SEEDS OF GOLD: THE IMPACT OF BIODIVERSITY ON CACAO PRODUCTION DECISIONS OF SMALL LANDHOLDER HOUSEHOLDS IN NORTHWESTERN ECUADOR

By

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To Clemencia Quishpe, mi mama Ecuatoriana

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LIST OF ABREVIATIONS

BIOFASCA	Cacao processing center ran by FASCA
CORPEI	Corporación de Promoción de Exportaciones e Inversiones
FASCA	Fundación Acción Social Caritas
FOCs	First Order ConditionsMPL Marginal Product of Labor
MRS_{LC}	Marginal Rate of Substitution between Leisure and Consumption
UOCAQ	Unión de Organizaciones Campesinas del Cantón Quininde

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Our study of Ecuadorian smallholder cacao farmers revealed that these farmers chose to use a farming method that is not most profitable, which appears to contradict the classical economic model of profit maximization. Many farmers still grow a less profitable variety of cacao, cacao nacional, in an agroforestry system instead of the more productive hybrid variety, cacao CCN-51, which is planted with few other crops and trees and uses many chemical inputs. Farmers must receive additional nonmarket value from cacao nacional such as ecological values, which induces them to raise cacao nacional. Our study uses a household model and shadow prices to capture t these nonmarket values in order to understand the full value of each production method to these smallholder farmers. Our study builds on the current models of shadow wages by not only including the biodiversity value but also showing the impact of segmented markets such as f fair trade, organic, or other markets on household income. Furthermore, the shadow wage takes into account the effect of imperfect substitution of family and market labor to better understand a household's labor decisions.

The agroforestry production of cacao provides the households with ecological services as well as a source of additional income and food. When the additional value from biodiversity is included in the shadow wage of traditionally produced cacao nacional, the shadow wage for cacao nacional is greater than that for cacao CCN-51. This shadow wage difference would predict that smallholder farmers would chose to raise cacao nacional in order to maximize household utility. Thus, smallholder Ecuadorian households are acting as rational actors when choosing to raise cacao nacional as this production system maximizes household utility.

CHAPTER 1
INTRODUCTION

Farmers through the world face multiple decisions from which crops to grow to where to market their products. Although these decisions have traditionally been conceptualized as choosing the option that is most productive and profitable, recent research has shown that farmers include many other criteria when making production decisions. Hilderbrand (2002) demonstrated that a livelihood model is a better method to describe production these decisions. The livelihood system includes household consumption and leisure needs as well as needs and production constraints. These competing objectives may lead the household to make decisions that contradict the popular notion of the rational profit maximizing decision maker. Even though the household may not be maximizing profit, these households are making rational decisions to maximize their total welfare or utility. Bechetti and Costantino (2008) found that household welfare is very important to production decisions. They found that farmers chose to participate in organic markets not just for the price advantage. They also participated in these markets because of the additional welfare benefits that the additional income provided as well as could be obtained directly from the production such as a nutritious, safe food source.

An example of the importance of multiple objectives in a farmer's production decisions is in the production of cacao in Ecuador. Many Ecuadorian smallholder cacao farmers produce a variety of cacao that is less productive and profitable, which counters traditional economic theory. Ecuadorian farmers include other factors besides profits in their decisions. Ecological factors are very important in their decision process. These traditional production systems use agroforestry methods and provide households with not only economic benefits but also a source of food and medicine (Bentley, Boa, and Stonehouse 2004). These additional benefits only occur to households that raise cacao in diversified or biodiverse production systems. Thus, Ecuadorian cacao farmers take into account this cropping biodiversity and all its benefits when making production decisions.

This paper develops a household model that includes biodiversity as a part of the decision criteria in Ecuadorian cacao producers' production decisions. Past work has examined shadow prices to examine market failures especially in the labor market (Le 2009; Arslan and Taylor 2009; Jacoby 1993). This work adds a new aspect by estimating a shadow wage and income that takes into account the additional value for biodiversity that is not captured in the market. The shadow wage is derived from a household model where a rational household chooses to maximize its utility in the presences of market imperfections, which may be different than the choice the household would make if such constraints did not exist. The distinctive characteristics of this analysis reveal that such market imperfections are associated with environmental goods, such as the ones resulting from intercropping of different crop varieties, rather than with transaction costs (de Janvry, Fafchamps, and Sadouelt 1991) and constraints in the labor (Jakoby 1993; Skoufias 1994; Le 2009), land and credit markets (Eswaran and Kotwal 1995; Carter and Yao 2002).

The shadow income for agroforestry cacao production was found to be higher than that for commercial cacao production system. This situation shows that the relevant imperfections is associated with over-employment, rather than with under-employment (Feather and Shaw 1999) of family labor as has been assume by most papers in the household models literature. Thus, a rational household would chose to use the traditional rather than the commercial system.

The production of Ecuadorian cacao provides a great case study to examine the effect of biodiversity on smallholder household utility and production decisions for several reasons. First, all households growing cacao participate in the cacao market as self-consumption is very close to zero. They use market prices as signals for the production decisions. Thus, this example allows for the disaggregation of the market imperfections in the cacao cash crop market from the total of the market imperfections to determine the impact of biodiversity on the shadow wage. Second, the manner in which traditional cacao is raised in diversified agroforestry systems provides a particularly good contrast to the manner in which modern varieties of this product are grown. This crop is important to the economy of many developing countries including Ecuador and other countries throughout the world that are cradles of biodiversity (Bentley, Boa, and Stonehouse 2004; Brush, Taylor, and Bellon 1992). Finally, the unique cacao specialty market that has developed in Ecuador for its traditional cacao production provides a good example to study the impact these premium markets on smallholder households.

Cacao's Importance to the Tropics

The tropics including Asia, Africa, and Latin America are known for their high levels of poverty and biodiversity. The impact of cacao production in these regions is large with 7.42 million hectares being devoted to this crop in 2007 that produces over five metric tons of cacao valued over 6.75 billion US dollars (Food and Agriculture 2009). Indeed, cacao is the second most important cash cop in the tropics (Steffan-Dewenter et al. 2007). An interesting fact about cacao is that much of its production is achieved by small landholders who produce between 70% and 90% of the world's cacao (Dahlquist et al. 2007). The average cacao farm size in Nigeria is just 1.7 hectares, 4.5 hectares in Ecuador, and 2.8 hectares in the Ivory Coast. These small landholders can be very productive. For instance, farmers in Sulawesi, Indonesia have been able to produce 2000 kg of cacao per hectare per year which exceeds production levels that can be achieved by commercial cacao producers (Rice and Greenberg 2000). So, cacao is important in the development plans for this region because of its ecological impact and importance to small landholders.

Cacao's Importance to Ecuador

One of these tropical countries heavily dependent on cacao production is Ecuador. During the late 1800s and early 1900s, cacao was Ecuador's most important export with large expanses of the coastal region devoted to the production of this crop. During this period, cacao was referred to as "Pepa de Oro" or "Seeds of Gold." In fact, cacao production helped the new country finance its war for independence against Spain. However, the crop was nearly destroyed by two fungi, monilla and witch's broom. The demand for cacao collapsed during the Great Depression. This economic crisis forced the large cacao haciendas to be divided into parcels that were sold to small landholders. The land reforms of the 1960s further divided these large farmers so that today most of Ecuador's cacao is raised on small farms (Vasco 2010). Today, 90% of cacao is produced on landholdings with less than 50 hectares and over 30% is produced on farms smaller than 10 hectares (Coporación de Promoción de Exportaciones e Inversiones 2009).

Even though cacao production may not be as large of a component of the Ecuadorian economy as it was 100 years ago, cacao continues to be important to

Ecuador. In fact, 12% of the country's economically active population is involved in cacao production, employing 600,000 Ecuadorians (Coporación de Promoción de Exportaciones e Inversiones 2009). Furthermore, Ecuador controls 60% of the market of the cacao used to produce gourmet, dark chocolates production and is one of only three countries where this high quality cacao can be grown. The variety raised in Ecuador is referred to locally as cacao nacional or cacao arriba in international markets (Asociacion Nacional de Exportadores de Cacao 2007).

The need for economic development in Ecuador is indeed acute. Forty-six percent of Ecuadorians live below the poverty line. Poverty is especially concentrated in the rural areas of the country (Central Intelligence Agency 2009). The promotion of cacao production is seen as an avenue to help alleviate this rural poverty. Because of the importance of cacao to Ecuador's economy and especially to small landholders, the Ecuadorian government along with local and international development organizations has begun to advocate cacao and especially cacao nacional as an economic development strategy.

Most of the cacao raised throughout the world is raised using hybrid varieties such as the CCN-51 variety grown in Ecuador. The advantage of cacao CCN-51 over cacao nacional is that it is more productive. However, cacao CCN-51 does not produce the high quality cacao that is produced by cacao nacional. Cacao CCN-51 is used in lower quality chocolates which garner lower prices (El Cacao Volvió Ser la Pepa de Oro 2007). Yet, cacao CCN-51 has been promoted to small landholders over the past 15 to 20 years as a superior option to cacao nacional because of its production advantages (Bentley, Boa, and Stonehouse 2004). During the past 5 years, some farmers have obtained access to specialty where they receive premiums for cacao nacional and organically produced cacao (Bentley, Boa, and Stonehouse 2004). Because of these new markets, Ecuadorian farmers are being encouraged to switch from producing cacao CCN-51 to cacao nacional. Indeed, the price premium for cacao nacional has expanded from nearly 20% to over 60% between 2004 and 2007 (El Cacao Volvió Ser la Pepa de Oro 2007). In fact, the Ecuadorian export institution, the Corporación de Promoción de Exportaciones e Inversiones (CORPEI), now even requires farmers to separate these two varieties to meet chocolate makers demand for cacao nacional.

In addition to the quality differences, these two varieties of cacao are raised using different farming methods. The traditional system used to raise cacao nacional includes a diverse array of crops and retention overstory trees to enhancing nutrient cycling (Bentley, Boa, and Stonehouse 2004). Cacao is commonly planted with plantains and/or bananas. Many farmers also plant oranges or other citrus fruit, or avocado in their cacao plantains. Farmers include many timber species such as laurel on their cacao parcels. One of the most popular tree species included in the cacao nacional agroforestry system is locally referred to as guaba. The guaba tree produces a long pod that contain a sweet pulp that surrounds its seeds and is an important nitrogen fixer, providing the system with a natural fertilizer. Rather than using chemical fertilizers and pesticides the traditional cacao production system uses mechanical methods to control diseases and pests, such as pruning. This approach to production varies greatly from the commercial method. Cacao CCN-51 is not as susceptible to sun damage and, therefore, is not grown in the traditional agroforestry system but in parcels that contain few other crops and trees besides cacao CCN-51. Cacao CCN-51 is also raised using more agrochemicals than cacao nacional.

CHAPTER 2
VALUE OF BIODIVERSITY

Biodiversity has not traditionally been considered a component of smallholder household's production decisions as it does not fit into the traditional profit maximization models. Many of the benefits of biodiversity are not received as cash income. There are positive externalities not realized in the market such as the aesthetic value that a farmer realizes from their biodiverse farms. In addition, there are benefits that may have monetary value but this value is not received directly and/or is not realized until sometime into the future such as enhanced soil fertility, which leads to greater production. Yet, some products of biodiversity do have a market value. For instance, a diversified cropping system produces a variety of crops that can be brought to the market. All these biodiversity values may influence farmers' willingness to receive lower prices for their products as the value they receive through the positive externalities of biodiversity may compensate for the lower price. Indonesian cacao farmers said that they would be willing to accept a price lower than full compensation for the smaller yields of traditionally raised cacao to grow cacao in an agroforestry system. These farmers would be willing to receive just a 0.36 U.S. dollars premium per kg for their cacao grown in an agroforestry system (Steffan-Dewenter et al. 2007).

Chapter 2 examines the current research on the ecological impacts of the biodiverse cacao nacional agroforestry system. The values are often difficult to capture in traditional markets. Yet, they would likely be included in a smallholder producers production decisions as they impact the sustainability of their livelihoods. The second section examines some of the use values such as meeting consumption needs that these biodiverse systems provide households.

Ecological Importance

The diversified cropping system of traditional agroforestry cacao systems such as that of the cacao nacional have been shown to enhance the diversity of native plants and animals (Reitsma, Parrish, and McLarney 2001). Both the above ground and below ground biological diversity of cacao agroforests have been found to be greater than that of commercial cropping systems and similar to that of long term fallowed fields but still less than primary forests (Duguma 2001). Cacao agroforestry systems in Indonesia were found to contain forty percent of the plant and insect species found in natural forests. This level of biological diversity can only be found when the cacao is planted in a diversified agroforestry system. Costa Rican cacao agroforestry systems were shown to have a diversity of bird species statistically significantly similar to that of a natural forest. Natural forests were shown to have 144 bird species compared to 131 in cacao agroforestry systems (Reitsma 2001). This potential to create a biologically diverse habitat is especially prevalent in deforested areas. However, the monoculture nonshaded cacao production practice which is the common method used in raising cacao CCN-51 have not shown to provide similar levels of biodiversity (Steffan-Dewenter et al. 2007).

