Paraguayan Tung (*Aleurites fordii* Hemsl.): An Important Small Farmer Crop Diversification Strategy

By

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The thesis: "Paraguayan Tung (*Aleurites fordii* Hemsl.): An Important Small Farmer Crop Diversification Strategy." is hereby approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE IN FORESTRY.

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PREFACE

"To multiply the harbors, does not diminish the sea" - Emily Dickinson

I interpret the words of Emily Dickinson as a challenge to explore our world and extend our boundaries in hopes of increasing knowledge or understanding and that this challenge is a positive pursuit. This pursuit is a necessary activity involved in problem solving or the basic act of trying to understand our surroundings. This is the approach I used as a Peace Corps Volunteer working in Natalio 25, Itapua in southeastern Paraguay.

I have the luxury of looking backward at my experience with greater understanding after having analyzed my time spent working and living in rural eastern Paraguay. My official function as a Peace Corps Volunteer in Paraguay was that of an Agroforestry Extension Agent. My eventual role was created as I became more knowledgeable of the culture in which I lived. My primary focus was the promotion of improved farming techniques, specifically the integration of trees into the farm system. The most successful projects involved the construction of seedbeds for fast growing tree species. These trees were used for a variety of purposes ranging from windbreaks to reforestation parcels. Alternative soil conservation techniques such as the use of green manure, methods to curb soil erosion and crop diversification were all concurrently promoted. In addition, I advised an agricultural cooperative in a nearby community in the use of green manures. Secondary projects included the maintenance and management of bee colonies with local youth; work focusing on increased honey production, potential markets, and overall improved bee colony health. It is important for me to mention that all of this work in Natalio 25 improved with each new lesson learned and mistake made, a product of living and working in a community for over two years. I realized that promoting self-sufficiency and securing stability in personal farming systems is admirable if farmers can manage outside the cash economy. Unfortunately the external outlay of cash cannot be avoided for such products as improved seed and the cost of education. Thus the small producer limits his ability to compete by the very nature of being small and diversified. Through my own process of trying to understand my surroundings and working successfully with my neighbors I was able to create a study whose aims were to understand more concretely the existing agricultural systems and also to arm farmers with the information needed to make informed planting decisions.

CHAPTER 1 INTRODUCTION

Paraguay is a country with a unique and separate history located in the heart of South America. This agrarian nation faces a complex world of change and daily reminders of its own history. As it struggles to keep pace with the world economy it faces many obstacles such as quasi-institutionalized corruption, political instability, and high levels of poverty. For example, the average household income in Paraguay is the lowest in MERCOSUR ("Common market of the south" comprised of Uruguay, Brazil, Paraguay, and Argentina), not surpassing $2000 per year (Miranda, 2000). The average number of telephone connections per 100 inhabitants in Latin America is thirteen, while in Paraguay it is 4.7. Paraguay is struggling to transform itself into a democratic nation after years of military rule and organized suppression of the populace. A military coup led by General Alfredo Stroessner in 1954, marked the beginning of a government that suppressed all forms of popular organization. Required affiliation with the traditional *Colorado* Party for all public employees, the legal profession, and officers in the armed forces, ensured General Stroessner control of the majority of the country's institutions. This system helped the General to strengthen the economic power of the state and to filter profits to his main supporters, large landholders and "neo-*Colorados*", a military and civilian group who invested in land (Fisher, 1993).

The historical and current inequity of land distribution in Paraguay plays a major role in the formation of farmer strategies to survive and prosper on Paraguayan lands. Paraguayan farmers with small landholdings balance production between several cash crops such as soybeans, cotton, tung nuts, tobacco and several subsistence crops.

I was assigned specifically to work with Paraguayan small farmers as a Peace Corps Volunteer in the agricultural zone of Natalio 25, Itapua, Paraguay. One goal as a Peace Corps Volunteer was to work with farmers in efforts to improve farm system health through the introduction of appropriate farm technologies. It was essential, however, to first understand the particular farm system used by rural Paraguayan farmers and the individual components that comprise the entire system. My goal then became to analyze and understand the farming system within which I lived. Through this process it became apparent that the farmers utilized different strategies and crops to stabilize their farm systems. The process of trying to understand strategies used to maintain farm health led me to choose a singular cash crop, specific in distribution to the area, as a means to describe overall farm health. This crop, tung, is used to illustrate small farmer crop diversification and farm stability.

The thesis describes the role of tung within small farmer agricultural holdings as a strategy to maintain system stability and health. I begin in Chapter two with a general economic and geographic overview of Paraguay followed by a description of Paraguayan agriculture. The study site, Natalio 25, and the local agricultural system are also discussed. Important subsistence and cash crops located in the eastern Department of Itapua are introduced with an emphasis on tung. Chapter three provides an explanation of the biology of the tung tree and details Paraguayan cultivation methods. The methods used to gather information in Natalio 25 are discussed in Chapter four. Interview responses are present in Chapter five with examples from individual informants. I discuss individual benefits from the incorporation of tung into the farm system in Chapter six, along with the importance and presence of crop diversification in Natalio 25. In

Chapter seven I bring closure to the study by making recommendations with a discussion as to the role of the small farmer, his specific utilization of tung as a diversification strategy for stabilizing the farm system, and the future of Paraguayan tung production.

CHAPTER 2 BACKGROUND

The Republic of Paraguay contains a total area of 406,752 km^2 located between 54° 19' and 62° 38' west longitude and between 19° 18' and 27° 30' south latitude. The Republic shares borders with Brazil, Bolivia, and Argentina (Figures 1 and 2). Paraguay is a landlocked country with connections to the sea at 1600 km via the Paraguay, Paraná, and La Plata rivers or 1200 km away overland via the Brazilian port of Paranagua. The highest point in Paraguay is at 690 m in the Amambay Range with the lowest at 55 m near the city of Pilar. Paraguay has a population of 4,157,000 (Hammond, 1998). Paraguay's climate has been called subtropical continental with disagreement over the classification between tropical and subtropical (IIED as cited in Grauel, 1994).

The Paraguay River separates the country into two different environmental sectors, the western "Chaco" region and the eastern region. The Chaco contains 61% of the country's total land area and less than 2% of the population (Peace Corps/Paraguay, 1990). The Paraguayan Chaco is an enormous plain within the Gran Chaco, which spreads across parts of Bolivia, Argentina, and Paraguay. The Paraguayan Chaco, which represents a total area of 247,000 km^2, is an alluvial plain with impermeable subsoil prone to flooding around the drainage basins of the Paraguay and Pilcomayo rivers (U.S. Government, 1990).

Figure 1: Latin American Map

Source: http:/www.latinsynergy.org/latinmap.htm

Figure 2: Map of Paraguay

Source: http://www.odci.gov/cia/publications/factbook/geos/pa.html

It could be argued that Paraguay exists as three countries in one, comprised of the capital, Asunción, the eastern portion east of the Paraguay River, and the third being the Chaco. Augusto Roa Bastos, arguably Paraguay's most famous modern author, described this division within his country as, "…Asunción, the capital, the mother of towns and the wet nurse of cities, ignores the interior, by dint of which, nevertheless, survives." (Appendix). Augusto Roa Bastos further explains this division while explaining the Chaco, "The Chaco-the unknown country within my country-is the country that I most love for its unfathomable solitude, which reflects my own; and I see in this land the forgotten memory and fragmented dimensions of our America that, all the same, cries out for integration and unity." (Bastos as cited in Zago, 1997).

Bastos is describing the marked differences and contrasts that exist between the geographic regions of the Chaco and eastern Paraguay including Asunción. Eastern Paraguay, in contrast to the Chaco, is thoroughly drained by dendritic waterways draining from the Paraná Plateau to the Paraná or Paraguay rivers. The weather in the region east of the Paraguay River is subtropical with lush forests and low rolling hills. Rainfall ranges from 1,500 to 1,700 millimeters per year with common summer temperatures of 30° C and a winter average of 16°C. The soils in eastern Paraguay range from residual lateritic to red-yellow podsols. The temperate rain and temperatures aid in the accumulation of organic debris in eastern forests. These soils are ideal for swidden production of beans, corn, and manioc with some problems in the establishment of unfertilized permanent farming (Reed, 1995). The eastern region of Paraguay, including Asunción, is where 96% of the population resides and is the region where the majority of the economic activity takes place.

Economy

Paraguay's economy is heavily influenced by the informal sector, which is comprised of urban street vendors, micro enterprises, and the re-export of consumer goods to the neighboring countries of Brazil, Argentina, and Bolivia. Forty-five percent of the Paraguayan labor force is devoted to agriculture, constituting 28% of the Gross Domestic Product (GDP) (CIA, 2001).

The 1970s saw major changes in Paraguayan economics due to construction, hydroelectric development, agricultural colonization, and cash crop exports (Library of Congress, 1988). Paraguay, during the 1970s, experienced what some call an "Economic Miracle" showing an annual growth rate averaging over 10% compared to a rate of 3-4% experienced in the previous decades. With a per capita growth of over 50% Paraguay was a strong promising force for the future among a continent of weak economies (Reed, 1995). At the time Paraguay was the most agriculturally dominated economy in South America but ranked only ahead of Bolivia with respect to Gross Domestic Product among the Spanish speaking countries. Agricultural colonization and increased export cash crop prices during the 1970s saw the rise in agriculture, specifically the increased production of cotton and soybeans**.** Dependence grew, however, on these two crops as commodity prices fell along with a world recession. Throughout the 1980s Paraguay remained vulnerable to world price changes and local weather conditions (Library of Congress, 1988). The recession reduced agricultural land values and production without dramatically affecting important imports or costs of machinery. The devaluation of the Brazilian and Argentinean currency during this time decreased Paraguay's trading power

(Reed, 1995). Real income on a per capita basis has stagnated at 1980 levels, reportedly due to inadequate infrastructure, political instability, corruption, and substantial internal and external debt (CIA, 2001).

Agriculture

The economic boom of the 1970s was a result of increased amounts of land dedicated to agricultural production via government colonization programs. The initial push to colonize the east was led by the president of the republic, General Stroessner, and implemented by the newly created Rural Welfare Institute (Instituto de Bienestar Rural--IBR). The colonization of "un-exploited" lands in the mid-1960s was termed the "March to the East". Land was made available through the redistribution of foreign corporation holdings and government lands located next to the border of Argentina and Brazil (Reed, 1995). This land also became available as result of landholders with large parcels who were unable to technologically intensify production or prevent invasion from squatters. The push for colonization was an attempt to both colonize the thinly populated regions in the south and east and to reduce population and socio-economic pressures of the central departments (Bray, 1991). From 1975 through 1980 the amount of land dedicated to agriculture in eastern Paraguay doubled. In order to realize this increased production and deliver commodities to international markets previously forested lands had to be cleared (Reed, 1995). Soybeans, cotton, and wheat comprised the major crops planted in the new areas of colonization.

Paraguayan household relocation decisions as a result of increasing family size and reduced soil productivity traditionally include the movement to abundant "non-

exploited" lands (Hay, 1993). Because of a rise in population density in the central region and subsequent colonization of the northern and eastern regions, international agencies provided the means to cut roads into these new areas. At the same time, resource poor Brazilians, who most often employed more technologically advanced farming methods and had better access to capital, were encouraged to settle the region (Hay, 1993). Many Paraguayans circumvented the IBR agency, privately clearing land and creating homesteads without land title, in order to take advantage of the fertile forested lands in the eastern departments of Itapua and Alto Paraná. The southern and eastern departments of Paraguay are blessed with fertile soils and well-distributed amounts of rainfall and became a major destination for agricultural colonization. Agricultural surveys conducted in eastern Paraguay indicate that 10% of the land is best suited for forestry use, 40% for livestock, 30% for intensive agriculture, and 20% for moderate agriculture or livestock use (Library of Congress, 1988). The surveys indicate that 50% of the land in eastern Paraguay is available to be intensively managed to produce crops or a combination of livestock production and crops.

Itapua

Itapua, the seventh department to be established within the republic, is located in the southeastern portion of the country with the Paraná River marking its eastern boundary. Itapua is 16,525 km^2 in size, 70% of which was originally forested and inhabited by the Mbyá-Guaraní. In 1975 the percentage of area forested in Itapua and Alto Paraná was 70%. By 1983 the percentage of area forested dropped to 43%,

according to LANDSAT satellite images (CONSORCIO ISPAR/MAG as cited in Kapp, 1988).

As with most of Paraguay, the Department of Itapua is heavily dominated by and dependent on agriculture as the mainstay of its economy. The agricultural economy is comprised of a combination of subsistence and cash crops. The primary cash crops grown in Itapua are cotton (*Gossypium hirsutum* L.), soybeans (*Glycine max* (L.) Merrill), yerba mate (*Ilex paraguariensis* A. St. Hil), and tung (*Aleurites fordii* Hemsl.).

The Department of Itapua contains three different types of farmers. The first are large transnational companies dedicated to agricultural export production who employ modern cultivation methods. Next are family farms that also employ modern technologies, cultivating export products. The last category are the small farmers, normally Paraguayan by birth, who combine subsistence agriculture with cash crop production (Campos as cited in Kapp, 1988). The small farmers, the largest sector of the labor force in Eastern Paraguay, typically farm parcels of ten hectares or less.

The following sections will describe the economically important crops found in the Department of Itapua (Figure 3).

