, mostly non-native. The management of existing resources, natural regeneration, was used as the primary future tree source, eliminating unnecessary material inputs.

In Kenya, alternatives to large-scale nursery seedling production for reforestation were studied (Mung'ala, 1988). They found that in the highland region of Kenya, farmers deliberately transplanted wildlings into agricultural land to improve the soil and

increase yields. Also, traditional methods of seedling production, similar to small-containerized nurseries in Paraguay, were practiced in rural Kenya. These small seedbed or small makeshift container nurseries required minimal time and material inputs. By producing seedlings, without compromising their resources, these farmers sustainably and independently solved their immediate forestry needs.

Reforestation Projects: Examples of why they fail

Reforestation projects can be found on every continent, attempting to improve or protect the quality of life of those who directly depend on the forest for food, medicine, and fuel. Locker (2000) refers to reforestation as the default option in environmental projects. Many projects have failed, ignoring basic social science principles, in the hopes of combining rural development and ecosystem preservation. An analysis of sixty eight impact evaluation studies of World-Bank assisted rural development projects found that 59% of these projects failed to achieve their goals because of socio-cultural and economic incompatibility in their design (Kottak, 1985). Almost all large-scale reforestation projects start with a large-scale nursery, at times costing millions of dollars, with little or no success. Through these failures we, as development workers, can learn what ingredients are necessary in developing sustainable forestry practices that benefit the people, not development agencies or governments.

Rural reforestation projects fail to achieve their goal due to a combination of many different factors, some cultural and site specific. Common downfalls include:

- A lack of consideration and needs analysis of the farmers involved
- Extensionist and technical support problems (using non-appropriate technology and methodology)
- The use of exotic tree species
- A focus on communal projects
- Project involving high risks for the farmers
- A failure to address/ acknowledge land tenure issues
- Expense

In Honduras, one reforestation project gave no consideration to the people's needs living in the community. The project contracted people to produce trees in financed nurseries and then paid them to plant the seedlings in land to landless farmers. Farmers living in the community were not asked their preference of tree species, nor given education on agroforestry. Organizationally, the project fell apart; the money to start the nursery came late, and arguments erupted in attempting to allocate the money. When the trees were ready to plant, the people were "forced" into signing a contract allowing 45 days to plant 60,000 trees. As a result, the community suffered and the project was a total failure. All that remained were haphazardly planted trees whose ownership and uses were unsure. Not even education or an understanding of how to develop a forestry system was left.

Similarly, after assessing the failure of a woodfuel development program in Kenya, it was realized that the project did not fit the farmers' needs (Mung'ala 1988).

The centralized nurseries focused on raising large numbers of seedlings (86 million in 1986) and distributing them. The species chosen had specific commercial uses and were not practical for most farmers. Because of large volumes and problems with transportation, many seedlings were left too long in polythene tubes and developed root spirals, which hinders establishment after outplanting. Also, they discovered that the insecticides and fungicides used in the nursery were too expensive and dangerous for the farmers. Additional costs for importing nutrient-rich soil required financial inputs. Post-project evaluation led the program to realize that they should investigate sustainable alternatives for future success.

Besides a failure to do needs analysis, problems can arise when extension agents running projects fail to respect the knowledge of farmers they are trying to assist and fail to use appropriate technology. During an evaluation of a large-scale afforestation project in the South Nyanza district of Kenya, it was pointed out that the foresters are trained in traditional forestry, which is biased towards the raising of timber trees for high potential zones, and lacked the technical expertise on appropriate treeplanting and management techniques (Obel, 1984; 18-32). Suggestions for improvement of the nursery project, a self-described "total failure," included understanding and gaining confidence of the farmer as well as assessing if he requires new material and technology or adaptation of methods currently used. Other problems the nursery had were distribution channels (50% of trees were not distributed), transportation difficulties and the lack of materials, tools, and permanent labor (Obel, 1984; 5-51).

Many reforestation projects use exotic species that are not familiar to local farmers. "In many cases the 'solution' to the problem has been grossly oversimplified

and the selection and introduction of fast-growing exotic tree species (notably the genus Eucalyptus) was, initially, heralded as a pan-continental panacea" (Wardell, 1987). As demonstrated above, many reforestation projects blatantly disregard farmers' needs and abilities to know what they want. As seen in the communities surveyed, Paraguayan farmers choose to work with native species, even when they have the option of using fast-growing exotic species. Using exotic species can have a negative impact on the overall ecosystem. For example, a monoculture plantation of Pairiso Gigante located in San Pedro, Paraguay attracted an unknown pest that attacked and severely damaged the trees. Small-scale farmers involved in the project lacked the technical skills and resources to combat the problem. Luckily the pest did not continue to destroy food crops. Careful thought to future problems such as this during the planning segment of a forestry program is the only responsible and sustainable method of working with subsistence farmers. If restoring or preserving remaining forest ecosystems is important, than restoration projects should focus on using native species.

In Tanzania, a study was conducted of eighteen communities that participated in a community reforestation project ten years previously (Skutsch, 1985). Even though all farmers surveyed held the same views on the value of trees, dangers of fire and cattle damage to young seedlings, and had the same level of silvicultural knowledge, only half of the communities successfully raised the trees. It was found that in all communities, farmers planted and raised the trees, but on their own land instead of the communal woodlot. This implies that people were not secure of their rights and that they did have an interest in planting trees. They live in the expectation that they will be cheated left, right, and center and development programs must take this into account (Skutsch, 1985).

Farmers in rural Paraguay share this insecurity, and hesitate when asked to work together, using communal resources. The right to freely work in groups has been allowed since the fall of Stroessner, in 1989, and people are not yet comfortable or trusting with the idea. Although farm families live in a community, it is the family, not the community which is responsible for the well-being of its members (Oksanen, 1987; Heist, 2001)

A study of rural land use in Nigeria, focusing on trees and soil conservation, found that families living near a forest reserve preferred fertilizer application (45%) to tree planting (29%) whereas families without a forest resource, like a reserve, accepted natural fallow (56%) over planting trees (21%) (Osemeobo, 1987). Farmers feared interplanting trees with food crops would adversely affect their crop yields. Planting trees could harm their food security, and was not worth the risk. When asked, they said that they would be more willing to plant trees if they were confident of the results. Furthermore, the study found that those who wanted to plant trees in an agroforestry system either had surplus farmland or their lands were no longer productive due to continuous cultivation.

Land tenure is a complex idea that affects many families in developing nations. If a farmer does not have ownership of his land, how can he be expected to express interest in a long-term project such as planting trees? It is not unheard of for farmers to plant trees as part of a reforestation project with the hopes or misunderstanding that they will receive land tenure. “Trees can be used to consolidate tenure aspects of ecologically necessary and beneficial changes, but again they may also be used for out-and-out grabbing of land" (Raintree, 1986). An analysis of participation in agroforestry projects in Nigeria found that the main reason for farmers adopting trees was to consolidate land

ownership under an individual land tenure system (Osembeobo, 1995). In Paraguay, whether families have ownership of their land is dependent upon where they live. Older communities such as Noviretá have been formally recognized and the landholders possess titles. Most younger communities that have been established through land-squatting, are fighting with bureaucracy and corruption to gain land tenure. The families in Missiones'i where Peace Corps volunteer Andrea worked as an agroforestry extensionist, did not hold titles to their land. As a result, few farmers wanted to adopt agroforestry practices. Land tenure is another facet of reforestation projects that needs to be addressed when evaluating farmer's needs and resources.