These biodiverse cacao agricultural system can provide many of the environmental benefits that natural forests provide. While the world's tropical rainforests are being destroyed, one of the critical objectives of the cacao agroforestry practice is to replicate the natural forest environment so that the beneficial qualities of the tropical forests can be achieved in these agroforestry systems so that the loss of natural forests can be mitigated. The protection of native plant and animal species is particularly important to Ecuador as it is one of the most biodiverse countries in the world with many plants and animals threatened with extinction due the loss of habitat (Conservation International 2007). To slow this destruction, many environmental groups are promoting the production of cacao nacional as a way of protecting this habitat. The additional ecological benefits these biodiverse systems provide include pollution and runoff control, improved soil quality through nutrient cycling and organic matter accumulation, and carbon sequestration.

Pollution Control

As compared to raising crops in intensive monoculture production, utilizing a cacao agroforestry system has shown to help prevent further degradation of water resources. In addition, the use of cacao agroforestry systems can ameliorate soil erosion which is critical in the sustainability of agricultural activity. The shade trees utilized in the cacao agro forestry practice provide several ecological benefits. One benefit is that the shade trees prevent some of the leaching of pesticides and other chemicals into groundwater. The root zone of the trees can prevent these chemicals from reaching the water supply. In addition, shaded farmer have lower run off rates and, thus, less soil loss. The tree root zone and the natural litter form the shade trees slow the runoff so less soil is removed. The canopy also protects the soil from the full impact of rainfall slowing down the raindrops as they fall so as to protect the soil from being loosened and washed away (Beer et al. 1998).

Soil Enhancement

The dense planting of trees and plants in cacao agroforestry systems provide a large level of litter and organic matter to be recycled back into the soil to maintain its fertility and long run sustainability. Total biomass in cacao agro forest systems in Cameroon was higher than that in food crop fields with 305 metric tons per hectare versus only 85 metric tons per hectare. Yet, this was much less than biomass in primary forests, 541 metric tons per hectare, and long-term fallow, 460 metric tons per hectare. These agro forestry systems proved to have larger amounts of organic matter and higher levels of calcium and magnesium in the soil than secondary forests (Duguma 2001). Cacao agroforestry systems have been shown to on average add 10 Mg of plant litter per hectare per year (Gamma-Rodriguez 2009). One study found that soil organic matter increased by twenty one percent in a ten year period under pruned *Erythrina peppigiana* and by 9% under laurel trees in fields that were converted from sugar cane production to a cacao agroforestry fields (Beer et al. 1998). Furthermore, soil decomposition rates and the abundance of soil arthropods were found to be greater in shaded cacao agro forestry systems as compared to systems that provide less shade (Steffan-Dewenter et al. 2007).

Carbon Sequestration

Cacao agroforestry systems can be a useful tool in the sequestration carbon in the effort to control global warming. In fact, these agroforestry systems seem to be able to store carbon at a similar rate of that of natural forests. Soil organic carbon stock in these systems is not significantly different from that of forests in the first 100 centimeters of soil with a rating of 302 mega grams of organic carbon per hectare (Gama-Rodrigues 2009). Another study found that cacao agroforest systems have shown to contain 62% of the carbon stock found in primary forests (Duguma 2001). The shade trees in the cacao agro forestry system store between 14 and 52 Mg of Carbon per hectare in the aboveground woody biomass. In fact, this agroforestry practice stores between 10 and 50 Mg of carbon more per hectare in the litter and soil organic matter than annual crops. Therefore, cacao agroforestry system could prevent the release of 1000 Mg of Carbon per hectare that would occur by planting annual crops (Beer et al. 1998). In Cameroon mature agroforestry systems have been found to fix 150 metric tons of carbon per hectare for mature trees and between 111 and 132 metric tons of carbon per hectare for younger cacao agroforestry systems. Even though these levels of carbon sequestration are lower than those found in natural forests at 307 metric tons per hectare, much more carbon is sequestered in a cacao agroforest than can be achieved in fields that only plant annual food crops (Rice and Greenberg, 2000). The carbon that is sequestered has been proven to be a well protected form of carbon so that it cannot be easily released to the environment (Gama-Rodrigues 2009).

Household Use Value of Biodiversity

In addition to the environmental services that cacao agroforestry systems, such as that used to produce cacao nacional, provide, this production method allows these households to meet their consumption needs. Many other products such as plantains and fruit that are important to the diet of Ecuadorian farm families are included in these biodiverse, traditional cacao production system. Even if a household may be able to earn much more cash income for cacao CCN-51, exclusively pursuing this alternative may not be the best alternative for a family as they would not be able to meet their subsistence needs because cacao CCN-51 is generally raised in a monoculture system without plantains or fruit trees. This tradeoff between working for cash income and providing subsistence was shown in a study in Brazil nut gathers in the Brazilian Amazon. Household consumption needs were not met as smallholder farmers dedicated their time to collecting Brazil nuts instead of growing subsistence crops (Ros-Tonen et al. 2008). Cash income may not be very important these Ecuadorian households as many of them do not depend on the purchasing of goods in the market to meet their family's needs.

The use value of these biodiverse production systems is shown in a study of Cameroon agroforestry systems. This research found that smallholder farmers received the highest level of net present value when a cacao agroforestry system included shade trees that provide an economic benefit such as fruit and/or timber trees. This system had a higher net present value than more commercial systems that had a few shade trees of one variety. These additional values provide an economic incentive to raise cacao in an agroforestry system (Duguma 2001). These diversified cacao, fruit, and timber agroforestry systems were found to have greater financial returns than plantations using conventional, leguminous trees. These systems also provide more consistent income from the multiannual harvest of cacao and other fruit trees in the cacao agroforestry system (Beer et al. 1998). Thus, smallholder households that raise cacao nacional in such a diversified agroforestry system obtain additional consumption and use values along with the nonmarket values that would make it the preferred production method for Ecuadorian smallholder producers..

CHAPTER 3
THEORETICAL FRAMEWORK

Modeling Specialty/Fair Trade Markets

The unique market for cacao nacional is similar to fair trade markets in that in both fair trade and specialty cacao nacional markets farmers receive a premium for their product. Thus, the work developed to explain how the fair trade markets influence smallholder farmers' production decisions can be applied to this situation of the specialty cacao nacional market. A model built by LeClair (2002) and critiqued by Hayes (2008) shows how the premium paid to participants in the fair trade markets affects labor allocations in the goods for this market. The model explains how a household would supply more labor to the production of the fair trade good due to the fair trade price premium. He models a household's income from production as

$$Y = (P - r)Q \tag{3-1}$$

where

Y is household income,
P is the market price for the good,
r is per unit costs, and
Q is the quantity of the good produced.

The model is then transformed for the income of a household that participates in the fair trade market.

$$Y = (P\,(1 + a) - r)\,Q\,\,(1 + b) \tag{3-2}$$

where

a is the premium paid for the fair trade market or the specialty cacao market
b is the additional output caused by the labor increase

This model of the fair trade market can be transformed for shadow income (y^*) which is developed later in the next chapter. The shadow income includes the additional value from biodiversity that is not included in the cash income the household receives. Thus, the shadow income represents the true value from production for the household. By the model developed by LeClair, shadow income in the standard market where no premium is given for cacao is

$$y^* = P_C Q_C + P_O Q_O + V - \textit{total costs} \tag{3-3}$$

where

P_C is the price for cacao in the standard market,
Q_C is the quantity of cacao produced,
P_O is the price for the other crops on the farm,
Q_O is the quantity of other crops produced on the farm, and
V is the value that household obtains from the biodiversity externality.

Our model alters LeClair's in order to reflect an agroforestry situation and specifically the cacao agroforestry system. Our model is applicable to many smallholder farmers as they commonly practiced diversified cropping systems that provide additional ecological benefits. Our model includes the income from cacao as well as the other agricultural products raised in the diversified system. The value the household recognizes for biodiversity (V) is also included. In our model the cost function is calculated according to land area. In a diversified cropping system, a farmer cannot disaggregate the inputs utilized for one crop from another. The entire production costs must be subtracted from the whole system rather than calculating the costs for each unit of production for each corp. Furthermore, the application of inputs by smallholder farmers is considered in terms of amount applied per unit of land. So, the costs would be measure in terms of units of land than by the quantity of the product produced.

The shadow income for the specialty market that includes the price premium (*a*) and the production increase (*b*) from added labor would be

$$y^* = (P_C(1 + a)\, Q_C\, (1 + b)) + P_O Q_O + V - \textit{total costs} \tag{3-5}$$

An important distinction between our model and LeClair's model is that the model includes the value of biodiversity. These ecological impacts must be included to better understand how smallholder household's production decisions are made. In addition, the inclusion of this factor is important in the evaluation of the fair trade and specialty markets since environmental improvement is the objective of many of these marketing schemes in order to better understand its full impact. LeClair argued that the premium could induce participants in fair trade markets to dedicate labor to these products thus increasing the supply and lowering the price of the good in the general market for all producers including those who do not participate in the fair trade markets. However, by including the value of biodiversity in our model, an additional positive benefit from fair trade and specialty markets must be included in agricultural markets. The premium could induce farmers to produce goods that enhance biodiversity which would be a great societal benefit, which contour LeClair's conclusions.

LeClair and Hayes' analysis is at a macro level that examines how the premium from fair trade or specialty markets affect market prices and labor supply in the entire system. The model does not examine the effects for an individual household's participation in specialty markets. In addition, a need exists to understand the impact of these specialty markets at the individual household level. A household level analysis allows for an understanding of how these markets affect the household's production decisions. Shadow prices provide a means to analyze the impact of these markets at the household level while including the impact that biodiversity on production decisions. The shadow wage for the sale of goods inside and outside the specialty or fair trade markets can be compared to determine which market provides more value for the smallholder household. In the following section, the household model is used to build a shadow wage to examine value that smallholder households place on the various planting options to make production decisions.

Current Conceptualization of Household Shadow Price Models

The household model provides a better explanation than the traditional profit maximization models for the production decisions of small landholder households. The household model as developed by Barnun and Squire (1979) integrates the household's consumption and production decisions with the objective of maximizing household utility. The model depicts consumption and production decisions as not being made separately; they are made simultaneously. Unlike commercial farmers who view their farms as a business in order to earn income to purchase products for their household needs, smallholder farmers do not separate these consumption and production activities. A smallholder household's consumption needs influences its production decisions, which would not be captured in a traditional model that does not consider these consumption and production objectives simultaneously.

A household will choose to maximize its utility through consumption and leisure. Given a budget constraint, the value of time is compared by family members to the value of other goods to determine how much to "enjoy life" or how much to work in order to be able to consume goods. While the work that the family undertakes off the farm is generally valued at a market wage with money that is earned used to purchase needed goods, the work on the farm can be valued in monetary or nonmonetary terms. In particular, many of the positive attributes or amenities generated from existing biodiversity in the farm cannot be traded in markets.

Our theoretical model is built upon the model of Le (2009), who developed a shadow wage and income using to explain imperfections in the labor market. The household model to build shadow wages, which is the marginal product of labor (MPL), was first used by Jacoby (1993) to explain the wage that the labors perceived. This work was furthered by Arslan and Taylor (2009), who develop a shadow price to explain the additional value that Mexican households place on traditional maize varieties that are not reflected in market prices. Our model expands on this work by adding a value for environmental factors to the shadow wage and income. Specifically, the value of biodiversity as perceived by Ecuadorian farmers is a component of the shadow wage and income these farmers realize.

Framework for Valuing Biodiversity

Our model is based on a farm household that maximizes a utility function of leisure (l) and consumption (C); $U(C, l; D)$ where D is a vector of household characteristics (e.g. preferences, number of children). C includes goods that are produced at home (v) or purchased in the market (c); $C = c + v$. The labor supply (h) is the total stock of time for the household (T) minus leisure (l), which is divided among two activities farm labor (L), market labor (M); $T – l = L + M = h$

The production function for the farm is $F(L, z; A)$. z is a vector of variable inputs (e.g. hired labor, fertilizer, insecticides etc.) and A is a vector of quasi fixed assets (e.g. land). The production function F for the diversified cacao agroforestry system is specified as $F(L, z; \mathrm{A}) = Q(L, z; A_Q) + V(L,z; A_V)$, where Q is the cacao production and V is the subsistence and environmental benefit derived from the production method. The production function takes this form since cacao is commonly grown jointly with other crops or trees (such as fruit trees, cassava, and plantains) for self-consumption. Since the two types of crops are grown in the same parcel, farmers do not account for the amount of inputs used for each crop. Rather, purchased inputs oriented toward producing the cash crop have the external effect of benefitting the production of intercropped crops and trees.