Figure 3: Map of the Department of Itapua

Source: Atlas de Paraguay, 1989

Important Small Farm Cash Crops in Itapua

Cotton

Cotton is well suited for the climate and soils in Paraguay and planting dates back to the time of the Jesuits, making it one of Paraguay's oldest crops. Increased planting and production occurred in the 1970s through the 1980s when the production of cotton jumped from 46,900 hectares in 1970 to 385,900 hectares in 1985. Paraguayan cotton is grown throughout Paraguay and is characterized by traditionally low yields and low

technological methods of harvest. Cotton is a the most common farm cash crop for Paraguayan small farmers. The majority of current Paraguayan cotton production is exported to Uruguay, West Germany, Britain, France, and Japan (Library of Congress, 1988).

Soybeans

Soybeans, unlike cotton, are a relatively new crop in Paraguay, first planted in 1967 (Figure 4). Soybeans found their way to Paraguay in the mid 1960's via Brazilian immigrants, a large portion of whom were of German descent (Bray, 1991). Soybeans replaced cotton as the dominant crop by the 1980s as a result of increased soybean prices. The amount of land dedicated to soybean cultivation in southeastern Paraguay is larger than any other cash crop (Figure 5). Large transnational companies produce the bulk of soybeans grown in Itapua. The companies plant soybeans in large parcels utilizing mechanized planting and harvesting methods. Family farms and small farmers also grow soybeans with much smaller individual parcels of soybeans. Small farmers generally plant between one and two hectares of soybeans per farm, if they choose to plant soybeans, which they plant by hand and harvest via contracted harvesters.

As the price of soybeans tripled in 1973, the area under cultivation jumped as a result. This increase in price attracted agribusiness from Brazil, the United States, and Italy which were interested in large-scale commercial production of soybeans. The soybeans produced in Paraguay are generally destined for world markets but a small portion, including locally processed oil, is consumed within the country (Library of Congress, 1998).

Figure 4: Field of Soybeans

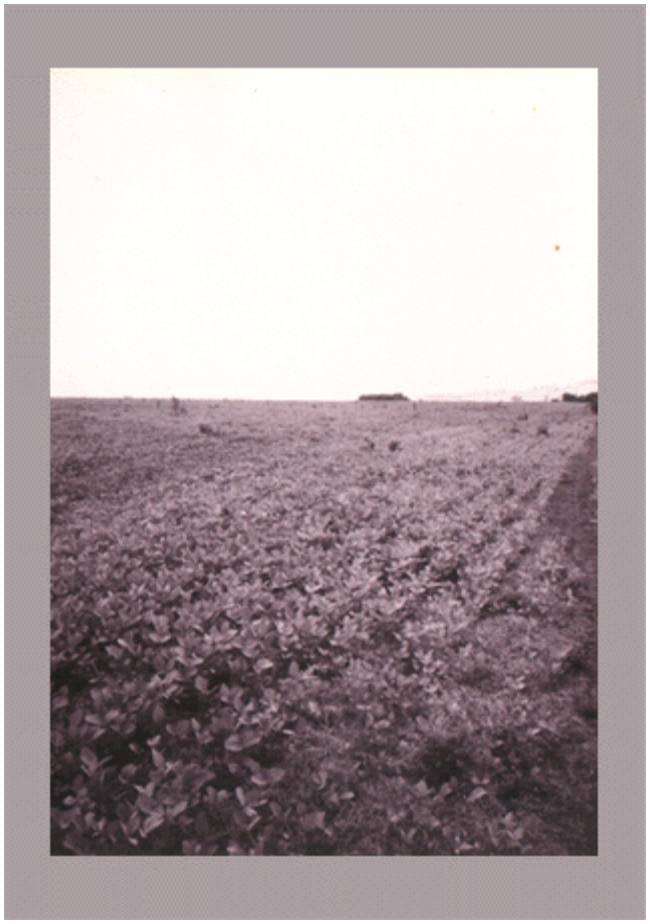
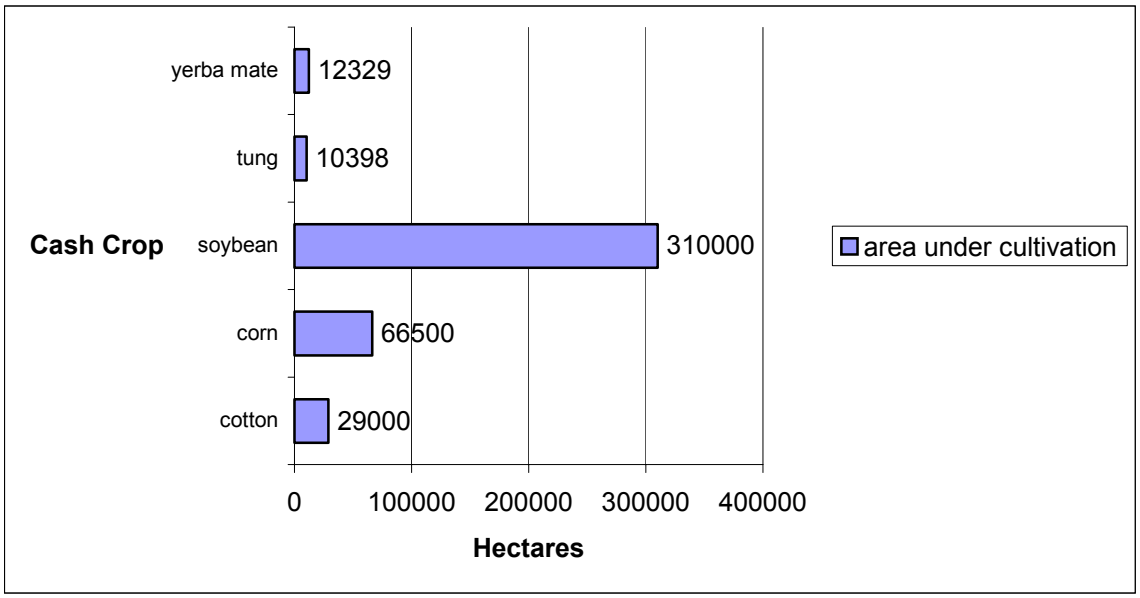


Figure 5: Number of hectares dedicated to several cash crops in Itapua, Paraguay



Source: Ministerio de Agricultura y Ganaderia. Producción Agropecuaria 1997/98 Asunción, Paraguay

Yerba Mate

Yerba Mate, a native tree species, is an important component of the agricultural system in eastern Paraguay (Figure 6)**.** The leaves and portions of new shoot growth are harvested and dried to produce a widely popular tea-like drink. Traditionally yerba, a forest understory tree, has been collected for domestic and commercial uses (Reed, 1995). Yerba is only grown, in significant amounts, in southeastern Paraguay for national consumption. National consumption is supplied mostly by large yerba producers in the Department of Itapua. Small farmers that choose to plant yerba generally plant parcels that are no greater in size than two hectares. The area under cultivation for the agricultural year of 1997/1998 was 29,280 hectares (Producccion Agropecuaria, 1998).

During the past 100 years, the extractive industries in Paraguay, including yerba mate, have experienced commercial booms and busts (Reed, 1995).

Figure 6: Mature Yerba Plant

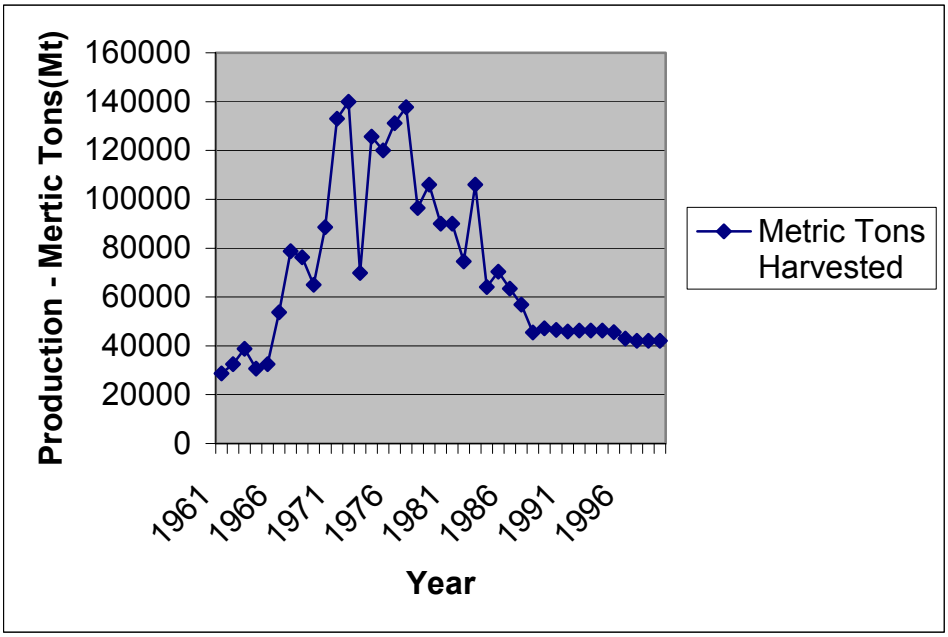
Tung

Tung, a native to subtropical China, is a fast growing deciduous tree, which may reach 20 feet at maturity (Figure 7). Tung is found only in southeastern Paraguay and planted by small farmers and medium sized family farms. Parcels of the tung crop are normally planted in 1-3 hectare plots by small farmers. Decisions to plant tung and thus the amount of tung planted in eastern Paraguay has been sensitive to changes in tung nut prices. This sensitivity has existed since the introduction of tung to Paraguay, 40 years ago. The production of tung has varied greatly from 1961, the year tung was introduced to Paraguay, to the present (Brack, 1992) (Figure 8).

Tung produces an amount of fruit sufficient to harvest after the third year. The fruit contains non-edible oil, which is extracted after drying. Each tung fruit contains 4-5 nuts, each of which is 20% oil when dried (Carter, 1998). Tung is grown in the southeastern region of Paraguay. Tung has a economic life of 30 years with mature trees producing between 2-3 tons of seed per hectare per year (Rehm, 1984). The area under cultivation in Paraguay as of 1999 was 10,000 hectares (FAO, 2001). Chapter three focuses on the botany and cultivation of tung in southeastern Paraguay.

Figure 7: Mature Tung Tree

Figure 8: Tung Production in Paraguay



Source: http://apps.fao.org/lim500/wrap.pl?Crops

Natalio 25

Natalio 25 is located in the District of Natalio, Department of Itapua, in southeastern Paraguay (Figure 9). Natalio 25 sits almost exactly equidistant, fifteen kilometers, from the towns of Maria Auxilliadora and Natalio 10. Route 6, which connects Cuidad del Este and Encarnación, the second and third largest cities in the country, bisects the city of Maria Auxilliadora.

Approximately 800 people live within the 6 *lineas* (roads within the community), which comprise Natalio 25. There are two primary schools in the area, one located 1km away in Natalio 26 and the other 2-km away in Natalio 23. Approximately 80% of the households have electricity. No central running water system exists in Natalio 25. The majority of the families in Natalio 25 draw their water from household wells.

Figure 9: Natalio 25

Source: Christopher J. Rosin

Local Educational Opportunities

Several families in Natalio 25 have been able to send their children to a local agricultural school called the Centro de Educacion, Capacitacion, y Tecnologia Campesina (CECTEC). The mission of the school and jointly the families, is to provide opportunities for people with limited resources. The school offers a chance to study, in order to maximize the value of family labor for agricultural tasks via improved appropriate technology. The school addresses the problems of farm labor underutilization and marketability. The school also attempts to solve the problem of how education widens the social gap, in rural Paraguay, between the educated and the uneducated (CECTEC-Manual).

Local Agricultural System

The lands surrounding Natalio 25 may be referred to as "new" agricultural lands when compared to other agricultural zones in eastern Paraguay. The lands chosen to be redistributed to peasant farmers through General Stroessner's "March to the East", included Itapua and Natalio 25. Land tenure history in Natalio 25 is recent enough to be able to speak directly with the farmers who cleared their parcels of land. The first families to arrive in the area did so approximately 30 years ago. According to the agrarian reform laws passed in the 1960s, rights were given to agricultural colonists to farm twenty hectare parcels. The forested parcels needed to be cleared to enable the cultivation of crops. Cash crops were planted in the newly cleared land, followed by

subsistence crops after production of the cash crops were no longer viable. The subsistence crops planted include peanuts, manioc, beans, and corn (Peace Corps/Paraguay, 1991).

Reduced production in these parcels often occurs as a result of poor soil conservation methods. Often the crops are planted along the contour, which are vulnerable to the heavy rains (1,200-1,800 mm/yr), which are common in eastern Paraguay from October to January. During these months recent preparation and planting of crops exposes and loosens the soil. Soil productivity is of major concern in the agricultural regions of Paraguay, including the Alto Paraná eco-region, which contains the most important agricultural soils in the country (Peace Corps/Paraguay, 1991). The Alto Paraná eco-region is comprised of the Departments of Alto Paraná and Itapua.

The majority of farmers in Natalio 25, Itapua rely on a small variety of cash crops as means of income generation. These include cotton, soybeans, yerba mate, and tung; plants whose primary role in the farming system is to bring in capital with little other on-farm use such as fodder or human consumption. While yerba mate may be found in almost every household in Paraguay, it is normally purchased already processed rather than produced on the farm for home consumption. While there are several other important cash crops in the region such as wheat, sunflower, and sorghum, small farmers normally avoid planting these mechanically harvested crops because of capital constraints. Several subsistence crops primarily peanuts, corn, and beans are sold if the amount harvested exceeds the expected family use for the upcoming year. Garden products such as squash, tomatoes, watermelon, and carrots can be suitably grown in Natalio 25. The most popular garden products are lettuce, onions, garlic, and peppers.