Last of all, reforestation projects that involve large-scale nurseries are expensive and can put developing countries in debt. An afforestation project in Kenya involved a loan of 10 million US dollars from the World Bank and credit of 10 million US dollars from IDA (Aworry, 1982). The project proposal included a goal of 6400 hectares of tree plantations established annually for 4 years for a total of 25,600 hectares. High cost projects do not guarantee success, as seen in the previous examples. Is the debt acquired by developing nations for these programs worthwhile?

Sustainability must be the focus of development, if success is the goal. Projects of all sizes and intent should learn from past mistakes, and learn the communities' needs and resources. "Unless a technology has been developed with the participation of its ultimate beneficiaries, it will have little possibility of actually fitting small farmer needs (Bray, 1991)."

Chapter 6 Case Studies of Three Farm Families

In September of 1998, three members of the Reforestation Committee began a reforestation project. Their original goal was to receive money from the reforestation initiative, Law 294. All families chose to use the largest section of farmland they could without jeopardizing their food or cash crop security. The Law included a fund to pay labor fees to do pruning and thinning every year, so on paper it seemed like a beneficial plan.

Family A

Family A owns ten hectares of degraded forest, five hectares of fallow fields, fifteen hectares of grazing land, five hectares of fields, and ten hectares of home / patio area. By Noviretá standards, they are financially secure. They own a significant number of animals and sell charcoal for supplemental income. Extended family still lives in the area and provides labor for the farm. The household consists of two older parents and two teenage grandchildren. The grandchildren's mother works in Argentina, supplementing the family's income. Both parents openly share the decision making of the family, which is rare for Paraguay. Usually the eldest father figure determines what will be planted in the fields.

The mother and father of the family decided to transplant three hectares of trees in the fallow field, which is located a kilometer from the homestead, and two hectares in a farm field. Interestingly enough, they were not afraid to experiment with an agroforestry system. The two-hectare field was kept free of weeds for the duration of my time in the

community. They even made an effort to replace the dead trees. A map of their farm is found in Figure 16.

They originally chose to plant the majority of the field with tajy hu, a valuable species, and kurupa'y kuru, which is the species they use to make charcoal. Forests with an abundance and variety of seedlings bordered the fields. The close proximity and the value of the species influenced their decision to start a reforestation plot. It was quick, easy work with the potential for a worthwile return. Relatives were hired to do most of the transplanting.

The ideal spacing for trees in Paraguay is 4 meters by 4 meters. Family A planted trees with a spacing of 2 meters by 3 meters. Potentially, the close location of trees will result in slow growth rates due to competition for resources.

Impressed with their growth after one year, they were determined to maintain them properly, to ensure quality trees. Tajy hu grows poorly and twisted in open areas and are the most delicate of the common species to transplant. (Many died in the transplanting process.) Disappointed in the results, the family asked me how to improve them. We pruned the seedlings and the family made the decision to leave badly shaped trees for future use. They decided to wait until the future to plant tajy hu, when the area would provide a protected haven. Only maintenance on the closer field has been implemented. Because of the distance, they have decided to let the distant field grow naturally.

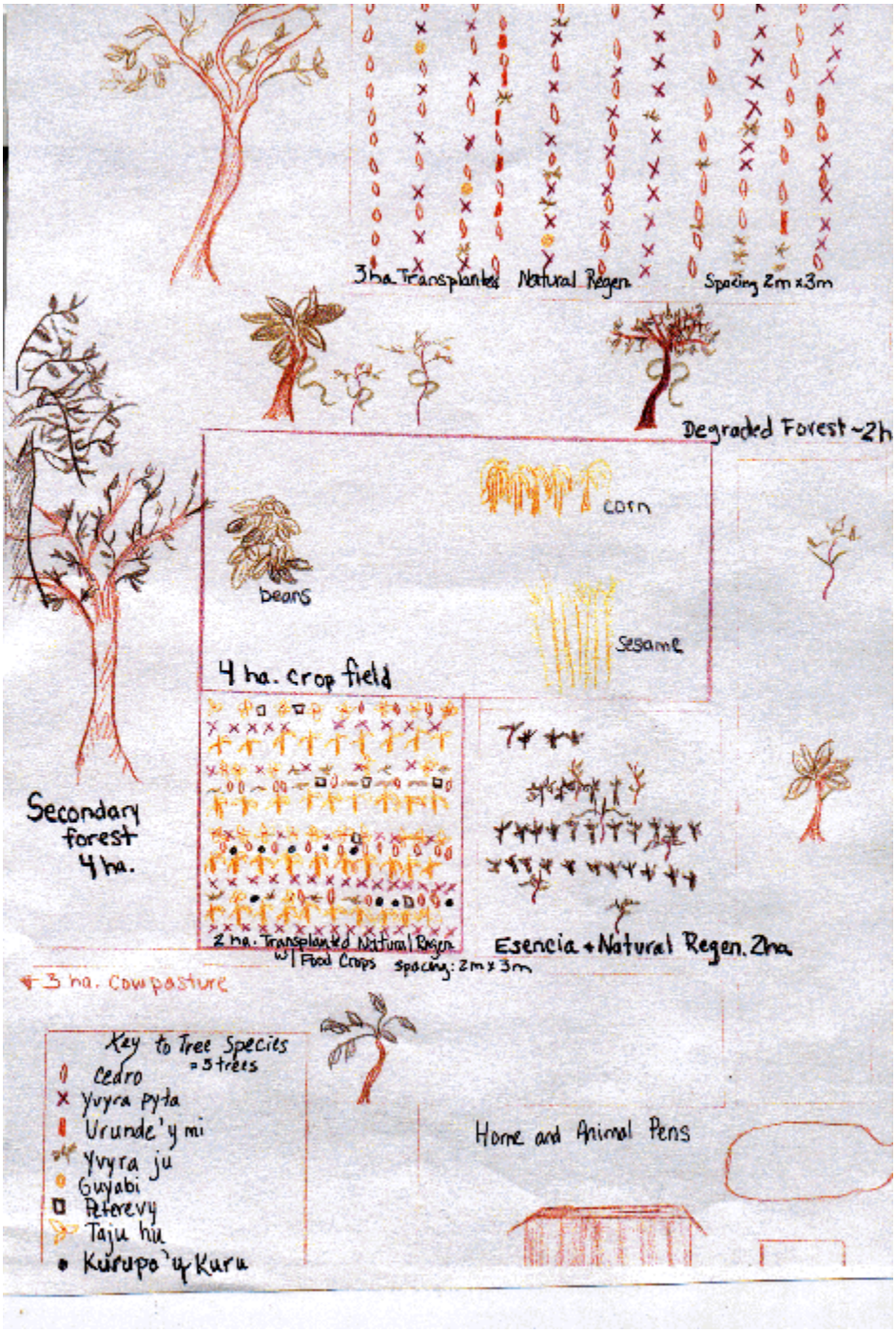

Figure 16: Family A farm map

Even though the family had the resources to establish a nursery, they chose to use natural regeneration. The mother of the family would give me a tour of the forest and field areas, pointing out the abundance of quality seedlings. She would say, "look, I have many trees to plant." Even though they have a significant amount of standing forest, they still are concerned with conservation. As a family, they rely heavily on the forest for medicinal plants, firewood, and for extra income making charcoal. All meals are prepared over a fire-heated stove or in a traditional brick oven. They have become examples for their children, who live nearby and are just starting their farms and families. Law 294 still lingers in their mind and they continue to think of ways to bring the government officials to their community to see the work they have done. Despite their frustration, they continue to care for their trees, unlike other members of the committee. They liked to tell me that, because of their work, they would have trees for the future.