Several authors have shown that when markets are imperfect or missing, profitability variables that are commonly taken as exogenous become endogenous. Specifically, they become functions of household characteristics and preferences Eswaran and Kotwal (1995) explained the case of imperfect credit markets. Carter and Yao (2002) discussed imperfect land rental markets. This situation is due to the fact that the farm household problem becomes inseparable. Households' production decisions are not independent from household consumption decisions. In this inseparable environment, A_Q, is an endogenous variable in the cacao production function.

The household maximization model can be summarized as

$$\text{Max } U(C, l; D) \tag{3-6}$$

subject to

$$\mathrm{p}Q(L, z; A_Q) + V(L,z; A_V) = p_z z + \omega \mathrm{M} + R + V(L,z; A_V) - C$$

and

$$\bar{M} \geq \mathrm{M}$$

where

p is the farm output price,
p_z is a vector of input prices,
ω are the market wages, and
R is other income.

The Langrangean of the problem can be expressed as

$$\mathcal{L} = U(C, T\text{-}h; D) + \lambda_1[pQ(L,z;A_Q) - p_z z + \omega M + R + V(L, z; A_v) - C] + \lambda_2(\bar{M} - M) \quad (3\text{-}7)$$

The first order conditions (FOCs) are

$$\partial U/\partial C + \lambda_1 = 0 \quad (3\text{-}8)$$

where

$$\lambda_i = MUC$$

$$-\partial U/\partial L + \lambda_1[p\,(\partial Q/\partial L) + \partial V/\partial L] = 0 \quad (3\text{-}9)$$

In the FOCS the $p(\partial Q/\partial L)$ equals MPL.

$$p\,(\partial Q/\partial L) + \partial V/\partial L = (\partial U/\partial L)/(\partial U/\partial C) = \omega_i^* \quad (3\text{-}10)$$

ω_i^* is the shadow wage, which includes the additional household production values that occur to the household outside of the market. The shadow wage is the marginal rate of substitution between leisure and consumption (MRS_{LC})

$$(\partial U/\partial L)/(\partial U/\partial C) = MRS_{LC} \quad (3\text{-}11)$$

Equation 3-11 reflects the fact that the household will choose to invest time working on the farm until the point that labor's *total* marginal product equates the MRS_{LC}.

The FOCs in Equations 3-7, 3-8, 3-9, and 3-10 include the value. The contribution of biodiversity to the model is evident when Equations 3-7, 3-8, 3-9, and 3-10 are compared to Equations 3-12, 3-13, and 3-14, which represent the standard methodology employed to determine the shadow wage in the household literature:

$$\lambda_i = \partial U/\partial C = MVC \quad (3\text{-}11)$$

$$-\partial U/\partial L + \lambda_1 p\,(\partial Q/\partial L) = 0 \quad (3\text{-}12)$$

$$\bar{\omega} = p(\partial Q/\partial L) = (\partial U/\partial L)/(\partial U/\partial C) \neq \omega_i^* \quad (3\text{-}13)$$

Previous studies ignore the biodiversity value include in the second term of Equation 3-9. This omission leads to a bias in the estimated shadow wages, when there are externalities derived from the production method. An important consideration is that $\bar{\varpi}$ in Equation 3-13 will be equal to the market wage ω when labor markets are perfect ($\bar{M}$ > M) but will be lower than ω when these market are imperfect and the labor constraint binds.

Following other household studies (Le 2009), the labor market failure is modeled as one of limited demand for labor. When this constraint binds, $\bar{\varpi}$, the production part of the shadow wage of labor, is below market wage. However, an important highlight is that under other types of labor market imperfection $\bar{\varpi}$ can be higher than the market wage. For example, when family labor and hired labor are not perfect substitutes, then the household is limited in its ability to provide farm family labor by the number of household members. In this case, when the marginal productivity of family labor on the farm is very high, the shadow wage of labor may be higher than the market rate.

Finally, even when the marginal value of the cacao productivity of labor is lower than market wage, i.e. $\bar{\varpi}$ < W, there is still potential for the *total* shadow wage of labor to be above market wage. This situation occurs when there are positive benefits derived from biodiversity in the production system.

Countervailing Market Imperfections

A positive effect of biodiversity, $\partial V/\partial L$ on shadow wages (Equation 3-9), can be seen as a countervailing effect, market failures, which may offset the difference between $\bar{\varpi}$ and ω derived from labor market imperfections. The value from biodiversity would increases the shadow wage high enough so that higher benefits are realized for farm work relative to market work, which could explain the lack of participation of farm households in the labor market. This hypothesis is explored in the estimations in Chapter 4.

The term reflecting marginal benefits of biodiversity from labor used in production, $\partial V/\partial L$, is difficult to measure because of both the multidimensionality of V (composed of self-consumption, medicinal plants, shade for the cacao, education of children, continuation of cultural identity) and the missing markets for some of its components (such as cultural or traditional values). In this analysis, a proxy measure is used (see Chapter 4), which allows for the estimation of a lower bound for the shadow wage.

Imperfect Segmented Product Markets

Another practice that is used in the literature in order to simplify the analysis is the normalization of the market price p, by dividing all variables expressed in dollar terms by an index that reflects the market price of produced goods. The problem with this strategy in a setting of imperfect or segmented markets is that farmers often face heterogeneous prices, depending on whether they have access to markets or not. In this case, this type of imperfection arises because of the existence of specialty markets with limited demand. Thus, separate shadow wages are estimated depending on whether farmers have access to specialty markets or not.

The estimation of the shadow prices are created using data collected from smallholder farmers in northwestern Ecuador. A description of the study site, survey methods, and results are included in Chapter 4. This data is then used to calculate the shadow prices according to this theoretical framework, which considers the value of biodiversity and segmented specialty markets.

CHAPTER 4
EMPERICAL IMPLEMENTATION

Research Site

Fifty households in the Ecuadorian counties of Santo Domingo de los Tsa'chila, Puerto Quito, and Quininde were interviewed in July and August of 2009 about their production methods, access to alternative markets, impressions of the profitability of their operations, perceptions of environmental quality, and satisfaction with their well being. A stratified sampling method was utilized that included participants from the three counties as well as from various socioeconomic classes and ethnic groups. The sample included mostly small and medium sized farming operations with 31 (62%) of the farmers surveyed having less than 10 hectares. Some of the most marginalized in Ecuadorian society either through ethnic discrimination or poverty are included in the survey. Thirteen indigenous Tsa'chila households, who until 100 years ago were the only inhabitants of the Santo Domingo area, were included in the sample along with four Afro Ecuadorian households. The rest of the participants in the survey are mestizos of mixed indigenous, Afro Ecuadorian, and Spanish ethnicities. This stratified sampling method allows the survey to address the concerns raised in a previous case study by Nelson and Galvez (2000) that found that the most marginalized populations had little access to the alternative cacao markets.

The counties of Santo Domingo de los Tsa'chila, Quininde (Rosa Zárate), and Puerto Quito are located in the northern coastal region of Ecuador (Figure 4-1). These three counties are located in three different provinces. Puerto Quito is in the Pichincha province, Quininde in the Esmeraldas province, and Santo Domingo in the recently created Santo Domingo province. Although there are several jurisdictions, the economic and cultural activity of the region centers on the main trade city of Santo Domingo, a bustling frontier city located 150 kilometers southwest of the Ecuadorian capital, Quito. Within the last fifty years, this region was settled as the Ecuadorian government encouraged residents of the mountainous region of the country to inhabit these less populated areas. This region continues to receive immigrants from other areas of Ecuador and Colombia. In fact, city of Santo Domingo is Ecuador's fasting growing city growing with an annual population growth rate of 3.7%. Due to this continuing influx of immigrants and transient population, the true population of Santo Domingo is unknown. However, it was estimated in 2007 to have 330,000 permanent residents and over 500,000 people living in the province at any one time. In 2007, Quininde was estimated to have 150,000 habitants; Puerto Quito was estimated to have 17,200 residents. While Santo Domingo is mostly an urban county with over 70% of its residents living in the city, Quininde and especially Puerto Quito are largely rural counties (Provincia de Santo Domingo de los Tsachilas 2010; Municipalidad de Puerto Quito 2009; and Municipalidad de Quininde 2009).

Besides the immigrants that moved to the area, there is a small but prominent Afro Ecuadorian and indigenous population in the area. The region of Santo Domingo was originally inhabited by the indigenous Tsa'chila nation that currently live in seven communities around the city of Santo Domingo. This group was traditionally hunters and gathers. Today, they have become farmers due to destruction of the forests where they used to hunt. Although there are only 3,000 Tsa'chila in the Santo Domingo area, they have had a large impact on the region and especially in the rural areas because of their historical significance and because of the large amount of land located within their communities (Gobierno de la Provincia de Pichincha 2003). There is a large Afro Ecuadorian population in the county of Quininde. The province of Esmeraldas is well known for its Afro Ecuadorian residents many of whom are descendants of slaves during the Spanish Colonial period. Slaves had originally had been brought to Quininde from Colombia to harvest rubber in the 1800s and stayed in the area after they were freed. In fact, the Afro Ecuadorians were some of the first residents of this region (Municipalidad de Quinindé 2009).

This region is a particularly poverty stricken area of Ecuador. Little data is available on the economic status of this region because of the transient nature of the population. High poverty rates are especially evident in Santo Domingo and Quininde were little of the city lacks access to running water and very few of the streets of these major population centers are paved. The rural areas have even less access to these basic services although almost everyone has been connected to the electrical grid within the last five years. The Tsa'chila and Afro Ecuadorian populations are particularly marginalized and often much poorer the rest of society. The symptoms of poverty are clearly evident in these populations as they lack to means to access adequate healthcare, education, and nutritional sources. These communities have abnormally high rates of infant mortality, tuberculosis and malaria infection, juvenile malnutrition, as well as low literacy rates as just more than half of members of the Tsa'chila nation are able to read and write (Gobierno de la Provincia de Pichincha 2003).

These three counties straddle and the equator so that the region has a very warm subtropical. These counties were once covered by lush tropical forests rich in biodiversity. This climate is also conducive to raising many varieties of tropical crops including plantains, passion fruit, cacao, African Palm, organs, pineapple, and coffee. Now, much of this forest has been lost as the settlers removed the trees to build their towns and cities and farms. Because of this rich biodiversity and extensive deforestation, many endemic species are threatened with extinction. This threat has promoted this region to be included within the Tumbes-Chocó-Magdalena biodiversity hotspot (Conservation International 2007).

Agriculture is the main economic driver in these three counties. Even the urban province of Santo Domingo, is heavily dependent on the trade of agricultural goods. Plantains and cacao are the main crops in the Santo Domingo area with many other tropical crops grown such as malanga , cassava, and passion fruit. Quininde has become well known for the production of African Palm on large plantations. Much of this county’s economy depends on the harvesting and process of the seeds of this palm for palm oil. However, most of the smallholder farmers are dependent on cacao production as they lack extensive landholdings to raise African Palm. The county of Puerto Quito is composed mostly of smallholder farms and has the advantage of being at a higher altitude than Santo Domingo and Quininde so that besides growing many the tropical crops they are able to raise some cooler weather crops. Many households in the three counties also raise livestock. Almost every farm has a few chickens and many have pigs. Beef cattle are raised in all three counties while many farmers from Puerto Quito have dairy operations.

Survey Dissemination

Three groups of farmers were included in the survey. The first group includes farmers who sold their cacao to a processing center run by a local nongovernmental organization, Fundación Acción Social Caritas (FASCA) in Puerto Quito. This organization is the social arm of the Catholic Diocese of Santo Domingo. The processing center called BIOFASCA uses the cacao purchased from the farmers to make cacao paste which is then exported to high quality chocolate producers in Spain and Italy. BIOFASCA purchases cacao in baba, in wet form, before it is fermented or dried so that it can complete the processing process to highest standards. Normally, the middleman purchases the cacao from the farmers once it has been dried and fermented. The middleman then discounts farmers when they do not complete these processes to the highest quality standards. The farmers receive a better price for their cacao from BIOFASCA as their product is not disconnected. In addition, FASCA pays for the organic certification costs for 147 farmers and then pays a premium for this organically certified cacao. Workers at the plant purchase the cacao directly from the farms so that the farmers do not have to pay transportation costs. An additional benefit of the FASCA cacao project is that it also provides technical assistance to any farmer who sells cacao to them.