Livestock may comprise part of the farm system depending on the amount of land individual family owns. Typical farm animals include cows, pigs, chickens, guinea fowl, geese, and in some cases rabbits. The management of Africanized honeybee colonies is a widespread and common farm activity (Figure 10).

Figure 10: Revision of an Africanized honeybee box

Work in the winter months is dominated by preparation for the upcoming summer season. Typical on-farm work in the beginning of the winter months involves the end of the harvest of yerba mate, tung, and what remains of the cotton crop. This is also the dormant season for trees and when most pruning takes place. These three crops represent three out of four of the most important cash crops in the region for small-scale farmers. When the harvests are complete this is the time to pay off debts, plan for the next season with actual crop maintenance time spent in the fields at a year long low.

Crop Diversification

Farmers in Natalio 25 utilize a variety of agroforestry and farming system strategies to provide stability on their farms (Figure 11). Farmers may choose to mix subsistence and cash crops in the same parcel, plant trees alongside their agricultural crops, and implement additional activities that increase the diversity of the farm system. Farmers use a diverse farm system as insurance against uncontrollable factors such as weather and crop price fluctuations. Farmers' decisions to intercrop is not an activity specific to Natalio 25. It is established that intercropping throughout the world can produce beneficial economic advantages and increase overall crop yields. Intercropping with trees can generate long term returns, improve fertilizer-use efficiencies, and reduce erosion on steep slopes (Nissen, 2000). In addition to the principal crop, a bonus crop may be grown in intercropping systems (Prasad, 1997). King and Chandler (1978) describe agroforestry systems as "sustainable land management systems that increase yield of the land, combine the production of crops (including tree crops and forest trees) and animals simultaneously or sequentially on the same unit of land, to promote appropriate management practices that are compatible with the cultural practices of the local population".

Figure 11: Examples of diversified Paraguayan farm systems

Corn interplanted with yerba and native and exotic trees species

Corn interplanted with yerba

There is enough evidence in the literature to suggest that forest trees and agricultural crops can be grown together without deterioration of the site. For example, in the taungya system described by Blandford (1958), ancient cultural practices were used by societies to simulate forest conditions on their farms in efforts to obtain the beneficial effects of forest structures.

Small-scale farmers in Natalio 25 attempt to balance their farm systems with involvement in both cash crop and subsistence production. Farmers utilize various activities to maintain their resource base, one of which is the diversification of the farm system. Beets (1990) defines the crop diversification as "…increasing the numbers of crops or production enterprises per farm…" as a means to raise farm productivity. Beets'

definition and subsequent separations of diversification strategies help to describe the farming system in Natalio 25. Two specific diversification strategies that farmers use in Natalio 25 which mimic strategies as described by Beets are multiple cropping as used in traditional systems to avoid risk and the inclusion of trees to increase cash income and sustainability (Beets, 1990).

The work of Ortiz (1976) on risk aversion and subsistence and cash crop decisions with Amerindians in Colombia explains the rationale and decisions of farmers when faced with uncertain incomes and the need to maintain the survival of the family unit. He states that the farmers will increase cash crop production to a size that is considered "feasible and safe", or which does not interfere with their production of subsistence crops. Crop decisions reflected the avoidance of debt. The farmers designated resources to maintain the stability of their family and increase production and income without "endangering the family". Ortiz's claim that the Amerindian farmers view their production as two "non-comparable ventures", a land allotment for cash crops or subsistence crops is similar to modes of production in Natalio 25.

In general farmers in Natalio 25 do not sell their subsistence crops and the cash crops that are grown are not edible or utilized and do not overlap. He explains that dividing land into categories of production, cash versus subsistence crops, does not infer that farmers wish to plant the same amount or the same crops year after year. Ortiz is explaining the flexibility of the farmers to shift production from cash crops to subsistence or vice versa depending on environmental and economic factors. Farmers in Natalio 25 practice similar production shift strategies but also have a larger range of cash crops from which to choose.

An example of a multi-cropping strategy in Natalio 25 involves the planting of subsistence crops such as corn and beans between rows of young tung trees. Farmers do not have to totally remove subsistence production from areas where they plant tung. Cropping systems that utilize different species use available resources more efficiently because different species occupy different niches. Farmer risk is reduced by diversity of crops (Noorwijk & Van Andel as cited in Beets, 1990). Farmers in Natalio 25 are conscious of the need to utilize strategies such as crop diversification to lessen risk and to strengthen their individual resource base. A goal of subsistence farming is maximization of insurance rather than to maximize production (Ortiz, 1976). Worldwide farmers use diversification as an insurance against various types of risk (Lucas as cited in Amend, 2002). Farmers in Natalio 25 may be compared to farmers worldwide in their attempts to maintain stability of the farm system through diversification.

Societal Structure

The current racial make up of the Paraguayan population is mestizo, mixed Spanish, and Amerindian. In 1539 Domingo Martinez condemned to the gallows many indigenous Paraguayans responsible for conspiring to kill the Spaniards living in Asunción at the time. The result of this public show of reprisal was that the indigenous population handed over all of their young women to the Spaniards (Zago, 1997). The unaccompanied male conquistadors and priests had children with Guarani women. With no new Europeans arriving in the region, the mestizo offspring inherited the rights of their European fathers but spoke the language of their mothers. Today 90% of rural

Paraguayans speak Guarani interspersed with a small amount of Spanish (Roett in Reed, 1995).

This historical mix of race helps to define the Paraguayan of today. This mix of heritage and culture is especially expressed in the Department of Itapua where settlements of Japanese, Brazilians, Germans, and Ukrainians may be found. Smallholder Paraguayan farmers of Natalio 25, as well as other small eastern Paraguayan communities, find that they are surrounded by farmers of varying ethnic backgrounds. In several communities the lands surrounding them are owned by large agribusinesses, land rich Paraguayans, or land rich foreigners. In effect, pockets of resource poor Paraguayan farmers, isolated indigenous groups, and foreign agribusiness make up the landscape in Itapua. That is not to say however, that resource poor foreigners are absent from the landscape.

A clear distinction may be seen between the agribusiness farming system and the resource-poor Paraguayan farming system. The most marked feature is the absence of trees. Agribusinesses concentrate on the production of soybeans and wheat and to a lesser extent sorghum and sunflowers. Each of these crops are planted in large tracts and harvested mechanically. The presence of roots and trees are an impediment to harvest with large machinery. High plant populations are recommended for high yields, 250 000 to 400 000 plants per hectare. Soybean are planted at a high plant per hectare density, making manual harvesting difficult (Mesquita as cited in EMBRAPA, 1994).

Manual harvest of soybeans in Natalio 25 is not practiced. Small landholder farmers manually plant and weed soybean with the use of hoes until the amount of leaves impedes movement between planted rows. The soybeans are harvested with large

threshing machines normally owned by agribusinesses in the area and are hired out to individual farmers.

While working in Itapua, specifically, Natalio 25, my aims were to more concretely understand the benefits received by Paraguayan farmers from the types of cash crops planted. I observed that small-scale Paraguayan farmers, with ten hectares or less, chose a variety of cash crops with each farmer possessing one or more of the four local cash crops. The area under cultivation of each crop varied for each farmer. I wanted to find out what the reasons were for planting each crop, specifically tung. I also wanted to discover, with respect to agroforestry systems in Paraguay, if tung offers specific advantages to the Paraguayan small farmer. My observations led me to develop the following question: Does planting tung offer farmers an increased soil conservation and economic potential? This question provided me with a basis upon which I conducted my field research.

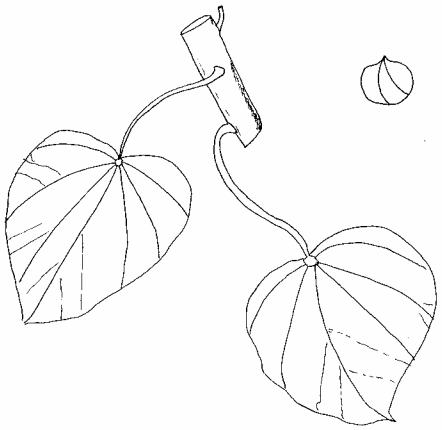
Chapter 3 Tung

Farmers in eastern Paraguay began to plant tung, *Aleurites fordii* (Hemsl.) also known as *Vernicia fordii* (Hemsl.) Airy-Shaw, approximately 40 years ago. Tung is a deciduous tree in the Euphorbiaceae family and a native to China that produces non-edible oil extracted from the endosperm of the tung seed. Fallen fruit is harvested because the valuable non-edible oil has uses ranging from waterproofing to drying agents in the paint and printing industries (Bernardini, 1983). Tung nuts are spherical, 5-8 cm in diameter, and contain 3-7 seeds per nut (Figure 12). Tung leaves are dark green, heart shaped, alternate, simple, and up to fifteen cm wide (Figure 13). Flowers are monoecious, pale-pink to white with 5-7 petals and form in clusters (Russell, date unknown).

Several other species of *Aleurites* produce tung-oil but usually produce low quality oil. *Aleurites montana* is the most commercially important tung species in China and is grown in the southern United States. Bees are essential in the transfer of pollen from anthers to pistil (Duke, 1983).

Figure 12: Tung Nuts

Figure 13: Tung leaves and nut

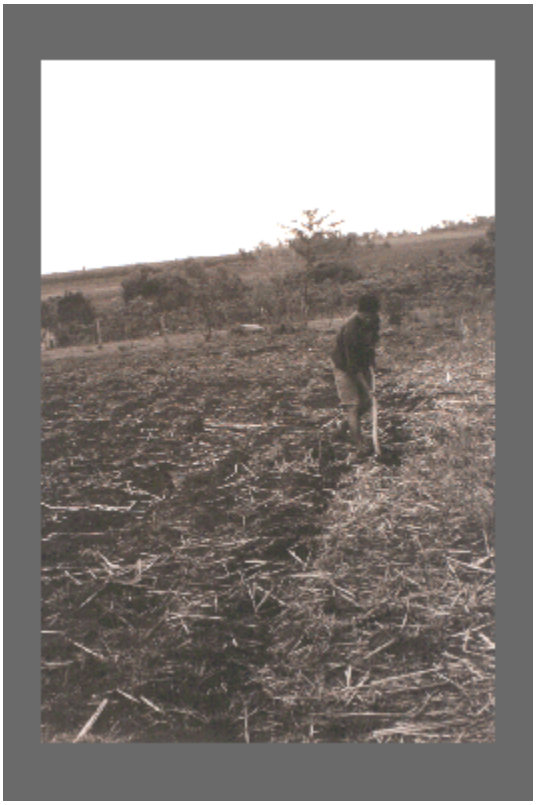


Source: Adapted from Brack, 1992

Climactic factors limit tung tree distribution to eastern Paraguay with the greatest amount of production found in the Department of Itapua. Tung trees require well-distributed annual rainfall of approximately 112 cm/yr and temperatures below 7.2°C for a period of 350-400 hours (Duke, 1983). These climatic conditions are found in the Department of Itapua.

Tung trees are propagated by planting two to three tung seeds per hole, 10 to 15 centimeters in depth. Seeds are planted in the holes by hand or with the use of a hoe (Figure 14). Normal spacing between trees is two to three meters, with spacing between rows of eight meters. Trees may be planted at densities between 125-750 trees/ha (Duke, 1983). Commercial production usually begins after the third year and may continue to produce for up to thirty years. The nuts drop from the trees in the months of April and May and are collected by hand. Since tung nuts drop over a period of two to three months they require several harvests. Tung nuts are left on the ground for a period of two to three weeks to allow for a reduction in nut moisture content, then collected. Some farmers choose to store their harvested nuts in dry areas, such as sheds, before they are sold.

Figure 14: Planting tung seeds



The maintenance of tung plantations requires farmers to keep the area surrounding the trees free of weeds. The weeds need only be cut or removed to a point as not to impede the hand harvest of the nuts. During the first three to five years after planting, the area between rows may be intercropped with maize, soybeans, or other subsistence crops (Figure 15). Intercropping with tung has been reported since the 10th Century in the Fujian Province of China with tea plants (*Camellia sinensis*) (Shoubo, 1997).