Family B

Family B has access, but not ownership to a ten-hectare forest that is shared by extended family members. To cut large standing trees they need to get permission from the oldest family member. Unlike Family A, they do not have an abundance of land or animals. This household is young, with three children under the age of sixteen. They are subsistence farmers and sometimes grow cotton as a cash crop. Most meals are cooked over a brick oven fueled by wood, and occasionally they use a gas stove.

As part of the Reforestation Project they transplanted natural regeneration into a one-hectare field with severely degraded soil. A map of their farm can be found in Figure 17. Seedlings were brought from a bordering forest and fallow field. This

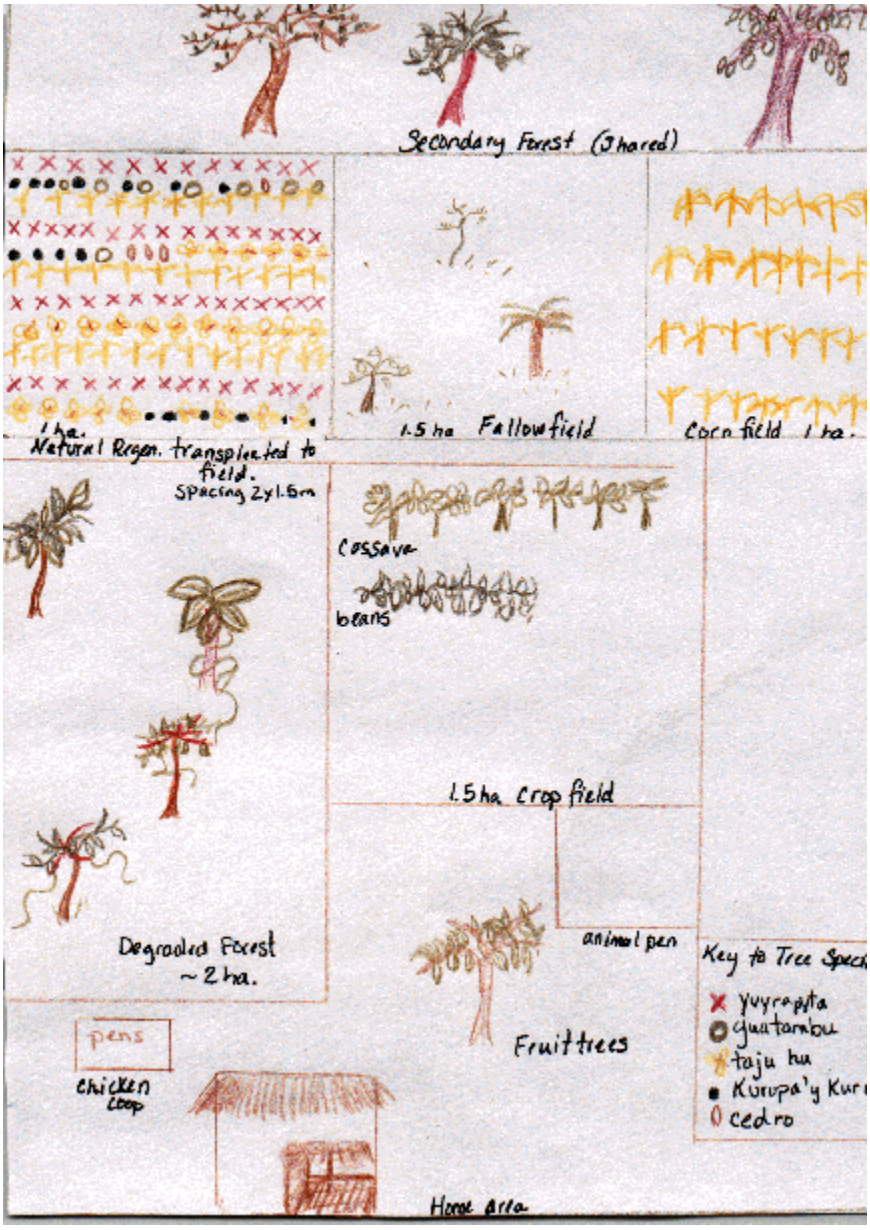

Figure 17: Family B farm map

agroforestry system was well maintained for the first year, cleaned and thinned. Similar to family A, few tajy hu survived. Family B planted the trees close together with a spacing of 2 meters by 1.5 meters. The trees were planted in rows by species, so the death of one species affects the overall dynamics of the system. Large gaps cause a tunneling effect of the strong Paraguayan winds, forcing crooked growth in the surrounding trees.

In September of 1998, family B planted the trees with cotton. In May the cotton was harvested and the replaced with corn, followed by beans in the fall. After one year of growth, the family had to move to care for an elder family member. A close relative moved into their home and resumed responsibility for the attached farmland. Unlike their predecessors, they did not have much of an interest in caring for the trees, or farming the land surrounding them.

Family B did not have a resource base as strong as family A, but similarly automatically chose to use natural regeneration. The abundant free trees made it a low input system to establish. This family valued natural regeneration and purposely left a degraded field fallow to recuperate the soil. He pointed out how fast the natural regeneration germinated and grew in the fallow field. Ideally, he said, the area could be thinned and managed after a year, creating a natural woodlot with valuable species.

Family B was pessimistic about the Reforestation Law, and gave up on the project after they had to move. It would have been hard to maintain from afar and he no longer had control over that farm. The family that replaced them did not value native tree

species as much as they had. However, the new family did choose to leave the transplanted trees standing. Interest was expressed in planting exotic species in a fallow field nearby. The fallow field was eventually burned for field area, which was terribly unsuccessful because of the poor soil quality. The new owner showed interest in developing a woodlot using exotic species and created a nursery to produce the seedlings. Unfortunately, the nursery failed due to a lack of care. During my remaining time in the community the original system continued to grow, and the new owner continued to make plans.

Family C

Family C owns ten hectares of forest, five hectares of fields, and two hectares of patio, home, and garden space. This family has always been concerned with the preservation of the forest and has maintained a swidden-fallow system to ensure future forest cover and quality soil. The household is comprised of older parents and two young adult children. One son works outside of the home, and the rest of the family and extended relatives work in the fields. Like most families in Noviretá, they are subsistence farmers and process *esencia* for a cash crop. The mother prepares all meals over an open fire and they rely only on medicinal plants for their wellness.