I accompanied the plant's agronomist as visited farms in the region. Farmers would call him and ask for his help, so we never knew which farms we would visit in a given day which made the sampling of the farmers random. In addition to the technical trips with the plant manager, I interviewed a few farmers as they came to the plant to sell their cacao. I was able to extensively interview 10 farmers in the Puerto Quito region which represents 20 percent of the study. I also had the opportunity to talk in depth with the plant manager, the director of FASCA, and workers at the plant about their thoughts and feelings about BIOFASCA as well as the cacao market and organic and fair trade markets.

I visited several of the communities around the city of Santo Domingo de los Tsa'cahila. I had served as Peace Corps Volunteer in the area from 2005 until 2008. During that time, I lived in an indigenous Tsa'chila community. Thus, I had the unique opportunity to interview s 15 Tsa'chila households. I also visited a few communities of the other communities I had previously assisted to plan a cacao conference in 2007. I stayed with a farm family in the village of Roca Fuerte for several days as a farmer took me to interview his neighbors. The interviews in the Santo Domingo area provided me with opportunity to talk with farmers who were not members of farmers associations nor had access to the organic and fair trade markets as the farmers. As Santo Domingo has by far the largest population of the three counties involved in my sample, the number of surveys conducted in this province is much greater than that of the other two with 30 farmers being interviewed or 60% of the total of those surveyed.

The final group of farmers that I visited was a group that participated in a larger farmers' cooperative near the city of Quininde that represents an association of nine smaller farmers' associations throughout the county of Quininde officially called Rosa Zárate. The larger farmers' cooperative, the Union de Organizaciones Campesinas del Cantón Quininde (UOCAQ), is building a cacao collection center similar to BIOFASCA process plant that control the drying and fermentation processes in order to so produce the highest quality cacao for export. They are currently working with Nestlé, which has offered to pay them up to 35 U.S. dollars more per quintal (100 pounds) for organic, cacao nacional if all the quality standards are met. This premium is quite large since cacao generally does not sell for more than 100 U.S. dollars per quintal. In addition, Nestlé is working with farmers to raise improved cacao nacional trees developed through the assistance of French agronomists. Besides selling to Nestlé, the cooperative is also examining the possibility of selling their cacao in fair trade markets.

While in the Quininde area, I traveled to several villages with the director of UOCAQ and an Ecuadorian agronomist, who works for Veterinarians and Agronomists without Borders. This international NGO has been supporting UOCAQ in the construction of the collection center as well as providing the farmers with technical advice as they work to become organically and fair trade certified. The agronomist provided the farmers with production and marketing advice as well as listened to their concerns about the project. I was able to interview the farmers from the various farmers' cooperatives as we visited their farms. I never knew which farmers I would be interviewing until I arrived in each community. I interviewed 10 farmers in the Quininde area, which represent 20% of those surveyed.

The results of the survey are included in the following sections. The first section describes the basic characteristics of the households in the survey, the second includes the characteristics of the parcels of cacao nacional and cacao CCN-51, the third examines the profitability of each variety, the fourth describes the farmers perception of profitability of cacao, the fifth describes farmers access to specialty markets, the sixth farmers likelihood to plant more cacao, and the last descriptive section details farms environmental perceptions. The last section is devoted to the creation of equations to the estimate the shadow wage and income.

Characteristics of Households that Produce Each Variety of Cacao

There are distinct differences between those households that that raise cacao nacional and those that raise cacao CCN-51 (Table 4-1). Households that produce cacao CCN-51 are wealthier than households that raise cacao nacional. Household incomes were recorded on a scale form one to nine. Household's that listed an income of one earned less than 100 U.S. dollars per month and those who said their income was over 800 U.S. dollars were listed with a nine. The average rating of total household income for families that raise cacao CCN-51 was 4.87 with a median of five while households that raise cacao nacional had an average score of 2.44 with a median of three. As households in both categories are statistically similar in size, household incomes can be compared on a one to one basis. So, there is a difference of at least 200 U.S. dollars between the total income that most households that raise cacao CCN-51 and those that raise cacao nacional. This difference is especially large in Ecuador as the minimum wage in Ecuador in 2009 was 218 U.S. dollars per month and the poverty line was 56 U.S. dollars per person per month. Not only is average total income statistically different between the two types of households, but average farm income is also statistically different although the difference is smaller. Households that raise cacao CCN-51 on average earn nearly 100 U.S. dollars more in farm income than those farmers who raise cacao nacional.

Other indicators of household wealth reveal a significant difference between households that raised cacao nacional and those who raise cacao CCN-51. Those households that raise cacao CCN-51 have larger homes and farms than households that raise cacao nacional. CCN-51 households have farms that are on average 28.44 hectares compared to 13.08 hectares for families that raise cacao nacional. In addition, households that raise cacao CCN-51 are more likely to own a car and have running water as compared to farmers who raise cacao nacional. Fifty percent of CCN-51 households own a car as compared to just 15.15% of households that raise cacao CCN-51. Twenty-five percent of households that raise cacao CCN-51 have running while just 6.25% of cacao nacional households have this service.

Parcel Characteristics

The parcels where cacao nacional is raised are larger, have older trees, and have a richer diversity of other crops and trees than parcels planted with cacao CCN-51 (Table 4-2). Cacao nacional trees are statistically significant older than cacao CCN-51. As cacao nacional has been raised in Ecuador for over 150 years and cacao CCN-51 for only 10 years, the cacao nacional parcels would be expected to be older. The average age of cacao nacional is 10.94 years old and for cacao CCN-51 is 3.94 years old. Although households that raise cacao CCN-51 have larger farms, these households plant their cacao on smaller plots that are more densely planted. The average parcel size for cacao CCN-51 parcels is only 2.57 hectares while cacao nacional plots have an average size of 4.50 hectares with cacao CCN-51 trees being planted at a density of nearly 700 trees per hectare while cacao nacional trees were planted at a density of about 500 trees per hectare. The fact that cacao nacional farmers plant their plots with fewer cacao trees allows them to plant other crops and trees dispersed between their cacao trees. In addition, cacao nacional requires more shade than cacao CCN-51 so more shade trees must be planted in these traditional cropping systems.

The survey results confirm the observation that the cacao nacional parcels are raised in diversified agroforestry systems while cacao CCN-51 is raised in less diverse systems. Farmers, who participated in the survey, were asked how many varieties and which varieties of crops and trees they planted in their cacao parcels. This study considered that the more variety of species of plants that were included in a parcel the more biodiverse the parcel. Both native species as well as introduced crops were included in this biodiversity measure. Cacao nacional farmers plant over two varieties of perennial crops with their cacao and at last one other tree variety while cacao CCN-51 are most likely to plant only one other perennial crop with their cacao. Thus, cacao nacional is raised in more biodiverse cropping systems that may provide additional ecological benefits.

Production and Profitability Values

Our survey results reveal a clear difference between cacao nacional and cacao CCN-51 in the use of labor and other inputs, yield, and profits from each production system. Households that raise cacao nacional are more dependent on family labor and utilize more labor overall for the production of cacao. Comparing the two cropping systems on a per hectare basis does not reveal the true difference between the two systems as cacao CCN-51 is planted much more densely than cacao nacional. In order to make an equal comparison, the two varieties need to be compared as if they were planted at the same density per hectare. A useful comparison can be made if the parcel area is converted to the density recommended by the agronomist at BIOFASCA, 625 trees per hectare. The hectare equivalent makes for a better comparison than on a per hectare basis for costs and profits between the two varieties. A parcel with less a tree density of less than 625 cacao trees per hectare would have a hectare equivalent smaller than the actual hectare size while a parcel with more than 625 trees would have a hectare equivalent value larger than the number of hectares in the parcel. Basically, the hectare equivalent designation allows each variety to be compared on a tree for tree basis. This term, hectare equivalent, is utilized throughout this study to reference this conversion. Table 4-3 lists the production costs, yield, revenue and profit on a per hectare basis while Table 4-4 lists these variables on a hectare equivalent basis.

The traditional cacao nacional production is much more labor intensive, less productive, and less profitable than cacao CCN-51. There is not a difference in the amount labor utilized on cacao CCN-51 production systems and the amount utilized on cacao nacional production systems when compared by labor use per hectare with an average of 33.62 days per hectare used to produce cacao CCN-51 and 33.96 days per hectare to produce cacao nacional. However, there is a significant difference in labor use when compared by hectare or equivalent with cacao nacional production systems using 63.77 days of labor per hectare equivalent while the cacao CCN-51 production system uses 28.75 days of labor per hectare equivalent. This difference in labor use by hectare equivalent is a better measure of input use as it compares an equal number of trees. In particular, there is a significant difference between the days of family labor used with 37.72 days of labor per hectare equivalent in the cacao nacional production system compared to an average of 16.16 days per hectare equivalent to produce cacao CCN-51. No significant difference was found to exist in the use of hired labor for the production of cacao CCN-51 and cacao nacional.

A large difference exists in the use of other inputs such as fertilizers, insecticides, and herbicides between cacao nacional and CCN-51 production systems. The cacao CCN-51 system uses an average of 51.50 U.S. dollars in other inputs per hectare equivalent compared to 28.78 U.S. dollars per hectare equivalent for cacao nacional parcels. Households that raise cacao CCN-51 substitute other inputs for labor especially herbicides. Weeding is one of the most labor intensive agricultural activities of the households as it involves going to the fields and cutting the thick weeds with a machete. There is a clear difference in amount of labor used for weeding. Cacao nacional production uses 29.14 days of labor per 625 trees and cacao CCN-51 production utilizing 9.24 days of labor per 625 trees. CCN-51 production uses chemicals to control these weeds while farmers who raise cacao nacional are use much more labor to control their weeds.

The market price for hired labor does not properly represent the cost the household realizes for utilizing this labor. First, many of the household members would not be able to participate in these markets such as woman and children. With few options for employment, the opportunity costs of many members of the household would be much less than the market wage. As many household members do not have any other option for employment, their opportunity cost would be near zero. Second, the household is really paying itself for this work. In order to try and capture the real cost for family labor, the costs and profits were calculated both as if family labor were valued at the market rate and at zero to examine the differences in the two values. The true cost to family labor is likely located somewhere between these two values. When family labor is valued at the market rate, the total costs for raising cacao nacional is much higher than that for cacao CCN-51. On average cacao nacional costs 564.61 U.S. dollars per hectare equivalent to grow while cacao CCN-51 costs on average 304.40 U.S. dollars per hectare equivalent. When family labor is valued at zero, then there is no significant difference in the cost to raise either variety, cacao nacional production costs average 258.40 U.S. dollars per hectare equivalent and cacao CCN-51 averages 165.14 U.S. dollars per hectare equivalent.

Most farmers measure their production on per hectare basis which reveals that cacao CCN-51 is much more productive than cacao nacional. In fact, higher yields are the main reason why cacao CCN-51 is touted as a preferred alternative to cacao nacional (Melo 2009). The study confirmed this perception that cacao CCN-51 has significantly higher yields. The farmers that participated in oyr study revealed that the average yield for cacao CCN-51 between September 2008 and August 2009 was 16.41 quintals of cacao per hectare compared to 8.97 quintals of cacao per hectare for cacao nacional. These values are very near the BIOFASCA's estimates of annual cacao production for cacao nacional and cacao CCN-51 which is 8 quintals for cacao nacional and 16 quintals for cacao CCN.51. However, this measurement of yield is not a true measure of cacao production on these farmers' fields as the tree density is much different for each variety. A much better measure would to compare the yield a tree by tree basis, which our study does by using the established hectare equivalent conversion. Using this measure average yield for cacao CCN-51 during this time period was 14.80 quintals per hectare equivalent compared to 11.66 quintals for cacao nacional per hectare equivalent. These values are not significantly different.

Households receive significantly larger revenue for cacao CCN-51 than for cacao nacional. In standard markets where farmers do not receive price premiums for cacao nacional, households who raised cacao CCN-51 received on average 1,393.97 U.S. dollars per hectare equivalent for their cacao in September 2008 through August 2009 while the average revenue for cacao nacional was significantly smaller at 834.88 U.S.

dollars per hectare equivalent. Households that raise cacao nacional and had access to markets, which pay a premium for this variety, received 1,060.86 U.S. dollars per hectare equivalent. The average revenue for organic cacao producers was 1,026.95 U.S. dollars per hectare during the year studied. Cacao CCN-51 also proved to be significantly more profitable than cacao nacional in both the traditional commercial market and when a premium was received for cacao nacional. There was a significant difference between the revenue of cacao CCN-51 and cacao nacional even when the value of family labor was discounted. The average profit for cacao CCN-51 was 1,223.84 U.S. dollars per hectare equivalent and the average profits for cacao nacional are 608.65 U.S. dollars per hectare equivalent and 677.90 U.S. dollars per hectare equivalent in the specialty markets.