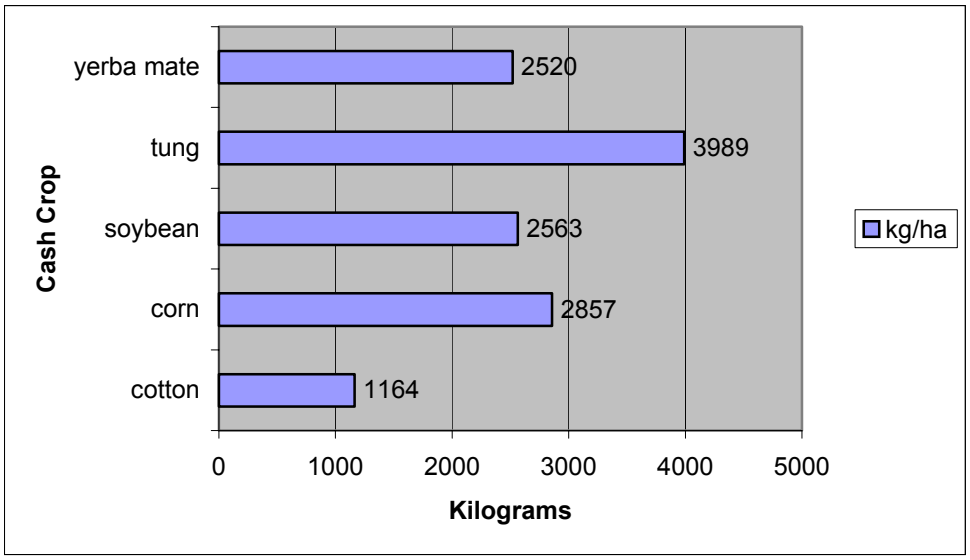
The growing tung trees benefit from the weeding and maintenance done in this area for the annual crops. Similar positive tree-field crop interactions are found in other

agroforestry systems (Bergert, 2000). One assumed expectation of an intercropping system is the increased overall production of the system and also the existence of a perennial crop without negative effects via the presence of an annual crop (Liyanage, 1984). Liyanage *et al*, illustrate additional positive benefits of intercropping such as more intensive land utilization, elimination of weeds, additional income generation, and income from cash crops in their work with intercropped coconuts in Sri Lanka.

After the tung trees are established, the weeding prior to harvest is the only maintenance activity. Farmers in Itapua generally do not prune tung trees or graft tung buds from other tung trees with desirable growth or production characteristics as is practiced in the United States. The yield for tung nuts in the United States is 4.5-5 metric tons per hectare (Duke, 1983). The amount of tung nuts harvested in Itapua for the agricultural season of 1997 to 1998 was 3989 kg/ha (Figure 16). Pesticides are not used in the regular maintenance of tung plantations in Itapua.

Figure 15: Young tung trees

Figure 16: Agricultural production per hectare for several cash crops in Itapua, Paraguay



Source: Produccion Agropecuaria. 1998. Ministerio de Agricultura y Ganaderia; Direccion de Censos y Estadisticas Agropecuarias. Asunción, Paraguay

There are many interesting changes and prospects involving tung that warrant further investigation. For example, possible changes in legislative regulation by the Environmental Protection Agency (EPA) involving reduced volatile organic compound (VOC) content of paints and coatings would favor the use of tung in the paint industry (Fact Sheet 10, 1997). Tung oil dries chemically rather than evaporating and does not release VOC's into the atmosphere, as do solvents used for the same reason. The Industrial Oil Products company is promoting the use of their product, TUNGSOLV 2000™, which they claim may substitute or reduce solvent content in paints. The creation of the American Tung Oil Corporation was designed to explore the possibilities of reviving the US production of tung. Approximately 4000 acres are scheduled to be planted in the next three years (Fact Sheet 10, 1997).

These proposed changes and increases in US production may have an effect on Paraguayan tung production and price. Possible effects include a lower demand for Paraguayan tung due to preference by US buyers for locally produced tung. US based consumers of tung oil may prefer locally produced tung which would have lower transport costs. If US consumption is fed by internal sources, a decrease in imported tung may result. Paraguayan tung production could face export problems if the US, a major consumer of tung oil, no longer requires Paraguayan tung. However, if tung oil use increased to a point which surpassed US tung production, Paraguayan and other tung producing nations could benefit from an increase in the demand for tung.

Tung trees were introduced into the United States in 1859 with significant efforts towards planting and harvest in 1905. The aim was to make the United States self sufficient in its supply of tung oil for use in the paint and varnish industry. Tung was

planted throughout the southeastern United States in the 1930's. However the market price of tung oil varied greatly in the 1940's and 1950's due to changes in the paint industry, weather hazards, and trade policies (Fry, 1973).

In addition, tung cultivation in the United States was susceptible to frost and hurricanes. Further, synthetic oil substitutes could be manufactured within the United States. The tung oil substitutes were not affected by import problems, such as civil war, specific to producing nations when the demand from the varnish and paint industry exceeded local production. US growers of tung increased production but not to the level needed to justify use of tung oil by American paint producers. Another factor for reduced tung cultivation was waning grower interest to plant tung when faced with the need to mechanize to be competitive. In addition, the tung oil was the sole product able to be utilized from the growth of tung trees. Individual American growers normally cultivated over 50 acres of tung, with some plantations as large as 500 and 1000 acres. Taxes were also cited as a deterrent to planting tung among farmers with larger landholdings (Fry, 1973).

A marked difference between the historical planting of tung in the United States and Paraguay is the role of operating costs and labor as components in tung cultivation. American tung growers were faced with increased operating costs, stagnant tung prices, increased taxes, and wage laws with respect to tung cultivation (Fry, 1973). Paraguayan farmers face different obstacles in their attempts to profit from tung cultivation. The majority of Paraguayan farmers do not employ machinery in their tung parcels. Major costs in tung production are harvest and pre-harvest cleaning which involve hiring workers with machetes to clean the area and hand pick the fallen nuts. Also property tax

is not a cost for farmers who do not have land title. For those that have land title the property tax is fairly low at 7000 Gs/hectare/year ($2.24). In addition, the area under cultivation in Paraguay is between one and three hectares per farm versus 50-1000 acres (20-400 hectares) traditionally planted in the United States. Historically tung production in the United States has not prospered and if demand increases, buyers may look to foreign sources for tung oil.

The "*Cooperativa Colonias Unidas, Agrop. Ind. Ltda.*", one of the largest agricultural cooperatives in Paraguay, is currently promoting tung planting. In the Department of Itapua this program was initiated to increase tung nuts produced in Itapua and, therefore, to provide more tung nuts for the tung oil processing plant which is owned and operated by the cooperative. Farmers traditionally leave the felled tung tree in the field to decompose. Efforts have begun to manage tung plantations owned by members of the cooperative in ways that will produce multiple benefits from planting tung. Instead of burning tung trees in parcels that are no longer producing fruit, the cooperative hopes to find alternative uses of the wood. Initial studies have begun to explore the possibility of tung as a source of furniture-quality wood. Local mills have produced furniture, veneer, and light construction materials from tung wood (Nunez, 1999). There are conflicting views between farmers as to the suitability of tung as firewood. Currently tung wood is not listed as a species of commercial timber value according to the forestry laws of Paraguay (Leyes Forestales del Pais).

CHAPTER 4 METHODS

I was interested in clarifying on-farm costs related to the production of tung versus other cash crops as well as advantages realized by farmers choosing tung. Tung exists only in eastern Paraguay and very little work has been done to explore agroforestry potentials incorporating tung. I began to try to understand the role of tung in southeastern Paraguay. Answering this question, or the process of finding an answer helped me better understand the site within which I lived and possibly helped my neighbors and friends make more informed decisions about planting and their future.

Both the process and methods used to gather the information will be discussed in this section. The information was gathered between September 1999 and September 2000. The first step in the process was to collect information through informal interviews. At the beginning of the study I was still relatively new to the community and informal interviews were appropriate for collecting preliminary data. I utilized unstructured interviews with individual informants as my next information gathering method. I created a questionnaire for use in structured interviews after I had administered the unstructured interviews. As my understanding of the agricultural system grew along with my familiarity of community members, I began to search for key informants. These informants were interviewed utilizing unstructured interviews. Each method used in gathering information was chosen reflecting my understanding of the community and subsequent ability to chose appropriate sampling techniques. A description of each method used in conducting the interviews is discussed.

Informal Interviews

Participant observation, which requires living in an area for weeks or months, is an effective tool in gathering information in small communities. An important key to gathering reliable information is community acceptance and full involvement in community life. Participant observation allows the researcher to be in contact with a continuous flow of information (Nichols, 2000). As a participant observer, I was able to assess community resources and areas of major concern. Living in Natalio 25 for two years allowed me to experiment with various information-collecting methods. This was a process of trying various approaches and deciding whether or not they were appropriate. Mistakes made while choosing differing collection methods as well as their administration was an important step in the gathering process. These mistakes allowed me to refine my data collecting techniques and to identify whether the methods were effective in eliciting pertinent information.

I began with informal interviews to gather preliminary general information about life and work in rural Paraguay. I used this method because I needed a general information base about Natalio 25 and the people living within the community. Bernard (1995) supports this initial approach by explaining,

> "Informal interviewing is the method of choice during the first phase of participant observation, when you're settling in and getting to know the lay of the land. It is also used throughout fieldwork to build a greater rapport and to uncover new topics of interest that might have been overlooked".

It was precisely this approach that led me to change my initial focus. I had initially chosen to analyze the differences in technological adoption by different farmers within the same farm system. It was through informal interviews and time spent living and working in Natalio 25 that I uncovered a more pressing issue. According to the local farmers the general question of annual change in the value of local cash crops was a central part of the decision making process. It affected topics ranging from crop planting to household expenditures. This could be described as my active process of redefinition through participant observation, an attempt to assess whether my current search warranted further thought and effort.

Unstructured Interviews

I utilized unstructured interviews with key informants, farmers that planted tung, and explained the aims of the interview. The interviews were conducted at my home, the homes of the farmers, in the farm fields, and while drinking *terrere* after working. Each informant was aware that the conversations were an attempt to gather information related to tung. I provided the opportunity for individuals to explain how tung fit into the local agricultural system and to make sure I understood the local system. This method of interviewing provided a forum where each informant was able, at their own pace, to explain their view of the local system via their personal observations and experiences. I was trying to elicit responses that were the observations of the informants. I was trying understand what each farmer thought with respect to the local farming system.

Structured Interviews

While gathering information through interviews and evaluating effectiveness of each method I decided to conduct several structured interviews. I began with a list of questions, which were discussed with each key informant in order to better quantify the information I was gathering (Table 1). After creating a list of questions for each key informant, I discovered that the farmers where not answering all of the questions and responses did not include any additional information other than the what the question specified. These types of questions normally elicited a single response of yes or no. I had difficulties administering the questionnaire to the majority of the farmers. Farmers would answer the first few questions with yes or no responses but would quickly change the topic or leave the interviewing session. Farmers were not comfortable with a set list of questions, some of which asked for information specific to their individual farm system. Questions that required responses related to farm systems in general or at a local level did not produce anxiety and information was given freely. It is pertinent to mention that up until 1989, the military dictator, General Alfredo Stroessner, had ruled Paraguay. During this 35-year dictatorship it was prohibited, at risk of government reprisal, to gather in groups of greater than three people. This had effects on community members desire to work together and freely give information. The recent history of Paraguay was taken into consideration while trying to define a suitable method of data collection.

Table 1: Questionnaire

General Questions

1. How many hectares do you own?
2. Are you the owner of the property? Do you have the title? Is the title paid for?
3. How many people are there in your family? Of that number how many live in your house?
4. How long have you lived here?
5. Do you have water sources on your property?
6. Do you have forested land on your property? How much?
7. What products do you use from your forested land?
8. What products do you produce and how much do you produce per hectare?
9. What kind of animals do you have and how many?
10. Do you have honeybees? Do you sell the honey? At what price?
11. Do you have fruit trees? How many? Do you sell the fruit?
12. Do you have tung trees on your property? How much? How old is your plantation?
13. What species? How old are the trees? To whom do you sell the fruit? At what price? Do you use outside help during the harvest? How much do you pay the workers? Per hectare how much time would you say it takes to harvest?
14. When will you cut down the plantation? Will you plant tung again? If not, then what crop? In the 3 years before your plantation has harvest able fruit, will you plant other products alongside your seedlings? If so, what?
15. How much maintenance does your plantation need per month?
16. In your opinion which of your cash crops is more price stable?
17. Do you perceive tung as a crop which is beneficial to the soil or are other crops more beneficial? Beneficial for the soil and/or the environment?
18. What is your cost per hectare to plant Tung, Soy, and Cotton? Per kilo what is the market price for Tung, soy, and cotton?

Key Informants

In order to gather pertinent information, it was necessary to identify people within the community who were knowledgeable about farming. This initial broad approach required definition because the community as a whole has knowledge about farming by virtue of their location and livelihood. I needed, however, to separate farmers and community members who were involved in the cultivation or harvest of tung trees and those who were not. It was important that I identify informants within the community who were in some way involved in the cultivation, harvest, or purchase of tung nuts. I was trying to identify key informants. Key informants are chosen strategically with respect to the structure of the society, selectively sampling members of the society with specialized knowledge (Tremblay 1957, as cited in Bernard).

I was unable to distinguish members of the community with specialized knowledge about tung when I first arrived to live in Natalio 25. The process of first learning how to live in the community was my initial concern. The three-month training period provided by Peace Corps gave me a general understanding of the farming systems in Paraguay. It was not until I had been able to work with many different farmers in Natalio 25 that I could begin to make judgements and discern differences between individual farmer's fields and their separate methods of farming. I initially chose to work with an existing farming committee, working in the farm fields of the individual members. As I worked with the members I realized that they were too involved with individual projects within the committee and it became necessary to seek out other less involved farmers. Another group of farmers who where geographically, and later I found, politically, separate from the farmers committee were willing to work with me. I

began to work individually with the farmers from the second, loosely formed group. I eventually worked with a few farmers who were part of the existing committee and a few who were not involved in any structured farmer group. I initially worked in the fields of all the farmers in order to gain comprehension of each individual farm system. An unexpected result of this attempt to better understand the farming systems was an increased rapport between the farmers and myself. Participating in day-to-day agricultural tasks with farmers created a forum within which to ask about the farms and reasons for choosing particular subsistence and cash crops. By working with the farmers I began to recognize which crops they had decided to plant that year and to ask what crops they had previously planted. In addition to uncovering personal crop histories I began to inquire about future planting decisions. After I had a firm grasp of the local agricultural system I began to inquire specifically about locally grown cash crops.