Family C planted trees in response to Law 294, like the other families. A map of their farm is found in Figure 18. Patches of forest and fallow fields filled with natural regeneration border all of their fields. Similarly to family A and B, the trees were closely planted, with a spacing of 1.5 meters by 2 meters. Choosing the trees they value most,

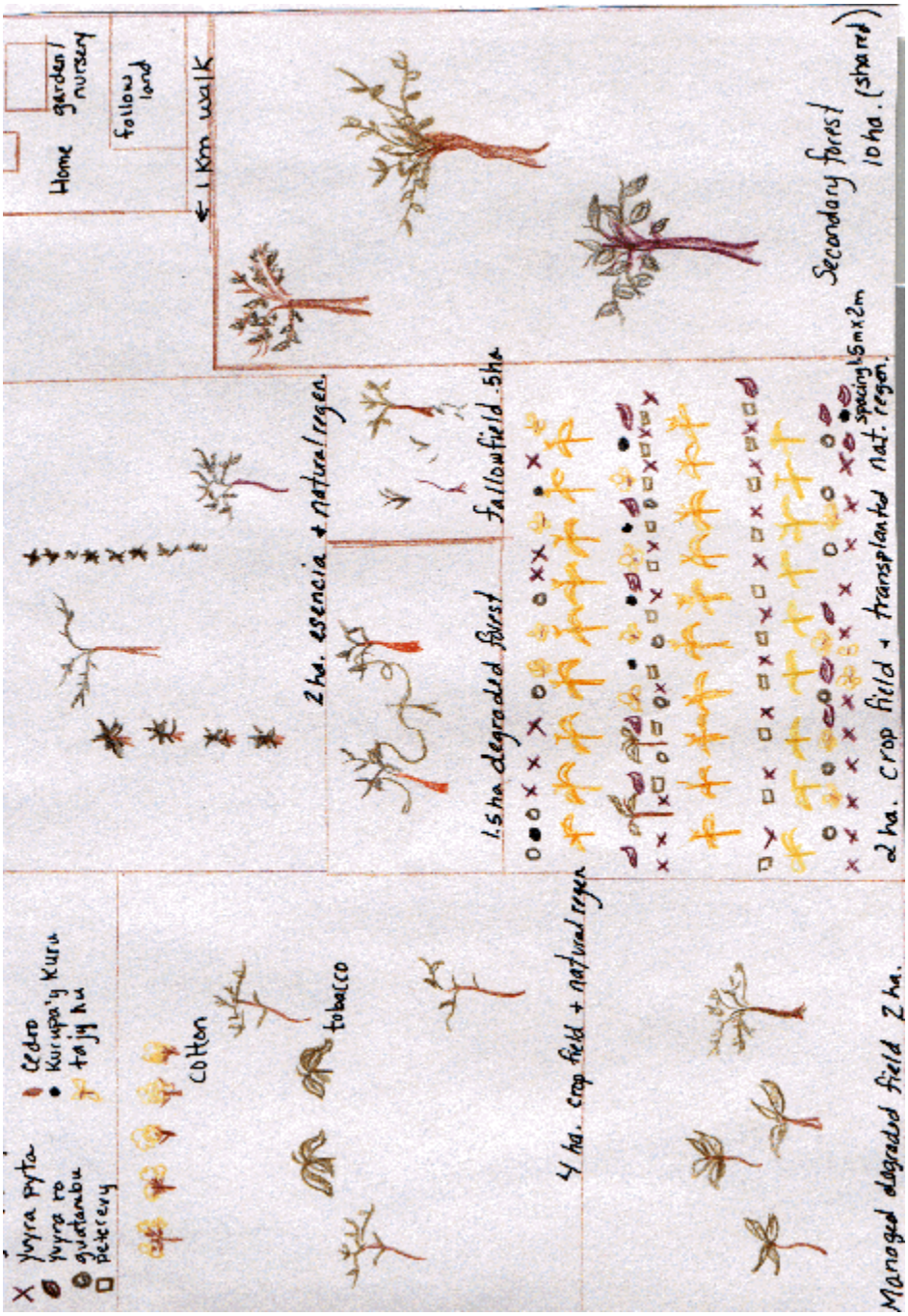

Figure 18: Family C farm map

they transplanted the natural regeneration to a field space of one and a half hectares (Figure 19). This required a minimal amount of work and was easy, according to the father.

This family also manages natural regeneration that has been left in fallow fields and germinates naturally in their field. They strongly believe that the simplest way to prepare for future wood use is to let anything grow that space allows. Every few years when they want to replace citrus trees for their *esencia* production, they build a nursery bed in their garden and successfully produce tree seedlings. Even though they have experience and skills with nursery production, they value using natural regeneration over nursery stock for reforestation.

Figure 19: Natural regeneration transplanted to a field

These three case studies further demonstrate how natural regeneration is valued in rural Paraguay. It is an accepted and practiced method of reforestation. Natural regeneration is utilized by everyone in a variety of ways; all fields in Noviretá contain at least one mbokaja tree, which grew from natural regeneration and consciously protected. In all three case studies, the farmers developed projects on their own, independent of technical assistance. They felt comfortable working in this manner and it did not stress their resources or jeopardize their livelihood. As a development worker I was able to assist them with specific problems and teach them management skills such as pruning, proper spacing, and thinning. I advised the families on pruning equipment, demonstrated pruning techniques in the field, and pruned their established systems with them as a method of teaching. While working in the fields, we would discuss thinning and proper spacing for trees in rural Paraguay. During planting sessions with families, I advised them on the proper spacing for the tree species we were working with. I feel that working in this sustainable manner is a cooperative process, involving exchanging ideas and information. All of the farmers in these case studies were proud to show me their trees in the beginning, demonstrating what they knew. After exchanging ideas, and experimenting with new ways of working, they felt that they learned valuable information. I learned how to work with other families in the community by using these three families as examples.

Furthermore, these families started projects on a small scale. New ideas and practices are most successfully brought into a farming system one step at a time. Small steps are a low-risk method of experimenting with the integration of new technology. It

is a way for small farmers in rural Paraguay to adapt to the growing environmental and sociological changes in their lifetime.

Chapter 7 Conclusion and Recommendations

Deforestation threatens the livelihood of the small rural farmer in eastern Paraguay. Population pressure, degraded soil, and a lack of technical support are all the cause and effect of the continual forest degradation and depletion. The traditional swidden-fallow farming system is no longer a viable option for subsistence farmers to produce their food and wood needs. Instead, fields are intensely farmed until they no longer can produce, and then the farmer cuts the forest for new fields. Population pressure has reduced the availability of land, and a lack of technical support assisting farmers in soil conservation, leaving farmers frustrated and unsure of their future. For some farmers, their reaction has manifested in peasant revolt – taking over unused land owned by wealthy and foreign landholders. Others continue to live, waiting for change.

In an effort to assist rural farm families improve their situation in Paraguay, development agencies, such as the Peace Corps, have initiated environmental programs focusing on agroforestry extension and environmental education. Rural development projects are only successful if they are sustainable. Therefore, they must address farmers needs and available resources. Projects involving excess work, material inputs, or high risk for farm families have the potential of failure. The goal of development is to empower families, helping them discover the tools necessary to sustain, or possibly improve, their livelihood.