Surprisingly, the few households that raise organic cacao are not profitable. When family labor input is included, the organic farmers had an average loss of 182.32 U.S. dollars per hectare equivalent and only an average profit of 233.57 U.S. dollars when family labor is not valued. This result is surprising as organic cacao has a higher market value than cacao sold in either the traditional commercial market or the premium paid for cacao nacional. Farmers stated that the average organic cacao price ranged from 90 to 110 U.S. dollars per quintal. This price is much higher than the price the farmers received in the specialty markets, 75 to 100 U.S. dollars per quintal, and in the standard markets, 60 to 90 U.S. dollars per quintal. Smaller yields and greater labor costs would make organic cacao much less profitable.

Perception of Profitability

One section of oursurvey asked farmers to rate the profitability of their cacao parcels from very good to very bad for their cacao nacional and cacao CCN-51 parcels and their farmers as a whole. The questions were asked with a time element as farmers rated the profitability of these three entities six years ago, three years ago, now, and three years in the future. A time element was included in order to try and measure sustainability. These scores were converted from one to five with the very good ratings given to a five and the very bad identified with one. These values were then averaged to determine the farmers' relative perceptions of profitability of each activity (Table 4-5 and Figure 4-2). Farmers on average gave significantly higher profitability ratings for both varieties of cacao than for their entire farm. Although the differences in perceptions of profitability for cacao nacional and cacao CCN-51 are not significantly different, the results show that famers believe that cacao nacional was more profitable than cacao CCN-51 six and three years and that it will be in the future. However, they see cacao CCN-51 as being more profitable now. This observation may be due to the fact that the average age of cacao CCN-51 in the survey is only about four years. Since cacao provides its first harvest at about three years of age, cacao CCN-51 was not productive during this period. As cacao CCN-51 is more productive than cacao nacional, farmers rate this variety as more profitable. They may believe that cacao nacional prices will be higher in the future as new markets develop for this variety. Thus, they gave this variety a high profitability rating for the future. As households are more dependent on family labor for production cacao nacional which may have less opportunity costs than market labor, farmers may view cacao nacional as less costly, thus, more profitable. Furthermore, as the market has responded by providing price premiums for cacao nacional and organic cacao, farmers seem to believe that they will receive much higher prices for cacao nacional in the future so that it will be more profitable than cacao CCN-51. They seem to believe that the price advantage will make up for the production differences.

Access to Specialty Markets

Our survey included questions about farmers' access to specialty cacao markets. The farmers were asked if they had access to markets were they are paid premiums for cacao nacional or markets for organic cacao. If they lacked access to these markets, they were then asked if they would like to have access to these markets and what factors inhibited them from having access to the more lucrative markets. Only 26% of households had access to the premium markets for cacao nacional. Of those households that did not have access to these markets, 42% of households would like to have access, 22% are unsure if they would like to access these markets, and only 6% were not interested in having access in these markets. Of those who did not have access, 43% were in the process of trying to gain access to the market, 35% were unaware as to how to access this market, 17% claimed that they did not produce enough cacao to sell the markets, and 5% thought that there was no demand for in this market. Even fewer households had access to organic markets, 6% of farmers having access to these markets. Yet, 58% of households would like to have access to organic markets. Of these farmers that would like to have access 79% listed that cost and knowledge about the markets prohibited their entry into this market. These results complement the results of the case study by Nelson and Galvez (2000) which found that many cacao farmers lacked access to fair trade markets. They found that the most remote, marginalized households lacked access to these more lucrative markets.

Likelihood to Plant Cacao

A good indicator of household long term expectations for cacao is household's intentions to plant cacao. The farmers that participated in our survey were asked if they would like to plant more cacao trees, which variety they would like to plant, and what factors inhibited them from planting cacao (Figures 4-3 and 4-4). Overall, they had high expectations for cacao as 88% of families would like to plant cacao and of those who would like to plant cacao 65.9% would like to plant cacao nacional. This result appears to contradict the traditional theory that households act as profit maximizing rational actors. A profit maximizing household should not choose to plant cacao nacional instead of cacao CCN-51 as cacao CCN-51 is more profitable. These planting preferences reveal that smallholder household's decisions are based not only on profit. These households would appear to receive additional value from cacao is captured in the market, which would induce to plant cacao nacional.

Perceptions of Environmental Factors

The section of our survey that examined environmental perceptions was conducted in the same format as that of the profitability perceptions. The farmers rated these perceptions over the past six years and into the future. A one to five scale of measuring the responses from very good to very bad was also used. The farmers were asked to rate their perceptions of water quality, soil fertility, and biodiversity of their entire farms as on their fields of cacao nacional and cacao CCN-51 (Table 4-6 and Figure 4-5). Farmers clearly perceived cacao nacional parcels to have better soil quality over the entire period than the entire farm and that of cacao CCN-51. Cacao CCN-51 was perceived to have better soil quality than the farm now and the future. One can question if farmers plant cacao in parcels that have higher soil quality than the rest of their crops. Then, the higher soil quality ratings would be due to planting decision rather than if cacao does indeed improve the soil quality.   This question is refuted when the ratings for cacao CCN-51 are observed and the age of the trees are considered. The farmers in our survey, as well as those who were early included in the study by Bentley, Boa, and Stonehouse (2004), had recently planted cacao CCN-51. They had planted this variety of cacao within the last ten years and the majority had planted it within the last five years. The farmers rated the soil quality of parcels planted with cacao CCN-51 to be worse than that of the entire farm six and three years ago when the seedlings would have recently been planted which would disapprove that cacao is planted in better soil. Farmers may have chosen to plant cacao in poorer than average soil. The reality that cacao CCN-51 parcels have higher soil quality ratings than the farm now and the future while have lower ratings in the past would demonstrate that cacao may improve soil quality.

For biodiversity perceptions, cacao nacional has a higher average rating than the farm in all time periods and cacao CCN-51 has nearly equal ratings as the entire farm. The farmers are nearly unanimous in stating that they had witnessed a large loss of native plants and animals on their farms over the last few years. However, the loss is rated to be less for cacao and statistically significant less for cacao nacional. These findings support the ecological research that claim that cacao agroforestry systems protect and even enhance biodiversity in comparison to other cropping methods. Yet, the farmers believe that the loss of plants and animals is so grave that the agroforestry system may not provide enough benefits to prevent a general decline biodiversity on the farms. Cacao agroforesty systems appear to a second best solution as compared to native forests in controlling the loss of native plant and animal species.

The descriptive statistics from our survey as well as the research on the ecological impact of cacao agroforestry systems reveal the importance of nonmarket values in the production of cacao. Smallholder households utilize these values in making production decisions. The shadow wage and income as constructed in Chapter 3 provide a solid framework for analyzing these additional values that are included in a smallholder producer's decisions. The following section uses our model in Chapter 3 to calculate a shadow wage and income for cacao producers in Ecuador that includes the value of biodiversity and accounts for the segmented specialty markets.

Estimation

In order to estimate the shadow income of Cacao Nacional, the shadow wage defined in Equation 3-9 are used. The budget constraint can be transformed to a linear budget constraint while allowing the household to still arrive at the optimal choice (Jacoby 1993, Skoufias 1994, Le 2009). The transformed maximization problem is:

$$\max U(C, l; D) \tag{4-1}$$

subject to

$$C - \omega^* h = y^*$$

where y^* is the shadow income

$$y^* = p\hat{Q} - p_z z + \omega M + R + \hat{V} - \omega^* h \tag{4-2}$$

$p\hat{Q}$ describes the market access while $\hat{V}$ captures longer term value of household production including the value the household places on the ecological benefits of biodiversity. $\omega^* h$ provides the shadow income from work.

Solving the maximization problem and after estimating ω^* and y^*; the optimal labor supply function can be estimated:

$$h^{\circ} = (\omega^*, y^*; A) \tag{4-3}$$

In our study, the focus is on the difference in shadow income across households that have differential access to specialty markets and who face different labor constraints (Equations 3-9, 4-1, 4-3). First, ω^* is estimated using the method of Skoufias(1994) but extending it with an estimated value for biodiversity. A Cobb Douglas production function for cacao and biodiversity ($Q(L, z; AQ)$ and $V(L, z; Av)$) is used to estimate them in logarithmic form in order to make them additive and to recover estimates of the input elasticities. Multiplying the labor elasticity in each equation (βLQ, βLV) by the corresponding predicted average product of labor ($\hat{Q}/L$, $\hat{V}/L$), gives us the marginal product of labor (*MPL*). In order to obtain ω^*, MPL is multiplied by the price to be received for the cacao, $\hat{p}$.

As the household's utility increases by both incremental income as well as benefits from biodiversity, its decisions are taken by jointly considering these benefits. For this reason, the equations that predict cacao production and biodiversity are solved simultaneously. By discovering the additional value that a household realizes through biodiversity, the shadow wage, which captures this nonmarket additional value as well as the production value from cacao, can be estimated.

Specific Estimated Equations

$$\text{Biodiversity}_i = \beta_0 + \beta_1 \text{ Log family labor} + \beta_2 \text{ Nacional*Log family labor} + \beta_3 \text{ Log hired labor} + \beta_4 \text{ Log other inputs} + \beta_5 \text{ Flat} + \beta_6 \text{ Hilly} + \beta_7 \text{ Insecure land rights} + \beta_8 \text{ Years land owned} + \beta_9 \text{ Ethnicity} + \beta_{10} \text{ Household size} + \varepsilon_1 \tag{4-4}$$

$$\text{Production} = \alpha_0 + \alpha_1 \text{ Log family labor} + \alpha_2 \text{ Nacional*Log family labor} + \alpha_3 \text{ Log hired labor} + \alpha_4 \text{ Log other inputs} + \alpha_5 \text{ Flat} + \alpha_6 \text{ Hilly} + \alpha_7 \text{ Insecure land} + \alpha_8 \text{ Years land owned} + \alpha_9 \text{ Ethnicity} + \alpha_{10} \text{ Household size} + \varepsilon_2 \qquad (4\text{-}5)$$

Definition of the Variables

The variables in Table 4-7 were included in both regression equations that predict the number of varieties of cacao as the descriptive statistics, past research, and/or field experience suggest that these variables may be significant factors in determining cacao production and amount of biodiversity in these cacao parcels. As in any production function, labor and other inputs are needed to produce a good. These variables are an important component of the regression.

Labor is divided into family and hired labor in order to examine the effect of the shadow wage and to determine the substitutability of family labor and hired labor. If hired labor and family labor have the same MPL which the coefficients represent, then they would be perfect substitutes and in a perfect market the MPL for both family and hired labor would equal the wage. All the labor coefficients are expected to be positive values for both equations as more labor would lead to higher production. They would not be positive if the household was at the point of maximum output with diminishing marginal production, which would be very unlikely. A similar conclusion can be made about the variable for the other inputs. This coefficient would be expected to be positive for production although it might not be for the biodiversity equation. The production of cacao CCN-51 is more input intensive than cacao nacional as shown by the survey results. Since cacao nacional is produced on more biodiverse parcels than cacao CCN-51, a negative correlation would be expected to between input use and biodiversity.

The labor value for cacao nacional is included in order to determine if a difference exists in the effect of the labor applied to cacao nacional on biodiversity and on production as compared to that of the other labor variables. Since cacao nacional production systems are more biodiverse than CCN-51 cropping systems, the coefficient of family labor in cacao nacional production in the biodiversity regression would be expected to be larger than the coefficient for family labor for all cacao production. As cacao CCN-51 has higher yields than cacao nacional, the family labor and hired labor coefficients would be expected to be larger than the coefficient for family labor for cacao nacional alone in the production regression.

The variables flat and hilly are included in the regressions. The steep slopes would be expected to be the most biodiverse parcels. Farmers tend to plant the flat areas first as they are easier to maintain and harvest. To prevent erosion the farmers in this area often leave the steepest slopes forested as the steep areas are often on stream and river banks. Thus, the steeper areas would be more likely to be forested and thus more biodiverse than other areas. The coefficient for flat would be expected to be a large negative number while the coefficient for hilly will be a smaller negative number.

The variable for insecure land rights definitely would be expected to have an impact on the biodiversity regression. Households who fear that their property rights may be removed would only invest in crops with short harvests such as annual crops instead of trees, which do not provide a revenue for several years. Thus, the insecure land rights variable is expected to have a negative coefficient in the biodiversity equation. The variable for the initial land size is a measure of the wealth of the household. A household's wealth would determine its ability to invest in its farm in order to increase production. A positive coefficient would be expected for this variable in the production equation. The length of time that someone owned property would influence the biodiversity equation. The longer a household has owned land the more it would be expected to invest in trees and other crops with long term return. So, they would be expected to have larger biodiversity coefficients. Since cacao becomes more productive over time, the coefficient for the length of ownership of the parcel would be expected to be positive for the production regression.