I narrowed my scope among all of the farmers I worked with within the first year to select key informants who were interested in working with me and who were open to questions about the economics of local cash crops and tung trees. Informal interviews were also conducted with farmers who did not plant tung but they were not interviewed as key informants. Farmers who chose not to plant tung, planted alternative cash crops such as soybeans or cotton. Resource poor farmers with small landholdings choose to plant a combination of cash and subsistence crops relative to the size of their parcels. If a farmer decides to increase subsistence crop production and decrease cash crop area he may face difficulties because tung nut producing parcels are not easily replaced or substituted with subsistence crops from year-to-year. Thus the land-poor farmers may not choose to plant tung in their fields. I was interested in analyzing the benefits realized

from planting tung and how tung diversifies the agricultural system and decided to interview farmers with a greater farm diversity which included tung. In general farmers without tung in Natalio 25 represent a segment of the population that do not have a sufficient amount of land to dedicate to the production of tung or they choose to plant an alternate cash crop. It may be that small farmers who do not choose tung decide not to plant tung because of both land restrictions and credit incentives that exist with other cash crops. These questions about perceived and real benefits specific to individual crop selection are important and warrant further study but are not within the scope of this study. Therefore farmers who did not plant tung were not chosen as key informants.

I spoke to farmers in Natalio 25 who had varying size parcels of tung. I also interviewed members of an agricultural cooperative called Oñondivepa located in Maria Auxiliadora, Itapua. I chose to interview members of the cooperative because they were knowledgeable of current agricultural prices. They lived far enough away from Natalio 25 to represent a distinct group of farmers, living in close proximity to a major national highway and selling their agricultural products to different buyers than farmers in Natalio 25. I also decided to interview the agroforestry professor at the local agriculture high school (CECTEC) located in Pirapey, Itapua. The professor specifically taught the implementation and benefits of agroforestry systems specific to the eastern agriculture zone of Paraguay. I chose to interview the professor in an attempt to gather information at a macro level which was missing from my interviews with individual farmers. All of the conversations and interviews throughout the study were conducted in Guarani, Spanish, or both languages. The decision to speak Guarani or Spanish was made by each individual informant.

It became apparent, through casual conversations, that farmers living in Natalio 25 were aware of the differences between their farming system and that of larger agribusinesses. In most cases the local farmers did not own enough land to compete with the large agribusinesses. It was not readily apparent as to why local farmers would chose to plant crops which required large land investments to be competitive. One goal of the interview process was to understand the role of tung in the broader agricultural context of Natalio 25 and farmer decision making processes. The next section contains interview responses from questions pertaining to the agricultural system in Natalio 25 and the specifics of planting tung.

CHAPTER 5 INTERVIEW RESPONSES

This section contains individual responses from farmers in Natalio 25, members of the agricultural cooperative Oñondivepa, and a professor from the local agricultural high school. The first section contains responses from farmers who live in Natalio 25 and who have parcels of tung. I interviewed a total of fifteen farmers. The names of farmers have been changed. The responses are a general summary of months of interviewing among all of the farmers rather than all of the information gathered. The conversations and questions were asked of each individual farmer separately but questions specific to the upcoming tung harvest were asked within the month of April, the portion of the year that farmers are preparing for the tung harvest. A total of six members of the Cooperative were interviewed. The professor at the agriculture high school was the sole informant.

Small Farmer Reponses

Jose

Jose is 27-year-old farmer with approximately five hectares of 23-24 year old tung trees. He plans to systematically cut some of the trees so as to not cut all of the trees at once and lose all production at one time. He estimates that his trees are 23-24 years old and the maximum output during the life span of this section of tung was 10,000 kilos per hectare. He was positive that even if the price of tung nuts fell to a 100 guaranies

(Gs)/ $.03US (3119.1 Gs = US$1, 1999) per kilogram he would profit from growing tung (CIA, 2001). He mentioned that he felt that he would not earn 1,000,000 Gs($320.61) per hectare growing soybeans, but that he would earn this much with tung if it produced its maximum per hectare output. Last year he paid approximately 2,000,000 Gs($641.21) to cover his total costs for help in the harvest and weeding. At a price of 300 Gs($.10) per kilogram and an estimated yield of 25,000 kilograms for all five hectares his gross earnings would be 7,500,000 Gs($2404.53) and 5,500,000 Gs (1763.33) net. When asked about transport of the tung nuts he proposed two options. First, a buyer would come and weigh the tung nuts on the farm. He thought the on-farm price the previous year was 250 Gs ($.08). He felt it was more economical to sell the tung nuts on farm, rather than incur transport cost to the factory. He mentioned a percentage discount for wet or dirty tung nuts at the factory. He did not trust the factory and their claims that a percentage had to be discounted because of high tung moisture content and the presence of foreign objects in his tung. He also mentioned that the factory employed people to transport tung nuts from the farms to the factory. He seemed to think there was a new buyer of tung nuts in the city of Encarnación with a silo at Cruce Santa Clara, 25 kilometers away. He was fairly confident that different varieties of tung nuts were available free from the factories. Jose wanted to plant more tung, with seven hectares as his ideal amount of land dedicated to tung trees.

Ricardo

Ricardo is a middle-aged farmer with a total of five hectares of land and slightly more than one hectare of tung. Ricardo planted tung in an area where he noticed bad erosion and in the first year left the weeds that normally are cleared annually, explaining that leaving the weeds was not a problem as tung does not produce until the third or fourth year. He mentioned that soil in a tung plantation is like that of a regular forest, falling leaves and weed residue are left to decompose prior to the harvest. He thought that the major buyers were companies in Brazil and the United States.

Ricardo also planted a parcel of soybeans that required approximately 400,000 Gs ($128.24) initial investment of capital each year. His input costs are from herbicide at 70,000 Gs ($22.44) per hectare and he has applied herbicide twice to his two-hectare plot of soybeans. This year he suspects the price to hire a thresher to harvest his soybeans to be 180,000 Gs ($57.71). The previous years rate seemed to be 150,000 Gs ($48.09). He also incurred labor costs of 40,000 Gs ($12.82) for planting the two hectares.

Rocky

Rocky is a farmer from Natalio 25 who owns a total of ten hectares with approximately four hectares dedicated to tung production. He proposed planting grass beneath the young tung as a method to reduce labor and provide more food for his cattle. To clean between the rows of tung he plans to disc with oxen and clean the remaining area with his machete. His son estimated they harvested 4000 kilograms in 1999 with an

on-farm price of 300 Gs ($.10) per kilogram. The family paid members of the community to bag and gather the tung nuts.

In February the family “cleaned” the tung plantation. “Cleaning” is weeding beneath the tung tree canopy and is done before the tung nuts drop. Cleaning makes it easier to harvest the tung nuts from the ground. While talking about soil fertility Rocky mentioned, " ...the fallen leaves from the tung make new or better soil...a neighbor recently cut down part of his tung plantation and planted corn which came up really well because the soil is improved."

When asked why a local farmer replanted a parcel that originally had soybeans with tung the previous year, Rocky responded that the soil is probably old and tired. A previous conversation with the local farmer revealed that his decision to plant tung was in part due to less overall risk and work to plant tung versus planting soybeans.

Rocky has another parcel of tung, approximately one hectare, that is five years old. He also has a plantation of three hectares and, in this parcel, was able to intercrop with corn for the first three years. He also mentioned that his maize came up well in an area where he had previously planted tung and had removed the tung trees to replant with maize. He planted at a spacing of 8x3 meters with one to two seeds per hole. He mentioned that other local farmers chose to plant at a spacing of 8x2 meters.

He calculated that with a three-hectare plantation one needs to hire six people for a week (five days) of work to harvest all the tung nuts. This, of course, depends on the harvest year. If a farmer does not have their own harvest bags, he must purchase them at a cost of 700 Gs ($.22) and at times bags are sold for 1000 Gs ($.32) a piece. He bought his bags for 700 Gs ($.22). He uses 100 bags. Last year he harvested 900 kg/ha but his

assumes that the most he can expect to harvest is 4000 kg/ha/yr. The normal person can harvest 30 bags/day and last year he paid 700 Gs ($.22) a bag, or 21,000 Gs/day ($6.73). A worker can assume 105,000 Gs ($33.66) for a week of work. The total labor cost is 420,000 Gs ($134.65) for four workers. Rocky thought 500,000 Gs ($160.30) sounded more accurate. Each bag contains approximately 25 to 27 kilograms. He thought that when the tung is six or seven years old it can produce 8,000 kilograms maximum and 2000 kilograms minimum. He thinks that last year the price was 200 Gs ($.06) per kilogram.

According to Rocky the reason to have a little of every crop is so that the money comes in in stages. He stated that cotton is harvested in March/April and tung in May which provides a bit of spacing between each harvest.

Cooperative Oñondivepa

This section contains interviews from members of the agricultural cooperative Cooperative Oñodnivepa, located in Maria Auxiliadora, twenty kilometers to the west of Natalio 25. The names have been changed.

Javier

Javier is a seventeen-year-old male whose father is a member of the cooperative and he works with his father to manage their farm. Their family has a total of sixteen hectares. The sixteen hectares are separated into areas of agricultural production, rangeland, and forest. The family plants manioc, corn, soybeans, and cotton in the

agricultural portion. They have never planted tung. Javier thinks that there are not enough people growing tung in his *barrio* to warrant on-farm visits from tung buyers. Javier made the point that there are several places to sell both cotton and soybeans and that his community is very close to a major road, which makes transport easier. He mentioned that those who have tung transport the nuts to the factory themselves.

The family rotates their cash crop every year between, corn, soybeans, cotton, or a combination of these crops. Last year they did not plant soybeans or cotton. They concentrated all of their production on corn in response to low cotton and soybean prices, which have not improved in the past five years.

Javier mentioned that his father had sold his cotton in 1994 for 1000 Gs ($.32) a kilogram. The year before last, 1999 he sold his cotton for 980 Gs ($.31). Javier explained that pesticides and gas prices have risen since 1994 but the prices for the agricultural products have not. His father prefers corn because you harvest it yourself and it is less work to maintain. When producing soybeans, to harvest your soybeans you must pay someone with a thresher to harvest it. He also prefers corn because it only requires a small amount of pesticides.

Javier mentioned that he would like to raise cattle and be a supplier to a local meat market. His family already has a few head of cattle and he would be able to start small. If he wanted to farm he thinks he would need a tractor to be successful and he doesn't have the money. He says he is fortunate to live in Itapua because the soil is better here and there is a larger variety of crops one can grow. Javier is studying accounting but says that there are many accountants in Maria Auxiliadora without work. When asked

about the future of agricultural prices he said the government needed to make reforms or help the farmers.

Santos

Santos is a member of the cooperative and also sits on the board that is in charge of the management of the cooperative. Santos mentioned that only a few members of the cooperative grew tung but that there were movements and promotion in Itapua to plant more tung. Cooperative members used to have much more tung than they do presently but replaced tung with other crops when the price was no longer high enough to warrant continued planting. Santos was commenting about the current situation with cotton in Itapua when he said, " I hope the Minister of Agriculture stops donating cotton harvest bags, seeds, and pesticides to the farmers. Do you know why? It is the major reason the cotton situation is so bad right now. All of the donations are put into the government budget at prices much higher than real market prices. Where does all this excess money go? Into the pockets of the politicians that is where. I know farmers who have gone to take out credit worth 300,000 ($96.18) to 600,000 ($192.36) Gs per hectare. They take home four bags of seed at one bag/per hectare. They end up planting only one bag and pocketing the rest of the money. When the people from the national credit agency, the *Banco de Fomento*, come to see their production, they claim that the seed was so bad that only one bag sprouted. They claim…how can I, a poor farmer, pay you back? I was only able to produce one hectare."

"The cotton that we, the cooperative promote, produces about 800-900 kilograms per hectare. The price for grade one cotton is 900 Gs ($.29) and 850 Gs ($.27) for grade two."

Leonor

Leonor is a middle-aged farmer and member of the cooperative. His two hectares of tung are four years old. He planted his tung at six meters by three and a half meters. He said that this spacing was closer than most farmers plant their tung. He said that because of this spacing he had very little weeds and little maintenance. He sprays the weeds one time with a herbicide that kills everything but a hardy weed called *amambái.* The word *Amambaí* refers to ferns, which are classified into three separate genera, but the farmer is probably describing *Amambaí-guasú* which belongs to the *Alsophylla* genus (Torres, 1996). His production is between 6000-6500 kilograms per hectare. He transports his tung nuts to a buyer in Yatytay with his truck.

"No one talks [In Paraguay] about the future of each crop. We have to wait and see what happens each year. Itapua is better off than other departments in Paraguay. The soil is of good quality. We have yerba, tung, soybeans, and cotton. I plant my two hectares of tung to have a more stable security base."

David

David is a teacher at the local agricultural high school called CECTEC, which promotes sustainable farming, increased small farmer production, and improved farming techniques. The interview was conducted in April of 2001.

When asked about the distribution of tung in Paraguay he responded that there is tung only in Itapua, there is none in the center of the country, nor in the north. He said, "I personally do not grow tung but have worked with farmers who plant it in conjunction with *pasto jesuita* (*Axonopus compressus*). There are native and exotic trees that will work well in tung plantations. The theory is that the exotic seedlings will "look for the light" and their growth form will be straight, or straighter than if left to grow in their open form."