During the two years I lived in Noviretá, I learned from the farmers and their families. I observed their knowledge of the environment that sustains them, their resources, and what they have done with these resources, without outside help. Many

families in Noviretá consciously protect and utilize natural tree regeneration in their homes and fields. Whether the trees are used for shade, firewood, soil rehabilitation, building, food, or to pay for a child's future education, the effort to improve their families' quality of life had been made. My role as an agroforestry extensionist was to assist them, through education, and example, in learning how to sustain and improve their efforts. Similarly, the Kenya Woodfuel Development Programme learned that when traditional knowledge and modern knowledge are exchanged and blended, it not only results in better tree production systems, but a substantial increase in tree-planting activities of the farmer (Mung'ala, 1988).

After studying and observing the quiet success of the farmers in Noviretá, and rural Paraguay, I feel that it is important to question the necessity of building a large tree nursery to produce tree seedlings. It is not compatible with the basic principles of sustainability; large tree nurseries are high-input, risky projects that have historically had a high failure rate in development, throughout the world and rural Paraguay.

Recommendations

Reforestation Projects

The focus of reforestation projects in Paraguay should be the protection and utilization of native species, in the form of natural regeneration. Paraguayan farmers are familiar with the natural systems in their environment. By encouraging farmers to utilize the resources they have, development workers can promote low-risk, low-input systems. Secondary forests (fallow) are an important aspect of conservation efforts in the tropics because they are located near human settlements, provide valuable resources such as food

and medicinal plants, and if managed well can take the pressure off primary forests. They are fast growing ecosystems: the rate of net primary productivity of secondary forests exceeds that of primary forests by at least a factor of two (Brown, 1990). Also, they are relatively easy to regenerate naturally (Ewel,1977 as cited in Brown, 1990).

Promoting trees to improve soil fertility is currently a focus of the Peace Corps Agroforestry Extensionist program. Using indigenous tree species is a feasible land use option for recovering degraded forest regions especially in areas with poor natural regeneration (Montagnini, 1995). In areas of rural Paraguay where there is little quality natural regeneration, educating and encouraging farmers to plant native tree species for both soil conservation and future seed source is important.

Small scale or containerized nurseries can be a successful method of producing seedlings for immediate needs or to replace unavailable native tree species. For example, during the second year of my service, I brought seeds of *urunde'y mi*, a valued native species that is threatened and unavailable in the Noviretá area. I mentioned the seeds during my routine visits to the families I worked with and many families expressed interest. Eleven families asked me for seeds, and two requested my assistance in establishing a seedbed. A majority asked for a handful and planted them in a small container amongst their medicinal plants. The two seedbeds were created in an existing garden. It is important to realize that, given the lack of natural regeneration for *urunde'y mi*, this was the smallest, easiest step possible. It resembles home and patio plantings, a familiar method for Paraguayan farmers. Occasionally, when working in reforestation projects, there is a need to propagate tree seedlings. For example, some Paraguayan farmers are interested in planting exotic species, citrus grafting, and replacing rare native

species. Small scale or containerized nurseries are the most sustainable method of producing these seedlings in rural Paraguay.

Peace Corps Training

Peace Corps training should include discussions regarding the above recommendations for reforestation programs. Additionally, the benefits of using natural regeneration as a primary seedling source for reforestation programs should be emphasized. This can be achieved by discussing the various ways that Paraguayans traditionally use natural regeneration and demonstrating successful systems developed by Paraguayan farmers. Technical information specifically focusing on natural regeneration should be provided and thoroughly discussed and practiced. Valuable information for each commonly used species should include transplanting techniques, the level of difficulty in transplanting, pruning, spacing, diseases, shade tolerance, and crop competition. A collection of this information can be found in Table 12.

Farmer-to-farmer methodology should be further emphasized in training and experienced first hand by visiting an experimental farm run by Paraguayan farmers, such as SEPA. Through this experience, trainees would become familiar with how to assist farmers in using natural regeneration, especially in describing difficult concepts such as thinning. Most farmers I worked with did not understand the importance of thinning. In their opinion, the more trees, the better. By addressing this difficult concept in training, agroforestry extensionists will be better prepared to teach the members of their communities the technical skills necessary to maintain and enhance a successful

Table 12: Technical Information, By Species, Necessary When Using Natural Regeneration In Rural Paraguay

Species, common name	Transplanting techniques	Transplanting (D = difficult, A = average, E = easy) / problems	Shade tolerance	Pruning	Observed diseases or pest problems	Interaction with crops / soil / weeds
Yvyra Pyta	Modified stump; bare root	E	Intolerant to Intermediate	Prune	None	Nitrogen fixing
Petereyvu	Bare root	D / delicate root system	Intolerant	Self pruning	None	Can't compete with weeds
Guatambu	Modified stump	A / small seedlings don't transplant well	Intolerant to Intermediate	Self pruning	None	None
Kurupa'y kuru	Modified stump	E	Intolerant	Heavy pruning	None	Nitrogen fixing; potentially allelopathic
Cedro	Modified stump	A	Intolerant to Intermediate	Prune if attacked by moth	Tip moth attack	None
Yvyra' ro	Modified stump	A / small seedlings don't transplant well	Intolerant	Prune in first years	Defoliation, cause unknown	None
Tajy hu (Lepacho)	Modified stump; bare root seedlings that have lost their leaves	D	Intolerant to Intermediate	Prune heavily in open areas	None	Slow growing; can't compete with weeds
Yvyra ju	Modified stump	E	Intolerant	Prune	None	Nitrogen fixing
Timbo	Modified stump	E	Intolerant	Constant pruning	Blister beatle (Family Meloidae) defoliate	Nitrogen fixing

Source: Peace Corps Paraguay, 1997

forestry system. The methods of explaining the concept of thinning can also be applied to spacing during tree planting demonstrations.

In conclusion, learning the needs of the community and the resources available is the first and most important step in sustainable rural development. Spending time asking questions about the methods that farmers have been using to keep their lifestyle sustainable can help one realize the indigenous knowledge in the community. The goal is to put people first; identifying culturally compatible goals and strategies for change and developing socially appropriate, workable, and efficient designs for innovation (Kottak, 1985).

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APPENDIX I
Statistical Results