Ethnicity is an important variable in the equation. This variable is included as a dummy variable distinguishing between those households that do and do not have a member of the Tsa'chila nation as its head. There is a significant population of indigenous Tsa'chila who farm large areas of the region. The Tsa'chila have a distinct culture from the rest of the population. They believe that all plants and animals have spirits and need to be protected. This belief would suggest that they would be more likely to protect the various varieties of plants and animals on their land. In addition, they use many medicinal plants that they grow in their fields which would add the diversity of plants in their fields. So, the ethnicity coefficient in the biodiversity regression would be expected to be a positive but may be negative in the production regression as Tsa'chila farmers do not have as much training in modern agricultural practices.

Finally, the household size variable would be expected to be an important variable in the equations. The coefficient for these variables would be expected to be positive for both the biodiversity regression and the production regression. The household would need to produce more to provide for the needs of additional household members and would be more likely to plant additional crops in its plots to provide for its consumption needs.

Results of the Estimated Equations

The estimated coefficients for the variables determining production of cacao and related biodiversity are presented in Tables 4-8 and 4-9. The biodiversity equation predicts the number of species of crops or trees in a parcel while the production equation predicts the amount in quintal of cacao produced. The most important input used for production of cacao on these farms appears to be family labor, whose log has a coefficient of 0.35 in the cacao production equation. Family labor, though, does not have a differential impact by type of cacao, whether nacional or CCN-51, on the cacao production equation. However, it does have a differential impact on the biodiversity equation. The interaction coefficient between family labor and a dummy for cacao nacional is not significant in the production equation, while it is in the biodiversity equation. The effect of labor on biodiversity production is significant for cacao nacional, but not for cacao CCN-51. This conclusion is inferred from the positive significance of the interaction term on biodiversity and the lack of significance of the family labor term that is not interacted with cacao nacional on biodiversity. Hired labor and other inputs have smaller coefficients, which are not significant for either type of production.

Land and several aspects related to land ownership are also important determinants of both biodiversity and cacao production. For example, the surface of the land, whether flat, hilly or steep, has a significant impact on both equations, although opposite signs. Flatter land influences productivity in a positive manner, relative to steep or hilly areas of land. The opposite is true for biodiversity production. Individuals confined to produce on steeper plots have a higher number of varieties in their farms.

This result confirms the observations that farmers leave the steeper areas forested to prevent erosion. A similar effect is observed through the initial amount of land that a farmer started cultivating. This coefficient suggests that less wealthy farmers have more biodiversity. Less wealthy farmers may be more dependent on their farms for subsistence and need to plant additional varieties in the plots to meet these needs. The number of years that a household has owned their land is positively correlated with both cacao production and biodiversity. Farmers who own their land longer have had more time to invest in their land in long term crops, enhancing crop diversity.

Our results support the conservation literature, which suggests that insecure property rights have a strong negative effect on biodiversity. However, insecure property results did not significantly affect cacao production. The result may be due to the fact that the sample is composed mostly of low income farmers with small noncommercial farms. The difference in access to credit because of land insecurity (Eswaran and Kotwal 1995), which affects productivity, is minimal relative to other farmers with land title. Those households with land title have very little extensions of land. The lack of land for collateral would also limit these farmers access to credit.

Finally, the variable indicating whether the household head belongs to the indigenous Tsa'chila group or not, indicates that households with this type of ethnic trait have more biodiversity but less cacao production, relative to other households in the sample. This results supports the hypothesis as Tsa’chila for cultural reasons chose to leave their land forested and also would produce less because they have less knowledge about modern agricultural practices. The final variable included in the regressions is the household size. Larger households would need more resources to sustain themselves. Thus, a larger household would be expected to plant more plantains and other crops needed to provide the household with food.

Shadow Wage Results

From the family labor coefficients in the previous section, the shadow wage is calculated for a day of family labor as described in the estimation section. Our results are presented in Table 4-10. The terms in the first column, w_Q* and w_V*indicate the two different components of our shadow wage (Equation 3-9): $w_Q^* = p(\partial Q/\partial L)$ and $w_V^* = \partial V/\partial L$. These two terms are not added directly, since the two dependent variables have different units. The first shadow wage represents the value of an extra quintal of cacao that will be produced with an extra day of labor, which depends on which market it is being sold on. The second is the value of the amount of an extra-variety that can be produced with an extra day of labor. Column two presents the marginal value of labor for all cacao and column three the marginal value that is to be added (or subtracted if the coefficient is negative) if the variety is nacional. In the table, N.S. stands for values that are not significant. Pv is the hypothetical value of the respective variety of crop planted in the parcel along with cacao; and 0.01 is the marginal productivity of labor when the cacao variety is nacional, the traditional variety.

Column two reveals that the only the shadow wage component which applies for all cacao production is higher than the mean of the wage obtained in the market (8.33 U.S. dollars). This shadow wage can be higher than the market wage when hired and family labor are not substitutes and family size limits the available family labor. However, it is still in the range of high market wages (the range of all daily wages is between 7 U.S. dollars and 12 U.S. dollars). A family selling their cacao in the specialty market will obtain about 1.5 U.S. dollars more per day of labor than a family who does not have access to this market (11.90 U.S. dollars compared to 10.40 U.S. dollars).

The value of biodiversity or of adding an extra variety consists of multiple market and nonmarket components. Some of these, such as self-consumption or production of substitutes for medicinal plants may be easier to estimate; but others, such as ornamental or ritual use, are at best difficult to estimate. In this sense, the variable Pv is "hypothetical". The third column of Table 4-10 shows that there is a "biodiversity premium" that is added to the shadow wage of family labor if cacao nacional is produced. However, a lower bound can only be created for this value based on the market price of goods for self-consumption, which will apply for specific cases. For example, if cacao nacional is intercropped with cassava, producing 50 quintals per intercropped hectare, at 7 U.S. dollars per quintal, the marketable MPL for this variety would be .49. The total shadow wage of intercropped cacao would be about 3 U.S. dollars higher. If cacao nacional is intercropped with oranges, the shadow wage would be at least 1.10 U.S. dollars higher (for 4000 Units/ha at 0.04 U.S. dollars per unit). Added to this shadow wage would be benefits like shade, soil enhancement, ornamental and cultural value, medicinal and ritual uses, etc.

Based on our analysis, Table 4-11 shows that the shadow price for a day of work in the production of cacao CCN-51 is equivalent to a high market wage. Furthermore, a day of work for producing cacao nacional may be higher than a high market wage once the additional biodiversity value is included. The shadow wage is particularly higher than the market wage for cacao nacional producers who have access to specialty markets because of the cash premium they receive. Through the analysis of the shadow wage, which includes both production and biodiversity values, cacao nacional provides more value to smallholder households than cacao CCN-51.

Summary of the Results

Our survey of cacao producing households in northwestern Ecuador produced a result that would seem to contradict conventional economic theory. Households would prefer to raise cacao nacaional instead of cacao CCN-51 even though cacao CCN-51 is more profitable. Our results also revealed that the cacao nacional production system provides some benefits that are not captured in the market such as soil enhancement and the protection of native species of plants and animals. The shadow prices provide a manner to include these additional values that the household obtains form cacao production. The shadow wage is higher for cacao nacional that it is for cacao CCN-51 and much higher when farmers sell in specialty markets. The shadow wage difference demonstrates that these households receive more value from cacao nacional than cacao CCN-51. The households act rationally when they chose to plant cacao nacional instead of cacao CCN-51.

Figure 4-1. Counties of Santo Domingo de los Tsa'chila, Puerto Quito, and Quininde

Table 4-1. Household characteristics

	Cacao CCN-51	Cacao nacional
Total income per month[1]		
Mean	4.87	3.44[t]
Median	5	3
Number of observations	15	34
Farm income per month[1]		
Mean	3.81	2.85[t]
Median	3	2
Number of observations	16	34
Percentage indigenous	31.25	29.41
Number of observations	16	34
Family size		
Mean	4.75	4.09
Median	5	4
Number of observations	16	34
Farm size (ha)		
Mean	28.44	13.08[tt]
Median	11	8
Number of observations	16	34
Percentage that own a car	50.00	15.15[ttt]
Number of observations	16	33
Percentage with running water	25.00	6.25[tt]
Number of observations	16	32
Rooms in the home		
Mean	4	3.25[tt]
Median	4	3
Number of observations	16	32

[t] Significant difference at the 10% level
[tt] Significant difference at the 5% level
[tttt] Significant difference at the 1% level

Table 4-2. Parcel characteristics

	Cacao CCN-51	Cacao nacional
Parcel area (ha)		
Mean	2.57	4.50[tt]
Median	2.00	3.00
Number of observations	18	51
Tree density (trees/ha)		
Mean	702.78	502.18[t]
Median	670	600
Number of observations	18	51
Tree age (years)		
Mean	3.94	10.49[ttt]
Median	2.00	6.00
Number of observations	18	51
Slope[a]		
Mean	1.83	1.82
Median	2.00	2.00
Number of observation	18	51
Number of annual crops per parcel	0	0.25[t]
Mean	0	0
Median	18	51
Number of observations		
Number of perennial crops per parcel		
Mean	1.33	2.65[ttt]
Median	1.00	3.00
Number of observations	18	51
Number of trees varieties per parcel		
Mean	0.61	1.08[t]
Median	0	1.00
Number of observations	18	51

[t] Significant difference at the 10% level
[tt] Significant difference at the 5% level
[tttt] Significant difference at the 1% level
[a] 1:Plain, 2:Hilly, 3:Steep

Table 4-3. Yield, costs, revenue, and profits per hectare

	Cacao CCN-51	Cacao nacional
Total labor (days/ha)		
Mean	33.62	33.96
Median	24.85	28.27
Number of observations	18	48
Family labor (days/ha)		
Mean	18.67	22.72
Median	14.52	18.00
Number of observations	18	49
Hired labor (days/ha)		
Mean	14.95	10.87^{t}
Median	11.33	8.67
Number of observations	8	49
Planting costs with family labor (USD/ha)		
Mean	55.71	43.00
Median	28.30	21.00
Number of observations	13	29
Planting costs without family labor		
(USD/ha)	47.65	18.85^{tt}
Mean	21.57	10.12
Median	13	30
Number of observations		
Other input costs (USD/ha)		
Mean	55.88	21.84^{ttt}
Median	48.8	7
Number of Observations	18	51
Total costs with family labor (USD/ha)		
Mean	355.99	296.91
Median	295.13	256.11
Number of Observations	18	48
Yield (quintal/ha)		
Mean	16.41	8.97^{tt}
Median	9.41	7.29
Number of Observations	18	49

Table 4-3. Continued

	Cacao CCN-51	Cacao nacional
Revenue in the standard market		
(USD/ha)	1419.37	648.90^{tt}
Mean	652.80	572.71
Median	13	31
Number of observations		
Revenue in the specialty market		
(USD/ha)	Na	824.41
Mean		600
Median		15
Number of observations		
Revenue in the organic markets (USD/ha)	Na	562.60
Mean		165.00
Median		3
Number of observations		
Profit in the standard market with family		
labor (USD/ha)	1066.54	361.31
Mean	263.06	261.74
Median	13	30
Number of observations		
Profit in the standard market without		
family labor (USD/ha)	1233.21	543.34^{tt}
Mean	495.07	513.00
Median	13	31
Number of observations		
Profit in the specialty market with family		
labor (USD/ha)	Na	644.63
Mean		511.60
Median		14
Number of observations		
Profit in the specialty market without		
family labor (USD/ha)	Na	762.20
Mean		600.55
Median		14
Number of observations		

Table 4-3. Continued

	Cacao CCN-51	Cacao nacional
Profit in the organic market with family		
labor (USD/ha)	Na	745.91
Mean		501.67
Media		4
Number of observations		
Profit in the organic market without family		
labor (USD/ha)	Na	870.87
Mean		614.03
Median		3
Number of observations		

[t] Significant difference at the 10% level
[tt] Significant difference at the 5% level
[tttt] Significant difference at the 1% level

Table 4-4. Yield, costs, revenue, and profits per hectare equivalent

	Cacao CCN-51	Cacao nacional
Total labor (days/hae)[a]		
Mean	28.75	63.77[tt]
Median	25.89	41.93
Number of observations	18	48
Family labor (days/hae)[a]	16.16	37.72[tt]
Mean	13.95	22.5
Median	18	49
Number of observations		
Hired labor (days/hae)[a]		
Mean	12.59	25.01
Median	11.81	11.19
Number of observations	18	49
Labor for weeding (days/hae)[a]		
Mean	9.24	29.14[tt]
Median	9.17	15
Number of observations	18	51
Other labor input costs (USD/hae)[a]		
Mean	51.50	28.78[tt]
Median	36.97	8.77
Number of observations	18	51
Total costs with family labor (USD/hae)[a]		
Men	304.40	564.61[t]
Median	289.60	327.21
Number of observations	18	49
Total cost without family labor (USD/hae)[a]		
Mean	165.14	258.40
Median	171.70	121.03
Number of observations	18	49
Revenue in the standard market (USD/hae)[a]		
Mean	1393.97	834.88[t]
Median	569.92	656.25
Number of Observations	13	31
Revenue in the specialty market (USD/hae)[a]		
Mean	Na	1060.86
Median		750.00
Number of Observations		15