"I teach the management of agroforestry in two forms. First, in the forest or below forest cover and secondly in systems without forest cover…here in Itapua there isn't any more standing forest in large parcels. We are evolving and changing our methods of teaching with systems that exist around this area…we are trying to deal with how to incorporate the mechanized farming system, a system which most small farmers compete against without being part of it. The most important thing or the base to all the agroforestry we teach is the conservation of soils. There are many things a farmer can do to save his soil and think about his soils future…farmers may use green manures and erosion barriers. The small farmer has many tools at his disposal to conserve his soil. The small farmer needs to forget about planting the crops that the large landholders plant….Cotton is more or less "okay" but soybeans and mechanized crops provide only enough money at the end of the year to pay off the bills accumulated during the year."

"Most farmers don't have any other options other than to work the land…. Most farmers have a small amount of land, normally between three and five hectares. The small farmer needs to plant a large variety of crops to be safe. The small farmer needs annual, medium, and long-term crops planted in the same parcel to be more sustainable.

If the small farmer has a monoculture of one crop he cannot easily change over to another crop if that crop is not producing or low market prices exist. The farmer needs to rotate his crops, for example change his manioc one year with corn the next."

"Here in Paraguay we historically have a migratory system of agriculture. The farmer worked the soil until it no longer produced and then moved to new areas. Traditionally people left trees to provide a bit a shade for their crops. They then planted beneath the shade of these trees. There are very few crops that need 100% of full sunlight."

Interview Response Summary

All of the people interviewed have, in their own personal context, a connection to the farming system in eastern Paraguay. Each participant was able to detail their involvement in the system or their understanding of how it functions. The farmer interviews have explained the planting costs of tung, the individual variances in plantation establishment and maintenance, and benefits from incorporating tung into the farm system. Members of the cooperative provided tung planting information in an additional agricultural zone of Itapua and price and production comparisons with other cash crops such as cotton. The professor detailed small farmer production, agricultural problems specific to Itapua, and recommendations for the application of sustainable small farming practices. The following section will further detail the connection between

farmers and tung in Itapua and how diversifying the farm system with the incorporation of tung is beneficial for the small farmer in eastern Paraguay.

CHAPTER 6 RESULTS AND DISCUSSIONS

The previous sections have described the economic and agricultural history of Paraguay, the agricultural crops grown in Paraguay, tung as a specific eastern Paraguayan cash crop, interviewing methods, and the role and views of farmers dedicated to the production of the tung crop. The discussion to follow will concentrate on the benefits of tung as part of the small farmer agricultural system in eastern Paraguay.

Tung trees represent one component of the small farmer agricultural system in eastern Paraguay. Planting and maintaining tung requires a small amount of on-farm labor, minimal establishment costs, and no pest control costs. Tung may be intercropped in the first years of planting with cash or subsistence crops to increase productivity per acre. Income derived from the harvest and sale of tung nuts overlaps slightly with the cotton crop and represents extended income generation over a period when there is no sale of other cash crops. Tung plantations may help to curb erosion and the continuous canopy help to protect soil from direct exposure to solar radiation. Shade provided by trees helps to keep soil temperatures cool, decrease evapotranspiration, conserve water, and promote microbial activity (Elevitch and Wilkinson, 2001). Tung trees produce a marketable product in the short term (fruit), with possible saw log or veneer production in the long term, and are a better soil stabilizer than annual crops. Tung has a natural resistance to pests and disease and thus may be grown with few or no chemicals (Jacobson et al, 1978). Plantations are ecologically beneficial due to this natural resistance, in addition to providing habitat for wildlife and curbing erosion (Fact Sheet 10, 1997). Several positive conservation and economic benefits may be realized from the

decision to plant tung. Tung trees represent an important component of the small farmers agricultural system. The following sections will describe in detail the individual benefits realized from planting tung.

Agroforestry Systems Incorporating Tung

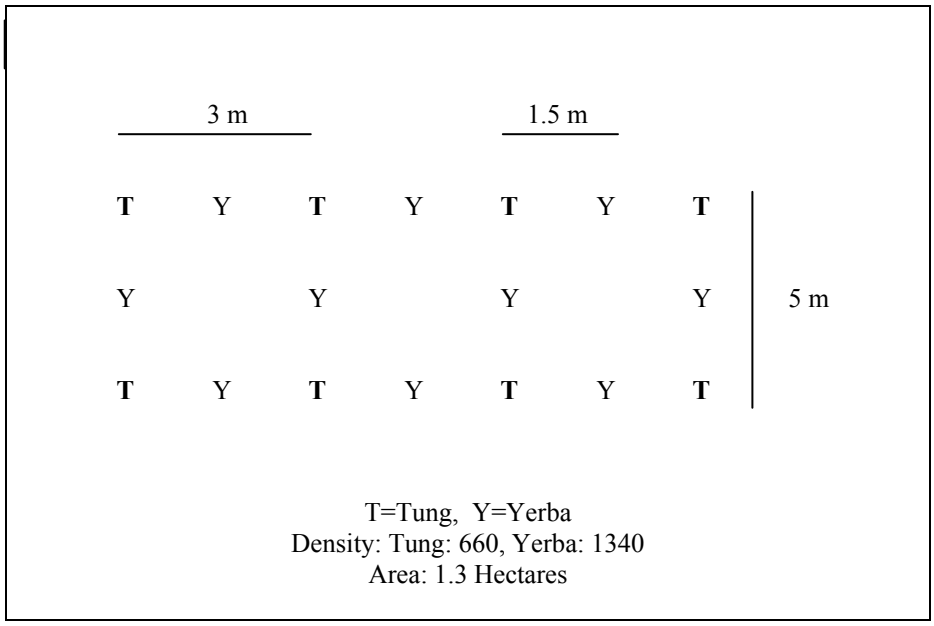
Farmers throughout Paraguay have and continue to experiment with the implementation of various agroforestry systems that include cash crops. The end goal of many of the experiments is increased crop production, the production of timber products, and maintenance or improvement of soil health. The suitability of soils and climate for the production of tung trees presents farmers in eastern Paraguay with another opportunity to experiment and implement agroforestry systems that include cash crops. One widespread example of a crop association with tung is planting maize or soybeans or both between rows of newly planted tung trees. Tung trees do not produce nuts until the third or fourth year and canopy closure does not occur until the fourth or fifth year depending upon the tree spacing. The intercropping of tung with soybeans and maize may be practiced until canopy closure. Intercropping with tung until the trees are old enough to create canopy closure enables the farmer to produce annual crops without the loss of subsistence crop production as a result of the decision to plant tung. Production of a subsistence crop such as maize or cash crop such as soybeans, may be realized from the first year of planting. Since no period exists without production, which may occur when planting tree crops without annual crops, farmers may easily implement an intercropping

agroforestry system. A potentially long waiting period between planting and production is one disadvantage realized by Paraguayan farmers who consider implementing pure tree crop systems (Peace Corps/Paraguay, 1991).

Local examples of agroforestry systems which incorporate tung exist in Natalio 25. One example illustrates the possibility of utilizing tung as a component of a silvo-pastoral system. A farmer living in Natalio 25 decided to plant his tung plantation with a larger spacing, three meters between tung trees and ten meters between rows. His idea was to create a plant spacing which allowed enough solar penetration to plant *Pasto jesuita*. *Pasto jesuita,* a forage grass, was able to thrive within his tung parcel. After the grass was established he was able to introduce his cattle into this area. His parcel is now 15 years old and he is able to graze his cattle in his plantation year round, excluding livestock only during the period of the most intensive harvest of tung nuts.

Various farmers have experimented with the planting of both tung and yerba in the same parcel. Brack, (1994) conducted an analysis of an agroforestry system in Lapachal, Itapua that contained both yerba and tung and recorded production per hectare in plots of equal size which contained tung alone, yerba alone, and tung and yerba mixed. The size of the parcel was 1.3 hectares with a density per hectare of 660 tung and 1340 yerba plants (Figure 17). The tung trees were fifteen years old and the yerba trees were eight years old.

Figure 17:Tung and yerba spacing and tree density per hectare



Source: Brack, 1994. Experiencias Agroforestales en el Paraguay. GTZ. Asunción, Paraguay

In addition to overall production of each individual crop, a cost analysis was performed which compared each crop versus the mixed crop parcel (Table 2). The total costs were highest in the parcel with both yerba and tung, but this parcel also displayed the greatest earnings among all three parcels. The mixed crop parcel showed a total gross earning of 2,448,000 Gs ($784.84) versus 1,800,000 Gs ($577.09) for yerba, and 648,000 Gs ($207.75) for tung.

Table 2 : Economic comparison of different tung and yerba systems in Itapua, Paraguay

	Yerba (Guaranies)	Tung (Guaranies)	Yerba with Tung (Guaranies)
Overhead Costs	124,000	84,000	124,000
Harvest	165,000	95,000	260,000
Transport	70,000	45,000	96,000
Pruning	46,000	24,000	46,000
Total Revenue	405,000	248,000	526,000
Gross Sales	1,800,000	648,000	2,448,000

Source: Brack, 1994. Experiencias Agroforestales en el Paraguay. GTZ. Asunción, Paraguay

The combination of tung and yerba on the same parcel is possible due to the physiological requirements of yerba. Yerba is an understory tree that can tolerate large amounts of canopy closure or shade. The open grown form of the tung tree is spreading and creates a dense overlapping crown when planted in plantations. Yerba is able to produce and thrive under the shade of the tung canopy while other shade intolerant crops may not.

The combination of both yerba and tung grown on the same parcel represent an system with several positive components. Yerba, after establishment, is a very low maintenance crop with low labor costs. Yerba provides a source of income in the winter months, the harvest season, while alternate cash crops are harvested in the summer. Although yerba often has low rates of germination, once it is established it is a low maintenance crop. Yerba may be a positive addition to parcels of tung due to its low labor and maintenance requirements, physiological requirements, and its ability to be intercropped with income and subsistence crops. Economically, planting both yerba and tung, may provide the farmer with higher per hectare profits than planting each tree individually.

A local farmer verified an additional possibility of incorporating tung into an agroforestry system. The farmer had decided to plant fast growing tree species such as Paraiso Gigante (*Melia azedarach* L.), Cedro Australiana (*Toona ciliata* M. Roem.), and Hovenia (*Hovenia dulcis* Thunb.) within his tung parcel (Figure 18). He explained that the seedlings are provided cover for their early growth and that the growth of the trees would be straighter in their search for light above the canopy. He commented that the shade from the canopy of the parcel did not allow planting of other crops. One goal of the introduction of trees to the tung parcel was that the trees would benefit his son who could harvest them when they were mature or, if an emergency arose, he could sell them.

Figure 18: Fast growing tree seedlings planted in a tung parcel

The preceding examples illustrate how intercropping and silvopastoral systems with tung can increase the amount of production possible per hectare and how it is possible to cultivate several agricultural products on the same area of land. Small farmers have the opportunity, with tung, to increase production and efficiency utilizing tung agroforestry systems.

Soil Conservation

Tropical and sub-tropical forests exist on potentially productive agricultural land but many forest stands grow on poor soil and the removal of forest cover can cause serious soil degradation (Mabberley, 1992). Soils in Paraguay are dependent on vegetation for stability and are generally poor (Reed, 1995). Trees as vegetative cover can improve soil health and ecosystem productivity (Evevitch and Wilkinson, 2001).

The incorporation of tung trees into the small farmer system provides several positive benefits in terms of soil health. Tung parcels in the first years of establishment may be multi-cropped with cash or subsistence crops. Farmers repeatedly commented on the activity of multi-cropping with tung and perceived this as a positive aspect of tung planting. Multi-cropping has many associated benefits such as the suppression of weeds, increased production of fodder, and increased environmental stability (Beets, 1990). Multi-cropping is often difficult to mechanize; mechanization is not a major obstacle in Natalio 25 because the majority of farm work is done by hand. The absence of heavy machinery, at least in the tung parcels, may help to reduce soil compaction.

Mature tung parcels form a semi-continuous canopy, dependent on tree spacing, creating shade during the spring, summer, and fall. The presence of trees and shrubs can reduce soil temperatures, increase infiltration and retention of soil moisture, and reduce water and wind erosion, which provide improved growing conditions for crops and grasses (Weber, 1986). Maintenance activities are not practiced until the tung harvest and pre-harvest begin. It is apparent, through multiple conversations with farmers about the need to increase farm labor efficiency, that farmers realized the small amount of labor

needed to cultivate tung nuts. A farmer in a Natalio 25 commented that if tung nuts were edible and tasty he would plant all of his land in tung, and only have to work one season a year. He also said that his income would be limited to one sum at tung harvest and that he would not be able to pay for unexpected expenses throughout the year.

The period prior to harvest allows for the growth of weeds that can tolerate the amount of shade beneath the tung canopy (Figure 19). When it is time to prepare for the harvest of the tung nuts, the weeds of the entire parcel are cut with machetes and left to decompose. Crop residues left in the field can increase the accumulation of organic carbon, nitrogen, phosphorus, potassium, and other nutrients (Prasad, 1997). Farmers mentioned the standard practice of replanting old tung parcels with subsistence crops when the trees are between 25-30 years old. Farmers realized that the soil was improved in areas where tung was formerly grown.