Appendix I. Statistical Results

Pearson Correlation Coefficients, N = 8
Prob > |r| under H0: Rho=0

	Age	Land Holder	Previous PCVs	Outside Org.	O.O. nursery	O.O. years	Distance to town	Distance to DEAG
Age	1.00000	-0.28086 0.5004	-0.06543 0.8777	-0.08443 0.8424	-0.43230 0.2848	-0.35992 0.3812	0.26164 0.5314	-0.09851 0.8165
Land Holder	-0.28086 0.5004	1.00000	0.43644 0.2797	0.33333 0.4198	0.14907 0.7246	0.50898 0.1977	0.47705 0.2320	0.31323 0.4500
Prev. PCV	-0.06543 0.8777	0.43644 0.2797	1.00000	0.43644 0.2797	0.58554 0.1272	0.74548 0.0338	-0.34273 0.4059	-0.30075 0.4692
O.O.	-0.08443 0.8424	0.33333 0.4198	0.43644 0.2797	1.00000	0.44721 0.2666	0.52623 0.1803	0.30580 0.4614	0.62228 0.0994
O.O. Nursery	-0.43230 0.2848	0.14907 0.7246	0.58554 0.1272	0.44721 0.2666	1.00000	0.77546 0.0237	-0.34026 0.4095	0.06911 0.8708
O.O. Yrs.	-0.35992 0.3812	0.50898 0.1977	0.74548 0.0338	0.52623 0.1803	0.77546 0.0237	1.00000	-0.19659 0.6408	0.02367 0.9556
D. to Town	0.26164 0.5314	0.47705 0.2320	-0.34273 0.4059	0.30580 0.4614	-0.34026 0.4095	-0.19659 0.6408	1.00000	0.78673 0.0205
D. to DEAG	-0.09851 0.8165	0.31323 0.4500	-0.30075 0.4692	0.62228 0.0994	0.06911 0.8708	0.02367 0.9556	0.78673 0.0205	1.00000
Running water	. .	. .	. .	. .	. .	. .	. .	. .
Winter Garden	-0.11536 0.7856	0.38297 0.3491	-0.13675 0.7468	-0.03482 0.9348	-0.07785 0.8546	-0.30545 0.4619	0.46224 0.2488	0.42094 0.2990
Summer Garden	-0.41553 0.3059	0.35218 0.3922	0.28820 0.4888	0.44023 0.2750	0.66937 0.0694	0.29394 0.4798	0.18029 0.6692	0.45338 0.2592
High Forest	-0.34630 0.4007	-0.21822 0.6036	-0.28571 0.4927	0.21822 0.6036	0.48795 0.2199	-0.07342 0.8628	0.12012 0.7769	0.52221 0.1843
Med. Forest	0.03622 0.9322	-0.44721 0.2666	-0.39036 0.3390	-0.74536 0.0338	-0.60000 0.1158	-0.64429 0.0846	-0.34901 0.3968	-0.63316 0.0920
Low Forest	0.19399 0.6453	0.57735 0.1340	0.56695 0.1428	0.57735 0.1340	0.25820 0.5370	0.67239 0.0677	0.25848 0.5365	0.26765 0.5216
No Forest	-0.19289 0.6472	0.65465 0.0781	0.85714 0.0065	0.21822 0.6036	0.48795 0.2199	0.55911 0.1497	-0.13613 0.7479	-0.22146 0.5981

Appendix I (Continued): Statistical Results

The CORR Procedure

Pearson Correlation Coefficients, N = 8
Prob > |r| under H0: Rho=0

	Running Water	Winter garden	Summer garden	High forest	Medium forest	Low forest	No forest	Park or reserve
Age	.	-0.11536	-0.41553	-0.34630	0.03622	0.19399	-0.19289	-0.13485
	.	0.7856	0.3059	0.4007	0.9322	0.6453	0.6472	0.7502
Land holders	.	0.38297	0.35218	-0.21822	-0.44721	0.57735	0.65465	-0.14907
	.	0.3491	0.3922	0.6036	0.2666	0.1340	0.0781	0.7246
PCV's	.	-0.13675	0.28820	-0.28571	-0.39036	0.56695	0.85714	-0.58554
	.	0.7468	0.4888	0.4927	0.3390	0.1428	0.0065	0.1272
O.O.	.	-0.03482	0.44023	0.21822	-0.74536	0.57735	0.21822	0.14907
	.	0.9348	0.2750	0.6036	0.0338	0.1340	0.6036	0.7246
O.O. nursery	.	-0.07785	0.66937	0.48795	-0.60000	0.25820	0.48795	-0.46667
	.	0.8546	0.0694	0.2199	0.1158	0.5370	0.2199	0.2437
O.O. years	.	-0.30545	0.29394	-0.07342	-0.64429	0.67239	0.55911	-0.59028
	.	0.4619	0.4798	0.8628	0.0846	0.0677	0.1497	0.1234
Distance Town	.	0.46224	0.18029	0.12012	-0.34901	0.25848	-0.13613	0.37527
	.	0.2488	0.6692	0.7769	0.3968	0.5365	0.7479	0.3596
Distance DEAG	.	0.42094	0.45338	0.52221	-0.63316	0.26765	-0.22146	0.55845
	.	0.2990	0.2592	0.1843	0.0920	0.5216	0.5981	0.1502
Running Water	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
Winter garden	.	1.00000	0.58854	0.38747	-0.20241	-0.06030	0.29630	0.45153
	.		0.1248	0.3429	0.6307	0.8872	0.4761	0.2614
Summer garden	.	0.58854	1.00000	0.74931	-0.51187	0.00000	0.51875	0.03937
	.	0.1248		0.0324	0.1947	1.0000	0.1878	0.9262
High forest	.	0.38747	0.74931	1.00000	-0.29277	-0.37796	-0.14286	0.29277
	.	0.3429	0.0324		0.4816	0.3559	0.7358	0.4816
Medium Forest	.	-0.20241	-0.51187	-0.29277	1.00000	-0.77460	-0.29277	0.06667
	.	0.6307	0.1947	0.4816		0.0240	0.4816	0.8754
Low forest	.	-0.06030	0.00000	-0.37796	-0.77460	1.00000	0.37796	-0.25820
	.	0.8872	1.0000	0.3559	0.0240		0.3559	0.5370
No forest	.	0.29630	0.51875	-0.14286	-0.29277	0.37796	1.00000	-0.48795
	.	0.4761	0.1878	0.7358	0.4816	0.3559		0.2199

Appendix I (Continued): Statistical Results

The CORR Procedure

Pearson Correlation Coefficients, N = 8
Prob > |r| under HO: Rho=O

	Access Nat. reg.	Trees Field	Trees Home	Transplant field	Trans. home	PC nursery	Success	Group nursery
Age	0.19289	0.19289	.	0.48778	0.61107	.	-0.40764	-0.43230
	0.6472	0.6472	.	0.2201	0.1075	.	0.3161	0.2848
Land	-0.65465	-0.65465	.	-0.74536	-0.14907	.	0.14907	0.14907
Holders	0.0781	0.0781	.	0.0338	0.7246	.	0.7246	0.7246
PCV's	-0.85714	-0.85714	.	-0.19518	0.58554	.	0.39036	0.58554
	0.0065	0.0065	.	0.6432	0.1272	.	0.3390	0.1272
O.O	-0.21822	-0.21822	.	-0.44721	0.14907	.	0.44721	0.44721
	0.6036	0.6036	.	0.2666	0.7246	.	0.2666	0.2666
O.O.	-0.48795	-0.48795	.	-0.46667	0.06667	.	0.46667	1.00000
Nursery	0.2199	0.2199	.	0.2437	0.8754	.	0.2437	<.0001
O.O.	-0.55911	-0.55911	.	-0.40509	0.21219	.	0.15818	0.77546
years	0.1497	0.1497	.	0.3195	0.6139	.	0.7083	0.0237
Distance	0.13613	0.13613	.	-0.50874	-0.28118	.	-0.08643	-0.34026
To town	0.7479	0.7479	.	0.1979	0.4999	.	0.8387	0.4095
Distance	0.22146	0.22146	.	-0.63689	-0.50242	.	0.12887	0.06911
To DEAG	0.5981	0.5981	.	0.0895	0.2045	.	0.7610	0.8708
Running	.	.	.	.	.	.	.	.
Water	.	.	.	.	.	.	.	.
Winter	-0.29630	-0.29630	.	-0.60723	-0.54495	.	0.23355	-0.07785
Garden	0.4761	0.4761	.	0.1104	0.1625	.	0.5778	0.8546
Summer	-0.51875	-0.51875	.	-0.82687	-0.27562	.	0.74812	0.66937
Garden	0.1878	0.1878	.	0.0113	0.5088	.	0.0328	0.0694
High	0.14286	0.14286	.	-0.48795	-0.48795	.	0.48795	0.48795
forest	0.7358	0.7358	.	0.2199	0.2199	.	0.2199	0.2199
Med.	0.29277	0.29277	.	0.60000	0.06667	.	-0.06667	-0.60000
forest	0.4816	0.4816	.	0.1158	0.8754	.	0.8754	0.1158
Low	-0.37796	-0.37796	.	-0.25820	0.25820	.	-0.25820	0.25820
forest	0.3559	0.3559	.	0.5370	0.5370	.	0.5370	0.5370
No	-1.00000	-1.00000	.	-0.48795	0.29277	.	0.48795	0.48795
forest	<.0001	<.0001	.	0.2199	0.4816	.	0.2199	0.2199