Table 4-4. Continued

	Cacao CCN-51	Cacao nacional
Revenue in the organic markets (USD/hae)[a]		
Mean	Na	1026.95
Median		1246.09
Number of observations		4
Profit in the standard market with family labor		
(USD/hae)[a]	1081.10	285.15[tt]
Mean	382.20	382.20
Median	13	30
Number of observations		
Profit General Market without family labor		
(USD/hae)[a]	1223.84	608.65[t]
Mean	345.45	569.92
Median	13	31
Number of observations		
Profit specialty market with family labor		
(USD/hae)[a]	Na	677.90
Mean		472.50
Median		15
Number of observations		
Profit in the specialty market with family labor		
(USD/hae)[a]	Na	677.90
Mean		472.50
Median		15
Number of Observations		
Profit in the organic market without family labor		
(USD/hae)[a]	Na	-182.32
Mean		288.39
Median		4
Number of Observations		
Profit in the organic market without family Labor		
(USD/hae)[a]	Na	233.57
Mean		496.37
Median		4
Number of observations		

[a] hae = hectare equivalent. Each parcel was converted to the amount of hectares it would contain if the trees were planted at a density of 625 trees per hectare.
[t] Significant difference at the 10% level
[tt] Significant difference at the 5% level
[tttt] Significant difference at the 1% level

Table 4-5. Perceptions of profitability

Variable Name	CCN-51 parcels	Nacional parcels	Entire farm
Profitability 6 years ago[r]	3.00	3.57	2.90[tt]
Profitability 3 years ago[r]	3.25	3.44	2.76[ttt]
Profitability now[r]	3.28	3.09	2.67[tt]
Profitability 3-5 years in the future[r]	3.92	4.11	3.46[ttt]

[r] Farmers scored the variables on a scale from one to five with one being very bad and five being very good.
[t] Difference between cacao nacional and the entire farm is significant at the 10% level
[tt] Difference between cacao nacional and the entire farm is significant at the 5% level
[ttt] Difference between cacao nacional and the entire farm is significant at the 1% level

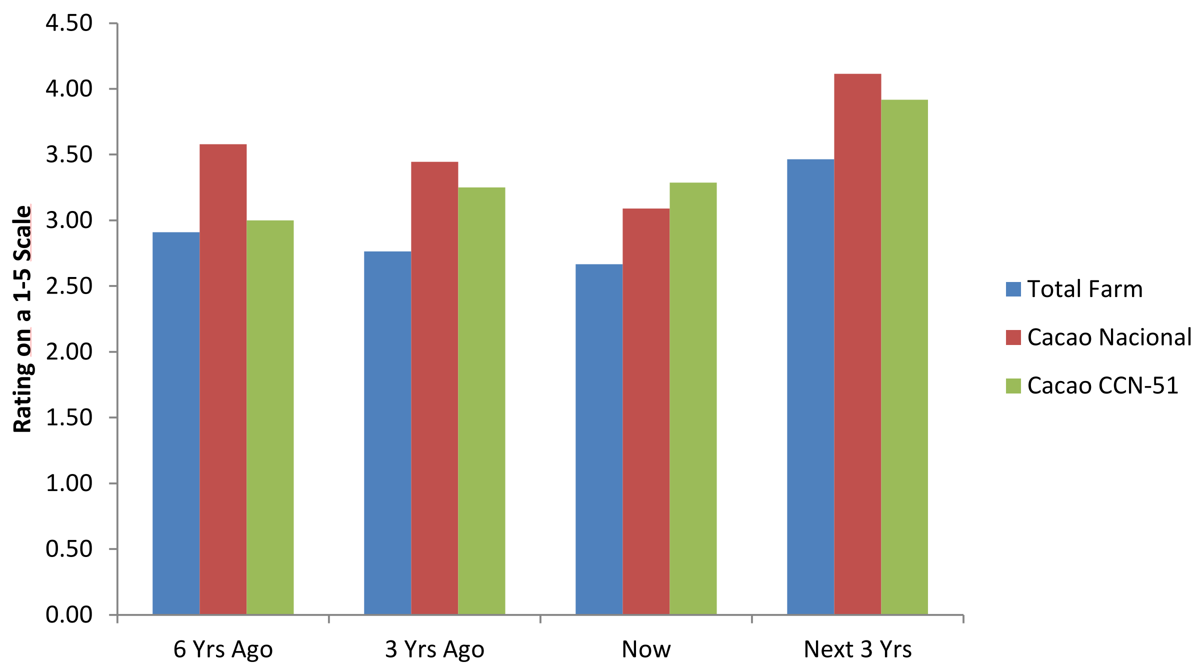

Figure 4-2. Perceptions of profitability

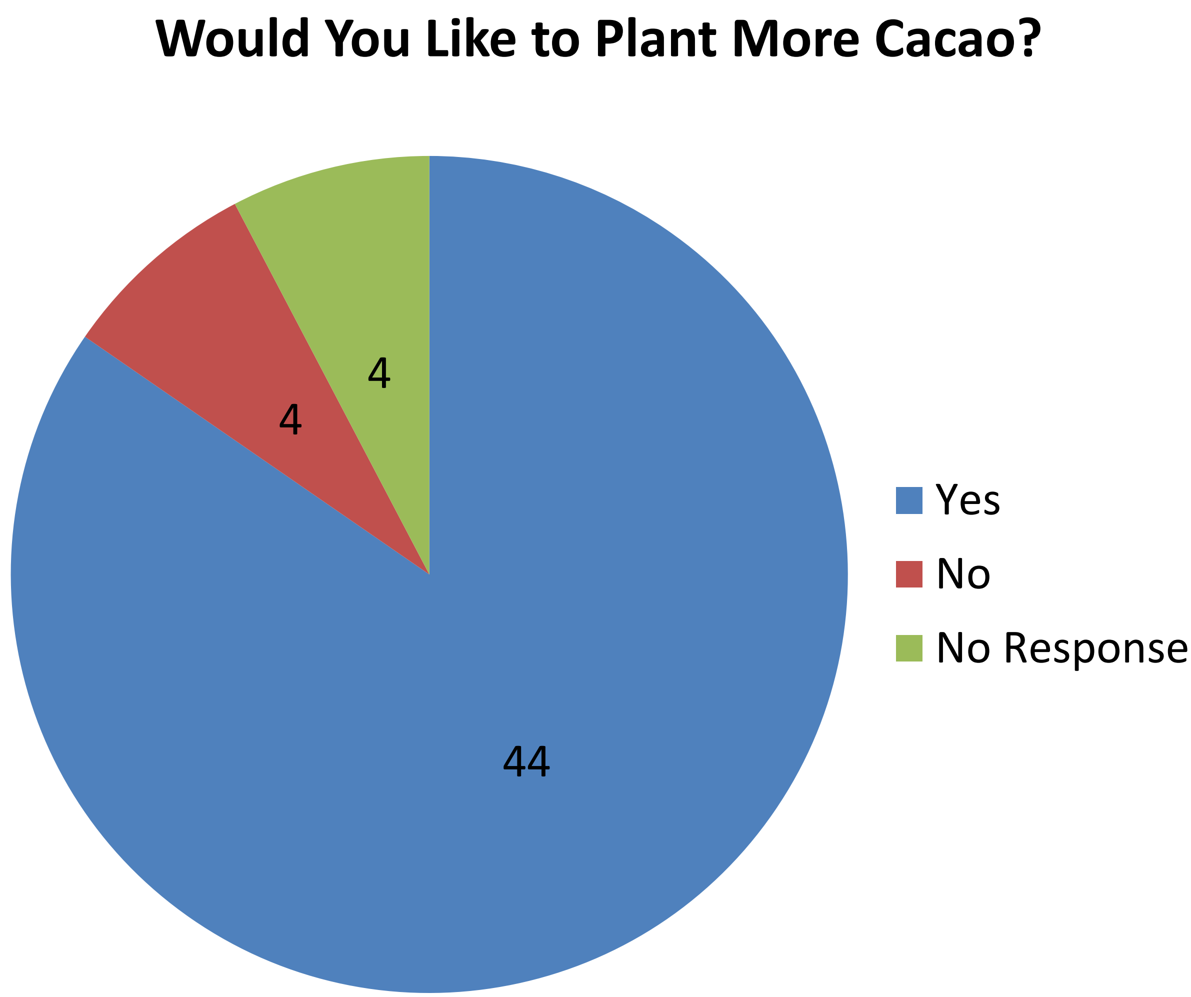

Figure 4-3. Likelihood to plant cacao

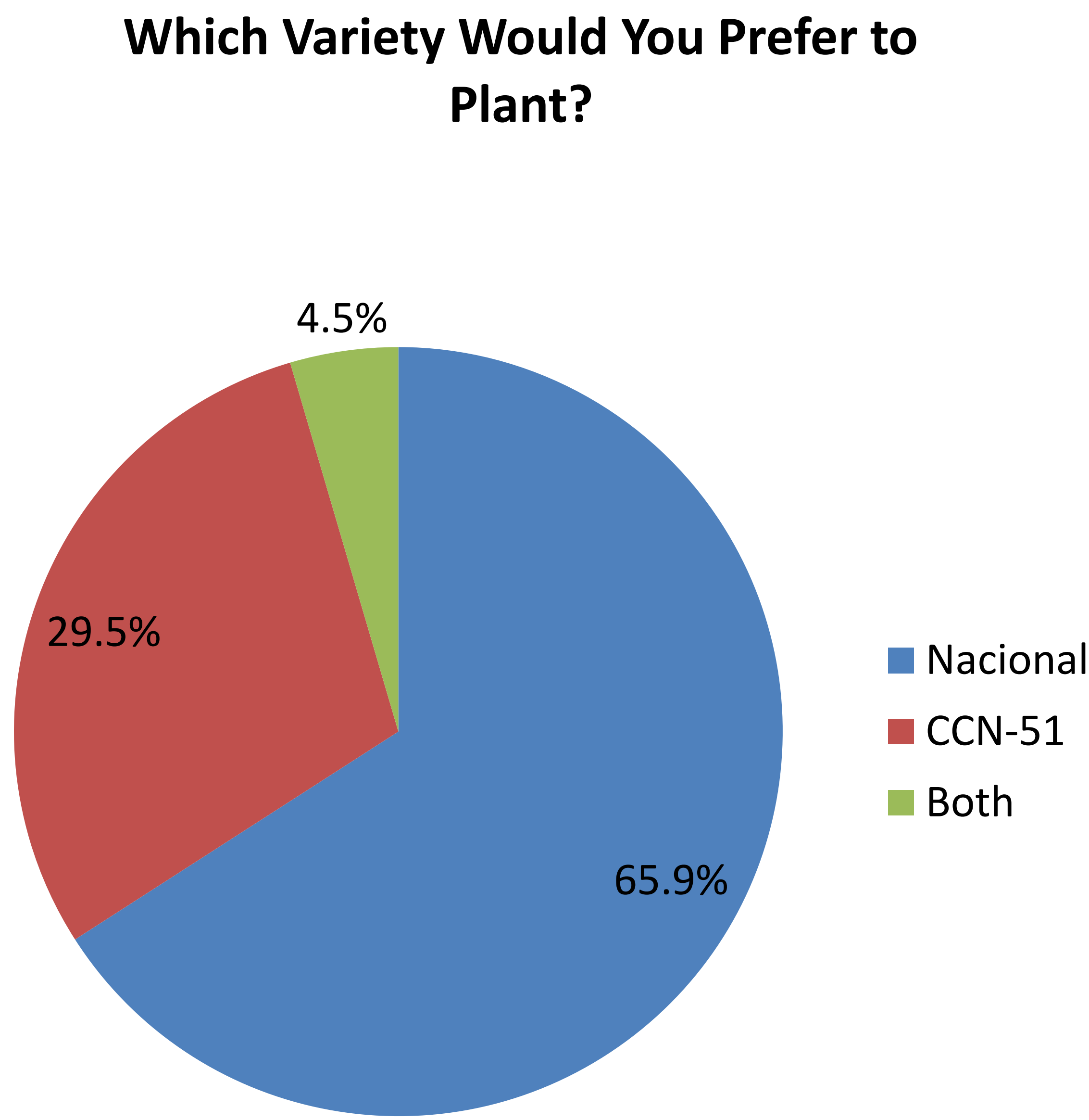

Figure 4-4. Cacao variety planting preferences

Table 4-6. Environmental perceptions

Variable name	CCN-51 parcels	Nacional parcels	Entire farm
Soil quality 6 years ago[r]	3.00	4.36[aaa]	3.76[ttt]
Soil quality 3 years ago[r]	3.00	4.25[aaa]	3.45[ttt]
Soil quality now[r]	4.00	4.24	3.10[ttt]
Soil quality 3-5 years in the future[r]	4.00	4.38[a]	3.07[ttt]
Biodiversity 6 years ago[r]	2.00	3.95	3.65
Biodiversity 3 years ago[r]	1.67	2.95[aa]	2.64
Biodiversity now[r]	2.50	2.42	2.04[t]