Figure 19: Mature parcel of tung with partial canopy closure

While gathering tung nuts with a farmer, I asked him what he thought of the soil in areas where tung is planted. He explained, "…it is likely that the leaves, which fall each winter, add nutrients to the soil. The soil in a tung parcel should be similar to that of the forest. I do not run my plow in the parcel and all of the weeds that are cut before harvest decompose within the parcel…. I often escape the heat of the day in the shade of the tung parcel when there are leaves and it is normally quite a bit cooler than in the soybean field I am hoeing."

Income stability-dispersion of funds

When faced with decisions concerning risk, such as the amount and type of crop to plant for the upcoming year, Paraguayan farmers are traditionally cautious and local in their analysis. The term local is used to explain the type of information that farmers normally receive through radio, extension agents, neighbors, and tung buyers. Typically farmers are aware of the current tung situation in Paraguay but not at an international level or, at times, regional level. With respect to tung, farmers are concerned about the price stability and speculate as to the next year's price. This same process is employed when making planting decisions for cotton, yerba, and soybeans. It is a slightly different process however when done with both yerba and tung. These two crops require longer initial time investments in order to reach harvest age and thus once established, their permanence on the farm is less affected by single year fluctuations in price. A farmer with a larger than average amount of land, 40 hectares, was convinced that tung would be more profitable than the soybeans he was growing. He had traditionally grown twenty hectares of soybeans with seven hectares of established tung. He had decided to plant his twenty hectares of soybeans with tung, continuing soybean production for the next two to three years until canopy closure. He cited lower maintenance and labor costs and reduced risk in terms of large price changes as the major reasons to replant with tung. However, some farmers have opted to cut down their tung parcels and replace them with other cash crops when they perceive a stagnation in the price of tung or speculate that the price is declining, or wish to plant crops with higher price per kilogram ratios.

Farmers carefully manage their resources to increase income and farm productivity without compromising the safety and health of their family (Ortiz, 1976). Farmers often do not have access to information to make informed crop price speculations.

In general farmers in Natalio 25 are aware of their personal costs related to tung production. They are not however aware of external pressures such as increased foreign supply which affect local crop prices. Table 3 shows the detailed cost per hectare specific to the production of tung. Table 4 compares the net income between tung and locally grown crops. Tung has the highest per hectare income at $326/ha, with the amount of labor dedicated to the crop lower than both soybeans and cotton. The information provided in Table 3 and 4 is from an independent study done with cooperation of the Ministry of Agriculture in Edelira, Itapua. The town of Edelira is located 35 kilometers from Natalio 25 and the farm system used in the study is similar to those found in Natalio 25.

The information provided by the farmers interviewed in Natalio 25 was consistent with the data reported in tables three and four. Slight variations in prices for agricultural products exist between individual farmers, but this is most likely due to different prices offered by on-farm buyers. For example, table three lists the price for tung at 380 Gs ($.12) per kilogram while the farmers reported that prices were 300 Gs ($.10) per kilogram with the lowest estimate at 200 Gs ($.06) per kilogram. Additional harvest costs incurred by farmers from Natalio 25 are consistent with harvest bag prices of 500 Gs ($.16) as shown on table three and a farmer response of 700 Gs ($.22). An additional source of variation, specifically for tung production, may be the age and subsequent

production levels of parcels of tung. New tung parcels (1-3 years) and old tung parcels (25-30 years) demonstrate low levels of production.

Table 3: Per Hectare Tung Crop Budget – Edelira - (Itapua, Paraguay)

	Unit	Quantity	Price	Sub-Total	Total	Income and Costs	% Total Costs
			Gs/Unit	Gs/ha	Gs/ha	US$/ha	
Income	Kg	3000	380	1140000	1140000	407	
Costs							
A. Technical Costs							
Seeds/Land Preparation/Planting[1]	Hectares	1	6200	6200			3%
Bags (4 years use)	Each	30	1000	30000			13%
Transport	Kg	3000	10	30000			13%
B. Physical Costs							
De-weeding	Days Wages	1	15000	15000			7%
Harvest	Bag	120	500	60000			26%
Bag Loading	Days	0.6	30000	18000			8%
Drying	Days Wages	4	15000	60000			26%
C. Interest[2]				8250			4%
D. Total Costs					227450	81	100%
Net Profit					912550	326	
Total Labor					6		
Return Per Day					162955	58.2	

1. US$ 1 = Gs 2,800(May 1998)
2. Calculated at 22% per annum of total technical costs for 6 months

Source: Sorrenson, W.J., Duarte C., Portillo, J.L. August 1998(a)

Table 4: Farm Budget-Conventional System

Crop/Activity	Area (ha)	Labor (Person – days)	Net Income (US$/ha)	Net Farm Income (US$)
Soybeans	7	116	132	922
Cotton	1.5	38	138	206
Maize	2	42	38	76
Peanuts	0.5	17	158	79
Various food crops	0.25	10	36	9
Yerba Mate	1	2	180	180
Tung/pasture	4	22	326	1304
Pasture-*Pasto cameroon*(Sugarcane)	0.25		17	
Cattle (tung plus new 4ha)		53		69
Forest	1			
Fallow	0.5			
Totals	18	300		2844

Return to Labor US$day=9.47

Source: Sorrenson, W.J., Duarte C., Portillo, J.L. August 1998(b)

Farmers are aware of the kilograms per hectare produced by each cash crop and distinguish between high cost and low cost crops. For example, informants repeatedly spoke about the high level of inputs needed to grow soybeans and their inability to reach the standard production level of 4000 kilograms per hectare, the average set by the Ministry of Agriculture. Farmers interviewed reported an average of 1500-2000 kilograms per hectare for soybeans. Certain farmers argued that it was not feasible to plant soybeans based on the amount of inputs needed versus expected income generation. Department of Itapua estimates of agricultural production for 1997/1998 may support the farmers' argument (Produccion Agropecuaria, 1998). The average soybean yield in the Department of Itapua is 2563 kg/ha. The average tung yield in Itapua is 3989 kg/ha. According to the farmers the local price was 330 Gs ($.11) for soybeans and 300 Gs ($.10) for tung. Using just this information it seems the obvious choice for income maximization would be tung. In addition, tung requires no pesticide use, low weeding maintenance, and low initial seed costs.

An additional benefit realized from planting tung is increased income spread over the course of the year. Farmers with tung begin to harvest their tung nuts in May, which is near the end of the cotton harvest. Farmers have already sold their cotton and can look forward to income from the tung nuts. Paraguayans do not receive or request credit for planting tung and therefore the profit from the harvest does not have to be discounted against loans specific to tung.

The arrival of farmers in Natalio 25 has brought with them dramatic changes in the landscape and natural forest structures (Figures 20 and 21). Annual crops were planted where original forest once stood. The infrastructure to support the transport and sale of the annual crops was created. Farmers who came to the area to take advantage of the land and agricultural infrastructure are now experiencing declines in soil fertility and diminishing agricultural returns (Derpsh as cited in Sorrenson, 1998). Farmers are becoming increasingly aware of the need to more intensively manage their land. One farmer in particular continually sought to increase his on-farm production through experimentation with new agricultural ideas and crops. Our conversations repeatedly revolved around the possibility of converting an area with marginal cash crop potential into a garden and tree nursery. This farmer had six hectares, a smaller than average farm size, and constantly looked for ways to increase his production with the fixed amount of land he owned. He converted this area into a home garden and nursery which provided food for the family and tree seedlings to be sold to neighbors.

Changes in land use by farmers is often influenced by variations in yields, income, and soil quality (Glas, 1996). Farmers in Natalio 25 employ several methods to accomplish this goal, one of which is the use of agroforestry systems in land management. An essential component of an agroforestry system is the creation of a plant community that is similar to the natural vegetation. This forest simulation can increase nutrient cycling, reduce soil erosion, conserve soil moisture, and meet farmer needs by sustainable production of crops (Beets, 1990). In particular, tung plantations represent an agroforestry system which incorporates both subsistence and cash crops.

Figure 20: Reduction in amount of original forest cover

Photo by Christopher J. Rosin

Figure 21: Changes in land use – Forest to Area of Agricultural Production

Photo by Christopher J. Rosin

Crop Diversity in Natalio 25

The results from my work in Natalio 25 relating to small farmer crop diversification strategies with specific inclusion of tung is consistent with respect to findings in the literature. The work of Ortiz (1976) with Colombian Amerindian farmers detailed strategies used in risk aversion and diversity by small farmers with respect to subsistence and cash crop decisions. He explained that, "…if a small farmer wants to survive and succeed, he must not only learn to combine resources to obtain high outputs but he must also take into account possible disastrous results." Farmers in Natalio 25 utilize similar strategies such as the combination of resources to increase production.

It is easy to draw correlations between Ortiz's description of the plight of the small farmer in Columbia and farmers in Natalio 25. The small farmer in Natalio 25 is faced with the task of producing crops that both provide food for the family and generate income. The farmer chooses crops according to his perception of the expected success of the crop. The farmer in Natalio 25 may choose between several cash crops as a source of income. He must take into account the price stability of each cash crop as well as speculate on upcoming harvest prices. Weather conditions influence production levels and the farmer must develop safeguards to deal with production uncertainties. Farmers in Natalio 25 often choose to diversify their cash crop production to deal with the uncertainties of production due to weather and fluctuations in crop prices. Farmers in Natalio 25 do so by choosing among four major cash crops or a mix of the four when making cash crop planting decisions. If one of their chosen crops does not produce well

the farmer still has the opportunity to rely on the second or alternate crops assuming the other crops do not also experience low production.

Farmers are knowledgeable about specific on-farms costs and cognizant of differences in the levels of risk associated with individual crop cash and subsistence crops. For example, farmers are quick to point out that they are planting their crops for the benefit of all parties involved in the production process minus themselves. I have heard farmers joke that they expect to have a great boll weevil season, judging by the amount of cotton they planted. One farmer refused to plant cotton because, according to his calculations, last year's cotton price was not high enough to generate enough income to break even. He was more confident that other cash crops were more suitable in his farm system and by planting alternate crops he could potentially lower his risk.

Farmers are aware of the positive effects of diversification. Farmers who choose to plant all four cash crops understand that they are lessening the chance of large-scale losses by diversifying their crops. The farmer may not use the term "diversity" or "diversification" but is practicing these strategies by deciding to plant multiple cash crops. It is not unlike the gambler who places four chips on four different numbers, half on red and half on black, on the roulette wheel. A bigger payoff could be realized if all four chips are placed on one color and one number but the chances of total loss are decreased if the chips are spread out over categories, colors, and numbers.

Farmers in Natalio 25 explain that they plant multiple crops to avoid large-scale losses from poor production or dedication to one cash crop. They are aware of the differences in scale between their farms and the agribusiness's but decide to plant similar crops. In attempts to explain the reasons for planting a variety of crops which include the

same crops as agribusiness, farmers point to existing crop infrastructures. Buyers, extension agents who promote commodity crops, warehouses, cooperatives, silos, and credit programs are all present. Often farmers mentioned that they would rather not have soybeans because they have to pay for harvest, herbicides, and seed but the money earned from soybeans helps to pay off other credit loans or sometimes just the initial investment to plant soybeans. The phrase "*algo es algo hei la ñati'y okuaruhina marpe*", helps to describe the continued planting of soybeans and other high maintenance cash crops. The Guarani-Spanish mixed refrain roughly translates to, "anything is something says the mosquito urinating in the sea" or "every little bit helps". The phrase both describes the relative size of each farmer contrasted against the agribusinesses and combined farming output of Paraguay and the fundamental need to generate income. This need is represented by the continued planting of cash crops, such as cotton, even if the planting cost almost exceeds the money gained from harvest.

Farmers in Natalio 25 juggle between a self-sufficient and a commercialized farm system. They do not produce, on-farm, all of their needs and are not completely self sufficient. One particular farmer demonstrated that he could not produce everything he needed for his family on-farm by asking, "You don't see trees that grow school books, school uniform bushes, or bicycle trees on my farm do you?".

Complete sufficiency, where total production and consumption in a community are equal, is now rare (Beets, 1990). On the other end of the spectrum, farmers do not produce strictly for the commercial sale of their crop(s). The level of diversity required to be totally self-sufficient is extremely high (Beets, 1990) (Table 5). Farmers prefer to purchase the products they do not produce on-farm. It is often easier to purchase goods

that require lengthy processing and high inputs of labor. The shift to less diverse production systems in the Third World is common and has led to less variation in the diet and a shortage of protein and vitamins in areas that depend heavily on one cash crop. Although it may not be worthwhile for farmers to become 100% self sufficient and thus highly diversified, it may be advantageous to strive for an increased level of diversification (Beets, 1990).

Table 5: Overview of Different Types of Economics with Different Degrees of Self-sufficiency

Type of Economy	Degree of self-sufficiency	Trade or commercial relations	Major characteristics	Incidence
A. Pure subsistence farm economy	Completely self-sufficient	None	High level of diversification, limited division of labor	Now are very rare; only in isolated areas
B. Barter economy	Largely self-sufficient	Some, but restricted to few partners usually living close by	Some specialization and division of labor	Still very common in more isolated parts of the Tropics
C. Diversified farm economy	Usually self sufficient for staples but not for various other products (clothes, cooking oil, etc.)	The farm is part of a group of farms in the area which is serviced by a limited number of input suppliers and middlemen buying produce	There is considerable specialization but farmers still produce, in small amounts, products for subsistence requirements	The most common system in the Tropics
D. Highly specialized, commercial farming; a money economy	Only one or two products are produced. Most house-hold requirements have to be bought	The farm is serviced by a large number of very specialized input suppliers, extension agents, and advisors. Credit is very important	The farm is highly business oriented and economic aspects play a dominant role	Still rare in the Tropics but increasing. Examples include vegetable farming and plantation crop based systems

Source: Beets, W.C. 1990. Raising and Sustaining Productivity of Small Holder Farming Systems in the Tropics.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

I have shown that incorporation of tung into the small holder farm systems in eastern Paraguay is a favorable farm activity. In conjunction with several other cash and subsistence crops, tung may add to the diversity of the system thereby increasing stability through a variety of crops.