Appendix I (Continued): Statistical Results

Pearson Correlation Coefficients, N = 8
Prob > |r| under H0: Rho=0

	Success	School Nursery	Success	Personal	Public Nursery
Age	-0.41182	0.59104	0.29120	-0.22034	-0.19289
	0.3107	0.1228	0.4841	0.6000	0.6472
Land	0.33333	-0.44721	-0.33333	0.57149	0.65465
Holder	0.4198	0.2666	0.4198	0.1389	0.0781
PCV's	0.43644	-0.39036	-0.21822	0.82246	0.85714
	0.2797	0.3390	0.6036	0.0122	0.0065
O.O.	0.33333	-0.74536	-0.33333	0.31644	0.21822
	0.4198	0.0338	0.4198	0.4451	0.6036
O.O.	0.74536	-0.60000	-0.44721	0.33584	0.48795
Nursery	0.0338	0.1158	0.2666	0.4160	0.2199
O.O.	0.37095	-0.67515	-0.49173	0.43919	0.55911
Years	0.3656	0.0662	0.2159	0.2763	0.1497
Distance	-0.01223	-0.10394	-0.16880	-0.14749	-0.13613
To town	0.9771	0.8065	0.6895	0.7274	0.7479
Dist.	0.22970	-0.42397	-0.17123	-0.23688	-0.22146
To DEAG	0.5842	0.2952	0.6852	0.5722	0.5981
Running	.	.	.	.	.
Water	.	.	.	.	.
Winter	0.52223	0.17127	0.31334	0.14947	0.29630
Garden	0.1843	0.6851	0.4498	0.7239	0.4761
Summer	0.96850	-0.51187	-0.35218	0.42790	0.51875
Garden	<.0001	0.1947	0.3922	0.2902	0.1878
High	0.65465	-0.29277	-0.21822	-0.20716	-0.14286
forest	0.0781	0.4816	0.6036	0.6225	0.7358
Medium	-0.44721	0.46667	0.14907	-0.08660	-0.29277
forest	0.2666	0.2437	0.7246	0.8384	0.4816
Low	0.00000	-0.25820	0.00000	0.22087	0.37796
forest	1.0000	0.5370	1.0000	0.5991	0.3559
No	0.65465	-0.29277	-0.21822	0.90594	1.00000
forest	0.0781	0.4816	0.6036	0.0019	<.0001

Appendix I (Continued): Statistical Results

The CORR Procedure

Pearson Correlation Coefficients, N = 8
Prob > |r| under H0: Rho=0

	Age	Land Holders	Previous PCVs	O.O.	O.O. Nursery	O.O. Years	Distance to town	Distance to DEAG
Park	-0.13485	-0.14907	-0.58554	0.14907	-0.46667	-0.59028	0.37527	0.55845
Reserve	0.7502	0.7246	0.1272	0.7246	0.2437	0.1234	0.3596	0.1502
Access	0.19289	-0.65465	-0.85714	-0.21822	-0.48795	-0.55911	0.13613	0.22146
n.regen.	0.6472	0.0781	0.0065	0.6036	0.2199	0.1497	0.7479	0.5981
Trees	0.19289	-0.65465	-0.85714	-0.21822	-0.48795	-0.55911	0.13613	0.22146
Field	0.6472	0.0781	0.0065	0.6036	0.2199	0.1497	0.7479	0.5981
Trees	.	.	.	.	.	.	.	.
Home	.	.	.	.	.	.	.	.
Trans.	0.48778	-0.74536	-0.19518	-0.44721	-0.46667	-0.40509	-0.50874	-0.63689
Field	0.2201	0.0338	0.6432	0.2666	0.2437	0.3195	0.1979	0.0895
Trans.	0.61107	-0.14907	0.58554	0.14907	0.06667	0.21219	-0.28118	-0.50242
Home	0.1075	0.7246	0.1272	0.7246	0.8754	0.6139	0.4999	0.2045
PC	.	.	.	.	.	.	.	.
nursery	.	.	.	.	.	.	.	.
Success	-0.40764	0.14907	0.39036	0.44721	0.46667	0.15818	-0.08643	0.12887
	0.3161	0.7246	0.3390	0.2666	0.2437	0.7083	0.8387	0.7610
Group	-0.43230	0.14907	0.58554	0.44721	1.00000	0.77546	-0.34026	0.06911
Nursery	0.2848	0.7246	0.1272	0.2666	<.0001	0.0237	0.4095	0.8708
Success	-0.41182	0.33333	0.43644	0.33333	0.74536	0.37095	-0.01223	0.22970
	0.3107	0.4198	0.2797	0.4198	0.0338	0.3656	0.9771	0.5842
School	0.59104	-0.44721	-0.39036	-0.74536	-0.60000	-0.67515	-0.10394	-0.42397
	0.1228	0.2666	0.3390	0.0338	0.1158	0.0662	0.8065	0.2952
Success	0.29120	-0.33333	-0.21822	-0.33333	-0.44721	-0.49173	-0.16880	-0.17123
	0.4841	0.4198	0.6036	0.4198	0.2666	0.2159	0.6895	0.6852
Personal	-0.22034	0.57149	0.82246	0.31644	0.33584	0.43919	-0.14749	-0.23688
	0.6000	0.1389	0.0122	0.4451	0.4160	0.2763	0.7274	0.5722
Public	-0.19289	0.65465	0.85714	0.21822	0.48795	0.55911	-0.13613	-0.22146
	0.6472	0.0781	0.0065	0.6036	0.2199	0.1497	0.7479	0.5981