[r] Farmers scored the variables on a scale from one to five with one being very bad and five being very good.
[a] Difference between cacao nacional and CCN-51 is significant at the 10% level
[aa] Difference between cacao nacional and CCN-51 is significant at the 5% level
[aaa] Difference between cacao nacional and CCN-51 is significant at the 1% level
[t] Difference between cacao nacional and the entire farm is significant at the 10% level
[tt] Difference between cacao nacional and the entire farm is significant at the 5% level
[ttt] Difference between cacao nacional and the entire farm is significant at the 1% level

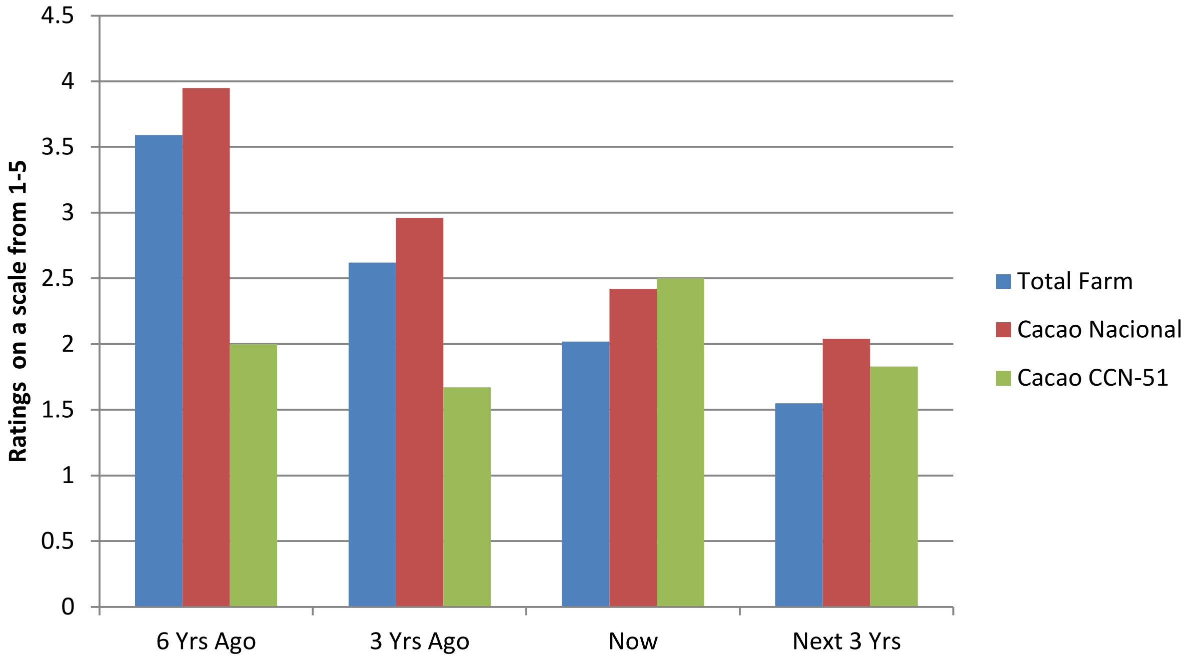

Figure 4-5. Perceptions of biodiversity

Table 4-7. Variables included in production and biodiversity regressions

Variable name	Description
Biodiversity	Number of additional varieties of plant species in the parcel
Production	Additional quintals of cacao produced
Log of family labor	Log of the days of family labor for all cacao production
Nacional * log of family labor	Interaction term of a dummy variable for cacao nacional with the log of the days of family labor
Log of hired labor	Log of the days of hired labor for all cacao production
Log of other inputs	Log of cost in US dollars other inputs besides labor for all cacao production
Flat parcel	Dummy variable indicating of the parcel where cacao is planted in a parcel with a flat terrain
Hilly parcel	Dummy variable indicating if the parcel where cacao is planted neither a flat nor steep terrain
Insecure land	Dummy variable to represent if the household has secure property rights (insecure property rights are those defined as communal land, squatted land, or inherited land)
Initial land	Hectares of land in household’s possession when the household began farming
Years land owned	Number of years that the household has the parcel of land
Ethnicity (head of household)	Dummy variable if the head of the household is indigenous Tsa’chila
Household size	Number of members in the household

Table 4-8. Coefficients of the biodiversity equation

Variable name	Coefficient	Standard Error
Log of family labor	0.09	0.07
Nacional * log of family labor	0.15[tt]	0.05
Log of hired labor	0.05	0.04
Log of other inputs	0.03	0.03
Flat parcel	-0.64[tt]	0.19
Hilly parcel	-0.40[tt]	0.19
Insecure land rights	-0.49[tt]	0.15
Initial land size (ha)	0.00[t]	0.00
Years land owned	0.01[t]	0.00
Ethnicity (head of household)	0.67[tt]	0.19
Household size	-0.05[t]	0.03
Constant	0.52	0.22

$F(11, 32) = 20.94$
Probability > F = 0
R-squared = 0.7518
Number of observations = 44
[t] Significance at the 10% level
[tt] Significance at the 5% level

Table 4-9. Coefficients in the production equation

Variable Name	Coefficient	Standard Error
Log of family labor	0.35[tt]	0.16
Nacional * log of family labor	-0.03	0.04
Log of hired labor	-0.07	0.10
Log of other inputs	0.06	0.07
Flat parcel	0.91[tt]	0.19
Hilly parcel	0.73[tt]	0.23
Insecure land rights	0.15	0.27
Initial land size (ha)	0.00	0.00
Years land owned	0.01[t]	0.00
Ethnicity (head of the household)	-0.92[tt]	0.28
Household size	-0.03	0.07
Constant	0.48	0.54

$F(11, 32) = 7.99$
Probability > F = 0
R-squared = 0.6302
Number of observations = 44
[t] Significance at the 10% level
[tt] Significance at the 5% level

Table 4-10. Shadow wage components by market

	All Cacao	Nacional
wQ*(in USD per day of family labor) in Standard Market	10.35	N.S.[t]
wQ*(in USD per day of family Labor) in Specialty Market	11.93	N.S.[t]
w_V*(in varieties per day of family labor)	N.S.*	Pv*0.01[a]

[t] N.S. means the value is not significant
[a] Pv is the value of the additional variety in the parcel

Table 4-11. Shadow wage by variety and market

	Price in US dollars per day of labor
Shadow value of labor for cacao nacional sold in standard markets	> 10.35
Shadow value for a day of labor for cacao nacional sold in specialty markets	> 11.93
Shadow value for a day of labor for cacao CCN-51 sold in standard markets	= 10.35

CHAPTER 5
CONCLUSION

New Conceptual Framework

A need exists to better conceptualize the production decisions of small landholder households. Many models of smallholder farmers' production decisions have begun to include factors besides profit maximization such as subsistence needs and overall household welfare. The environmental impact of production methods are also important factors to smallholder households as these variables impact the sustainability of their farms. In addition, these factors provide the household with aesthetic and other values. A biodiversity measurement is one way to capture this ecological value as the research on agroforestry cropping systems have shown that these diversified cropping systems provide many ecological services important to smallholder households. These biodiverse systems also provide many monetary benefits such as additional incomes sources and meeting consumption needs. The biodiversity factors have proven to be an important consideration in the production decisions of smallholder cacao producers in Ecuador as these farmers would prefer to raise cacao nacional which provides many ecological and other benefits that are not obtained in cacao CCN-51 parcels.

In order to analyze the importance of biodiversity in the production of cacao, we created a model that disentangles the effects of family labor for biodiversity and for the production of cacao by analyzing shadow prices. Shadow wage and shadow income value biodiversity which has not been included in past models of shadow wages and labor. Our model also takes into account of the effect of segmented markets. Segmented markets exist in the Ecuadorian case by certification requirements and limited demand in specialty cacao nacional markets. Our modeling technique is useful for the study of other crops that participate in segmented markets such as in the fair trade markets, not just the cacao nacional specialty market.

The shadow wage in this model is the sum of the traditional measure of the shadow wage, household's MPL for cacao production, and the new variable, the MPL of biodiversity. Our analysis of the shadow prices for cacao in northwestern Ecuador reveals the households receive a higher shadow income for planting cacao nacional than for planting cacao CCN-51. Only a lower bound for the shadow wage could be developed as the aesthetic and other nonmarket values of biodiversity were not captured in the survey. The magnitude of the difference between the market and shadow wages depends on the crops planted in the cacao parcels. The shadow prices also show that family and market labor are not perfect substitutes. Family labor receives a very high value that would induce family members to work on the farm instead of participating in the labor markets. The shadow wage for cacao production is at the upper bounds of the labor market and the shadow wage for cacao nacional sold in specialty markets is even higher. Thus, smallholder households in Ecuador would be able to maximize the value of their labor by devoting to production of cacao nacional.

Impact on Current Research

Our analysis of shadow wage extends the theoretical work of Jacoby (1993) and Skoufias (1994). Our model adds to this work by showing the importance of including externalities, such as the benefits from biodiversity, in computing shadow wage in segmented markets. By examining segmented markets, our analysis of shadow income enhances the work on fair trade of LeClair (2002) and Hayes (2008) by examining the impact of these markets at the household level. The determinants of market access in these specialty and fair trade markets were also examined. Our surveys revealed that many farmers were excluded from these markets. Our model could help create a better understanding of the failings of these methods in reaching smallholder households. Our model of shadow prices has shown to be effective in trying to capture the non market benefits that farmers realize in their production and take into account in making copping decisions.

Need for Further Research

Our study leaves several areas to be examined to better understand smallholder household's production decisions. First, this research was not able to fully explore the impact of risk on these decisions. Research on agroforestry has shown that these diversified cropping systems are less risky than monoculture production methods as a household has additional income sources to meet its needs (Reitsma 2001). The household welfare impacts of growing diversified, organic production systems compared to monoculture commercial production systems such as between cacao nacional and cacao CCN-51 need to be examined. The former production system is argued to be more ecologically sustainable but the human welfare impact also needs to be examined to truly understand the impact to total welfare of each production system. Finally, methods need to be utilized to give a value to the non market benefits for biodiversity. Only by placing a value on these factors can shadow wage be crated that includes all the externalities rather than creating a lower bound for this wage as was included in our study.

These additional nonmarket values are especially important in developing countries where many households are dependent on their farms not only for cash income but also for meeting subsistence needs. The Ecuadorian cacao case provides a good example of the need for the inclusion of additional values in the household decision model. When comparing the shadow wages, the traditional production methods for cacao nacional proved to best production decision when the value for biodiversity was included in analyzing the smallholder household's production decision. The shadow wage and income that includes biodiversity as a value in the price provides an additional method for determining the true value of a production method to smallholder households.

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BIOGRAPHICAL SKETCH

Trent Blare was raised on a ranch in western South Dakota where he first gained a passion for agriculture and the rural lifestyle. While in high school, Trent was very active in 4-H and FFA. The activities in these organizations enhanced his interest in agribusiness. So, he decided to pursue a degree in Agricultural Economics at the University of Nebraska- Lincoln where he was an honors graduate and Chancellor's Scholar. He had the opportunity to participate in two undergraduate research opportunities while at the University of Nebraska. He first worked with political science professor Dr. David Rapkin to examine the impact of the United States' position in trade negotiations in the World Trade Organizations. He continued this work with his adviser Dr. E. Wesley Peterson to build a model that explained the impact on American small grain producers of a new trade deal in the World Trade Organization.

One of the highlight of Trent's life and professional development was his service in the Peace Corps. Trent lived in a Tsa'chila indigenous community for three years. He worked with the community on an eco tourism project as well as helped improve their production and marketing of cacao. This experience spurred Trent to continue his studies in Food and Resource Economics at the University of Florida with a focus on agricultural development. While at the University of Florida, Trent has been active in the Tropical Conservation and Development Program, which provided him with funding to pursue his research on Ecuadorian cacao production in the summer of 2009. Trent plans to continue his work in agricultural development and especially his research on cacao in Ecuador as he begins a PhD in Food and Resource Economics at the University of Florida in August of 2010.