If I had the task of advising small farmers with respect to farm management and planting decisions specifically with the incorporation of tung, I would first ask each farmer specific questions pertaining to their farm size. I would begin with questions that could help both myself, and the farmer understand the health, size, and peculiarities of his particular parcel of land. After a careful examination of the farm and farm family, I would recommend, in Itapua, that the farmer plant a variety of all four available cash crops if there was sufficient land to produce both cash and subsistence crops. The area dedicated to subsistence and cash crops would depend on family size and the age of family members. The farmer who ultimately plants all four cash crops would require enough family labor to ensure successful harvest of all crops.

I would also discuss with the farmer the importance of choosing the location of each crop within his farm. If the farmer was fortunate enough to have no slope within his parcel and homogenous soils, then the location of each individual crop would be arbitrary. Unfortunately most farmers in Paraguay have erosion problems due to slope and the erosion is often exacerbated by inappropriate planting methods. To address erosion problems, an explanation of how trees as vegetative cover can reduce erosion could be discussed. I would then explain to the farmer, if he was not familiar with tung,

the various benefits that could be received from tung. I would point out to the farmer that tung can be planted in a variety of ways which incorporate subsistence crops, fast growing tree species, and livestock all on the same parcel of land. I would ask farmers to make specific comparisons between crop maintenance and profits between soybeans and tung to illustrate how tung is not labor intensive and to illustrate its income generating potential. Initial establishment costs are low for tung and this information could also be used to explain the ease of planting and maintaining tung. Farmers worried about incurring loans would not have to plan for loan repayment due to these low establishment costs.

While explaining the rationale of planting similar crops as agribusiness, I would make the argument that while the small farmer cannot compete with agribusiness they can take advantage of the infrastructure and existing markets to produce a variety of crops with income generation at several times throughout the year. I would also remind farmers about the winter income generated from the yerba harvest. I might mention that by planting tung they posses a crop which is not grow in large plantations by agribusiness, therefore they do not compete with agribusiness for tung. I would also discuss the importance of understanding local and regional level markets and urge each farmer to make attempts to obtain information, from all available sources, as to movements in crop prices and agricultural reform.

If the particular farmer had a very limited amount of land, such as three hectares, I may not advise planting tung but advise dedication to subsistence production. For this particular farmer I may suggest planting tung along the borders of his property or livestock parcels to generate additional income in the late summer.

Much more research needs to be done with respect to alternative non-oil tung products, both locally and in other nations where tung is grown. Future world demand of tung oil and price stability needs to be assessed to be able to recommend to farmers that replanting or continuing with tung cultivation is a viable economic alternative.

Ultimately I would explain to farmers that a farm with a variety of cash and subsistence crops can better weather periods of low production and price instability. The farm that includes tung within this variety contains a crop with various planting options and income generating potentials.

Natalio 25 and the World at Large

Barkin (1998) suggests that solutions for alleviating poverty for the increasing number of rural poor and solving environmental problems should be less market dependent, solutions which work within a system that is not fully integrated into the global marketplace. He argues that official development theory stresses market led structural changes and this will not reduce the disparity between rich and poor. Instead he proposes a system or approach that recognizes limits to capital and natural resources, one that specifically focuses on rural development to alleviate poverty and increase sustainability. An attempt to apply this solution to Natalio 25 would effect major changes. The current system is linked directly to the global marketplace via the production of soybeans, cotton, and other internationally cultivated crops. The current agricultural system in Natalio 25 and the Department of Itapua is heavily dependent on

the production of export crops. The infrastructure for the cultivation of export crops exists with the strategic location of grain storage silos, processing stations, and transport. This infrastructure was created to accommodate the production of large quantities of the export crops.

The questions that need to be addressed are questions, which uncover feasible options. For example, what would replace the existing income generating crops in Natalio 25? Are alternate markets available, or can they be created? If these alternate markets cannot be created, then in which direction should the focus shift and to what degree? Would the shift towards a full removal from the current farming system be adequate or appropriate? A partial removal?

An evolution towards producing for basic needs instead of for profit seems to be the direction that Barkin (1998) suggests. An extreme example of a shift towards complete subsistence farming conjures up images of villages and villagers living without the aid of modern tools, without the aids of technology. This sort of proposed evolution towards complete subsistence would involve a societal reversal or drastic social change. In attempts to understand how rural communities could be more sustainable due to incomplete integration to the global marketplace I look towards Natalio 25 for answers. Farmers involved in agriculture in Natalio 25, as in most of southeastern Paraguay, must be part of a global marketplace. Farmers compete worldwide for buyers of their agricultural products. For example, cotton and soybeans are grown around the world and Paraguayan farmers have to be part of this world market if they hope to find an outlet for their product. The small farmer lacks the capital and natural resources, in this case land, to be able to compete with larger farmers who cultivate these cash crops. It is important

for the small farmer to diversify his production in attempts to minimize risk. The farmers in Natalio 25 are aware that they cannot compete with large agribusiness but are also aware of their need to generate a source of income, often found by planting the same crops as the large landholders. Unfortunately, due to economies of scale, the small farmer has a narrow margin of safety in the face of bad years, poor weather, low production, or financial loss. In addition, small farmers often do not have access to credit because of the size of their landholdings. Large agribusinesses have more access to loans and credit support for dealing with periods of low production. The majority of farmers are well aware of the inequity of their profession but alternate options are not present or are not easily recognized. Removing small farmers from the predicament of having to compete with agribusiness could be realized by a switch to alternate income generating crops. Locating ideal replacements involves choosing crops with a variety of markets, both local and regional to provide a stable outlet for farmer production.

To broaden the possibilities for Paraguayan farmers a discussion of regional and niche markets is relevant. Somewhere between production for strictly global markets and subsistence production lies the possibility of inclusion in regional and niche markets. Barkin's (1998) idea of rural development as a tool to alleviate poverty would need to contain a combination of niche or regional market products and may remove, if only partially, the small farmer from a position dependent upon changes in the global raw commodity market. Applying this idea to produce for a regional market in Natalio 25 would require a shift to crops that are regionally or locally consumed. Although there is no local consumption of tung oil, which makes inclusion into a regional market difficult, climatic conditions favor the inclusion of tung in niche markets. Tung distribution is

limited to areas that have adequate rainfall and hot summers and cool, but not cold, winter temperatures to induce nut production. In the event that tung demand increases, the limited distribution of tung will favor farmers in Paraguay who currently produce tung.

Developing such a niche market is not merely conjectural. A similar niche market involving the extraction of non-timber products with limited distribution is seen with the production of vegetable ivory in Ecuador. The Ecuadorian farmers produce vegetable ivory, used to make high quality buttons, which are eventually sold to Italian high-end clothing producers. The tree that produces vegetable ivory, *Phytelephas aequatorialis*, has a limited range with little or no local consumption (Southgate, 1998). The Paraguayan tung market is similar to the Ecuadorian market in its limited range and non-consumptive nature. Not unlike Ecuadorian farmers, Paraguayan farmers sell tung to a tightly controlled market with a limited number of buyers. Both tung and vegetable ivory face similar constraints to efforts to increase the number of buyers of their products. The majority of vegetable ivory is bought by a select group of Italian button makers and other clothing manufacturers are hesitant to use vegetable ivory without a guarantee of a supply that would replace plastic buttons. Tung faces similar constraints from the paint industry and reluctance to switch from solvents to tung in light of proposed legislation limiting solvent use. Although the farmers may not use or buy the finished product of their labors, they have successfully tapped into markets which, because of climatic conditions and fortuitous buying arrangements, find an outlet for their production.

Small farmers must manage their land intensively to maximize production and also have the information necessary to make informed planting decisions using a large

variety of crops. Unfortunately, large-scale education programs that emphasize the importance of appropriate small farmer land management do not exist. Each farmer must make individual decisions that improve or maintain the stability of his or her system.

Many farm families are vocal in their discontent and perceived mismanagement of governmental agricultural reforms. It is possible that the rural political climate in Paraguay is at a crossroads. In the Department of Itapua the *Cooperativa Colonias Unidas*, has begun the practice of "*Tractorazos*" in order to get the attention of the government and the public. The "*Tractorazos*" are organized displays of protest with the use of tractors, to block principal transportation routes. The participants normally include both large and small landholders and members of the cooperative. These protests are proof that there are problems and dissatisfaction with the current agricultural system.

Paraguayan small farmers and the disadvantaged may have a somewhat reactionary position as a result of perceived government stagnation in agricultural reforms. Farmers are dubious about the promise of erasing farm debts brought about by inflation and low market prices for viable farm products. Farmers may take more drastic measures if they do not perceive change or an attitude of support from the government.

Crop price fluctuations are a specific concern and cause of farmer discontent in Paraguay. Farmers in eastern Paraguay are dependent on year-to-year fluctuations in crop prices for the health and stability of their farm system. Large changes in crop prices or perceived instability may motivate farmers to remove particular crops from their system. Conversely, large increases in the value of crops may motivate farmers to dedicate more land to the production of the increased value crop. Farmers may monitor farm health in terms of soil fertility. Farmers may be prompted to implement soil

conservation techniques such as the use of green manures when they notice a decrease in production. Farmers also measure farm system health in terms of decreased risk. A particular system with lowered financial risk could be one that incorporates a diversity of crops. Diversity of subsistence crops can reduce financial stress during low agriculturally productive years by reducing the amount of food staples that need to be purchased. This assumes that one or more of the crops will produce an amount sufficient to offset the agricultural crop with low production. Cash crop diversity is also a method to reduce financial risk and increase farm stability. Farmers that rely on one cash crop per season may be at greater risk or experience greater financial stress if the price for that individual crop drops or weather conditions cause decreased levels of production. This situation is especially true for farmers that are involved in the production of global commodities such as soybeans or cotton.

The ideal situation for resource poor farmers in eastern Paraguay is to plant a variety of cash and subsistence crops within their farm system. Farmers who plant a combination of soybeans, yerba, cotton, and tung may be able to withstand, financially, the yearly fluctuations in crop prices as compared to farmers with just one cash crop. Farmers who plant tung, after initial establishment, possess a crop with positive farm system attributes.

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APPENDIX

After two years living and working in the Paraguayan countryside I moved to the city to work for an integrated past management firm. While working in the Capital, Asunción, I had the opportunity to compare my life in the countryside against the life of the city.

La Lucha : Asunción contra "El Campo"

The difference between the city and countryside could be described on a similar level as the difference between countries in separate hemispheres, complete with different climates and cultures. Asunción, the capital, runs to its own meter. It has purchased its own metronome straight from *Cuidad del Este* (the capital of falsified goods and a mainstay of the current economic stability of Paraguay), with a convenient added feature - the ability to change the pace of the metronome while it reads another tempo. At first glance this may seem to be a hindrance or have an effect on the credibility of the music Asunción intends to create, but on the contrary…it gives Asunción the ability to perform its own music, at its own pace without interference…unless however someone brings forth a new properly functioning metronome. This idea of isolation and disregard to standards is an everyday occurrence in Asunción and has been for quite some time. The city seems to operate in a vacuum and is continuously surprised when discontent arrives at its doorstep. Lately this has been in the form of unhappy *campesinos* demanding improvements that range from agricultural reform to improved public health care. The advantage the City has with respect to its isolation is that the interior of the country is relatively unaware as to how the City survives, operates, and lives its life. The City is the brain of the body and selectively sends information to the rest of the body. It keeps the *campesinos* uninformed, thus they are unable to understand the system and take steps to make improvements that may eventually materialize and trickle down as physical improvements in the interior. A disadvantage the City posses is its

misunderstanding of the rural agricultural life of its people. It has evolved into a separate country, trying hard to separate its ties with "*los demas*" that do not reside in the city, speak mostly Spanish and comment with scorn about "*El Campo*" and the people who live there. The City is a child with many toys and access to information, which is extremely possessive of its collective wealth and has created a complicated web of safeguards to maintain this wealth. One of the strongest safeguards to the perpetuation of the norm is a mutual understanding of the corruption that exists and its identification as a necessary means to maintain this wealth. The people of the city however, are not entirely fortunate to have free access to information. This is evident in the publication of a variety of daily newspapers that are aligned with political interests. It is necessary to read the four most popular newspapers to obtain a bell weather curve of the current state of affairs. This approach of weighing of information to discern a version of the truth finds its way to the most basic of daily tasks. For example, someone not familiar with the city may ask a passerby directions to point A or which bus one needs to take to arrive at point A. The Paraguayan passerby, instead of stating that he/she does not know where point A is located, will give you directions to some other local, rather than stating they do not have the answer. In order to achieve the needed information one must sift through several versions of the assumed truth to make a decision as which way to proceed. This approach may be a safeguard to deal with a perpetual uncertainty or feeling of premeditated failure.