Appendix I (Continued):Statistical Results

The CORR Procedure

Pearson Correlation Coefficients, N = 8
Prob > |r| under H0: Rho=0

	Running Water	Winter Garden	Summer Garden	High forest	Medium forest	Low forst	No forest	Park Reserve
Park Reserve	.	0.45153 0.2614	0.03937 0.9262	0.29277 0.4816	0.06667 0.8754	-0.25820 0.5370	-0.48795 0.2199	1.00000
Access Nat. regen.	.	-0.29630 0.4761	-0.51875 0.1878	0.14286 0.7358	0.29277 0.4816	-0.37796 0.3559	-1.00000 <.0001	0.48795 0.2199
Trees Field	.	-0.29630 0.4761	-0.51875 0.1878	0.14286 0.7358	0.29277 0.4816	-0.37796 0.3559	-1.00000 <.0001	0.48795 0.2199
Trees Home	.	.	.	.	.	.	.	.
Trans Field	.	-0.60723 0.1104	-0.82687 0.0113	-0.48795 0.2199	0.60000 0.1158	-0.25820 0.5370	-0.48795 0.2199	-0.06667 0.8754
Trans Home	.	-0.54495 0.1625	-0.27562 0.5088	-0.48795 0.2199	0.06667 0.8754	0.25820 0.5370	0.29277 0.4816	-0.60000 0.1158
PC Nursery	.	.	.	.	.	.	.	.
Success	.	0.23355 0.5778	0.74812 0.0328	0.48795 0.2199	-0.06667 0.8754	-0.25820 0.5370	0.48795 0.2199	0.06667 0.8754
Group Nursery	.	-0.07785 0.8546	0.66937 0.0694	0.48795 0.2199	-0.60000 0.1158	0.25820 0.5370	0.48795 0.2199	-0.46667 0.2437
Success	.	0.52223 0.1843	0.96850 <.0001	0.65465 0.0781	-0.44721 0.2666	0.00000 1.0000	0.65465 0.0781	-0.14907 0.7246
School Nursery	.	0.17127 0.6851	-0.51187 0.1947	-0.29277 0.4816	0.46667 0.2437	-0.25820 0.5370	-0.29277 0.4816	0.06667 0.8754
Success	.	0.31334 0.4498	-0.35218 0.3922	-0.21822 0.6036	0.14907 0.7246	0.00000 1.0000	-0.21822 0.6036	0.44721 0.2666
Personal Nursery	.	0.14947 0.7239	0.42790 0.2902	-0.20716 0.6225	-0.08660 0.8384	0.22087 0.5991	0.90594 0.0019	-0.33584 0.4160
Public Nursery	.	0.29630 0.4761	0.51875 0.1878	-0.14286 0.7358	-0.29277 0.4816	0.37796 0.3559	1.00000 <.0001	-0.48795 0.2199

Appendix I (Continued): Statistical Results

The CORR Procedure

Pearson Correlation Coefficients, N = 8
Prob > |r| under H0: Rho=0

	Access	Trees Field	Trees Home	Transplant Field	Trans. Home	PC Nursery	Success	Group Nursery
Park	0.48795	0.48795	.	-0.06667	-0.60000	.	0.06667	-0.46667
Reserve	0.2199	0.2199	.	0.8754	0.1158	.	0.8754	0.2437
Access	1.00000	1.00000	.	0.48795	-0.29277	.	-0.48795	-0.48795
Nat. reg.		<.0001	.	0.2199	0.4816	.	0.2199	0.2199
Trees	1.00000	1.00000	.	0.48795	-0.29277	.	-0.48795	-0.48795
Field	<.0001		.	0.2199	0.4816	.	0.2199	0.2199
Trees	.	.	.	.	.	.	.	.
Home	.	.	.	.	.	.	.	.
Trans	0.48795	0.48795	.	1.00000	0.46667	.	-0.46667	-0.46667
Field	0.2199	0.2199	.		0.2437	.	0.2437	0.2437
Trans	-0.29277	-0.29277	.	0.46667	1.00000	.	0.06667	0.06667
Home	0.4816	0.4816	.	0.2437		.	0.8754	0.8754
PC	.	.	.	.	.	.	.	.
Nursery	.	.	.	.	.	.	.	.
Success	-0.48795	-0.48795	.	-0.46667	0.06667	.	1.00000	0.46667
	0.2199	0.2199	.	0.2437	0.8754	.		0.2437
Group	-0.48795	-0.48795	.	-0.46667	0.06667	.	0.46667	1.00000
Nursery	0.2199	0.2199	.	0.2437	0.8754	.	0.2437	
Success	-0.65465	-0.65465	.	-0.74536	-0.14907	.	0.74536	0.74536
	0.0781	0.0781	.	0.0338	0.7246	.	0.0338	0.0338
School	0.29277	0.29277	.	0.60000	0.06667	.	-0.60000	-0.60000
Nursery	0.4816	0.4816	.	0.1158	0.8754	.	0.1158	0.1158
Success	0.21822	0.21822	.	0.44721	-0.14907	.	-0.44721	-0.44721
	0.6036	0.6036	.	0.2666	0.7246	.	0.2666	0.2666
Personal	-0.90594	-0.90594	.	-0.36964	0.39076	.	0.67379	0.33584
Nursery	0.0019	0.0019	.	0.3675	0.3385	.	0.0669	0.4160
Public	-1.00000	-1.00000	.	-0.48795	0.29277	.	0.48795	0.48795
Nursery	<.0001	<.0001	.	0.2199	0.4816	.	0.2199	0.2199

Appendix I (Continued):Statistical Results

The CORR Procedure

Pearson Correlation Coefficients, N = 8
Prob > |r| under HO: Rho=O

	Success	School Nursery	Success	Personal Nursery	Public Nursery
Park	-0.14907	0.06667	0.44721	-0.33584	-0.48795
Reserve	0.7246	0.8754	0.2666	0.4160	0.2199
Access	-0.65465	0.29277	0.21822	-0.90594	-1.00000
Nat. Reg.	0.0781	0.4816	0.6036	0.0019	<.0001
Trees	-0.65465	0.29277	0.21822	-0.90594	-1.00000
Field	0.0781	0.4816	0.6036	0.0019	<.0001
Trees	.	.	.	.	.
Home	.	.	.	.	.
Trans.	-0.74536	0.60000	0.44721	-0.36964	-0.48795
Field	0.0338	0.1158	0.2666	0.3675	0.2199
Trans.	-0.14907	0.06667	-0.14907	0.39076	0.29277
Home	0.7246	0.8754	0.7246	0.3385	0.4816
PC .	.	.	.	.	
Nursery	.	.	.	.	
Success	0.74536	-0.60000	-0.44721	0.67379	0.48795
	0.0338	0.1158	0.2666	0.0669	0.2199
Group	0.74536	-0.60000	-0.44721	0.33584	0.48795
Nursery	0.0338	0.1158	0.2666	0.4160	0.2199
Success	1.00000	-0.44721	-0.33333	0.53370	0.65465
		0.2666	0.4198	0.1731	0.0781
School	-0.44721	1.00000	0.74536	-0.42455	-0.29277
Nursery	0.2666		0.0338	0.2944	0.4816
Success	-0.33333	0.74536	1.00000	-0.31644	-0.21822
	0.4198	0.0338		0.4451	0.6036
Personal	0.53370	-0.42455	-0.31644	1.00000	0.90594
Nursery	0.1731	0.2944	0.4451		0.0019
Public	0.65465	-0.29277	-0.21822	0.90594	1.00000
Nursery	0.0781	0.4816	0.6036	0.0019	