

ABSTRACT

Casey, James Francis. Examining the Adoption of Agroforestry in Southeastern Mexico: Three Essays from a Survey with Farmers in Calakmul, Campeche. (Under the direction of Robert C. Abt.)

In three essays, farmer preferences are analyzed using Contingent Valuation and Choice Modeling. Particular attention is paid to the role of uncertainty, investment in human capital and the importance of forest conservation. The data analyzed in each of the three essays was collected by the author from July 1997 through March 1998. The first essay empirically tests the hypothesis that investment in human capital increases the likelihood of participation in an agroforestry development program. Results support the hypothesis that human capital investments that reduce uncertainty, improve the likelihood of participation in an agroforestry development program. In the second essay a choice modeling experiment (CM) is used to assess the value farmers have for different agroforestry systems and the individual attributes that make up each system. Results suggest that farmers in Calakmul place a value on 1) conserving and increasing local forest cover, 2) working in a nursery in order to obtain seedlings, and 3) receiving enough technical assistance to get started with a program. The third essay uses an application of the discrete-choice contingent valuation method to estimate the willingness of farmers, in southeastern Mexico, to participate in forest conservation efforts. The estimated values of the marginal effects from a probit model (Cameron 1987) are used to develop welfare estimates. Results suggest farmers are willing to work slightly less than three days per month in order to preserve an area of community forest.

**Examining the Adoption of Agroforestry
In Southeastern Mexico:
Three Essays from a Survey with Farmers
in
Calakmul, Campeche**

By

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PERSONAL BIOGRAPHY

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DEDICATION and ACKNOWLEDGEMENTS

There are Angels all around us. For 22 years my own personal angel took the form of my sister, Kimberly. But, she left me in September of 1996 after being my spiritual guide for many years. In that same month, another angel entered my life. This time it took the form of Lisa Brigette D'Amelio. Lisa and I were married in October of 1998 (one of two of the happiest days of my life!) and have since brought another angel into the world, our daughter, Catarina Maria, who was born May 2, 2001 (the other happiest day!). Were it not for the brilliance and beauty of these three angels, I would not be writing this today.

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Introduction

This project began in July 1996. It was part of “Phase II of the US/Mexico Agroforestry Development Project.” Along with the International Center for Research in Agroforestry (ICRAF), the United States Forest Service was working in Southeastern Mexico developing and disseminating agroforestry technologies to improve farm production, while conserving and increasing forest cover. My first site visit occurred in February of 1997. With funding in hand from the National Agroforestry Center in Lincoln, NE, I was off to Guatemala in July 1997 for four weeks of intensive language instruction. The survey development phase of the project began in August and the interviewing of farmers began in January after 5 months of survey development. Surveying continued through March and a total of 186 farmers were interviewed.

These farmers live in the buffer zone of the Calakmul Biosphere Reserve. The core zone of this reserve permanently protects about one million hectares of forestland, but also removes this land from potential agricultural development. ICRAF’s aim in this region is to design agroforestry systems that will be readily adopted and utilized by farmers to help alleviate poverty and decrease rates of deforestation. Much is known about the soils and plants of Calakmul. However, there is a dearth of socioeconomic information. This is true, not only for Calakmul, but for Latin America in general.

Mercer and Miller (1998) state, “Priority areas for future research include theoretical and empirical analyses of agroforestry adoption decisions, improved economic analyses, and policy studies at local, national, and regional levels.” In a survey of all articles published in the journal *Agroforestry Systems*, Mercer and Miller (1998) identify significant gaps in socioeconomic research. From 1982 – 1996 only 22% of the articles

published in *Agroforestry Systems* pertained to socioeconomics. A total of 113 articles were published in this 14 year time period. If this were not troubling enough, there are 4 specific factors that these essays will address. First, only 3% of the socioeconomic papers were empirical in nature and utilized multiple regression for the analysis. Second, less than one-third of the socioeconomic papers used data from formal surveys. Third, only 16 surveys had a sample size of 100 or greater and fourth, Latin America is under-represented with only 11% of the socioeconomic articles dealing with Latin America (Mercer and Miller 1998). Although more recent work by Caviglia (1999), and Caviglia and Kahn (2001) has improved our understanding of the adoption process as it pertains to agroforestry, there is certainly more to be done.

The three essays that follow aim to provide more insight into the agroforestry adoption decision. Particular attention is paid to the role of uncertainty, investment in human capital and the importance of forest conservation. Again, the data analyzed in each of the three essays was collected by the author from January 1998 through March 1998 with funding assistance from the USFS and in collaboration with ICRAF.

The first essay empirically tests the hypothesis that investment in human capital increases the likelihood of participation in an agroforestry development program. Results support the hypothesis that human capital investments that reduce uncertainty improve the likelihood of participation in an agroforestry development program.

In the second essay a choice modeling experiment (CM) is used to assess the value farmers have for different agroforestry systems and the individual attributes that make up each system. Results suggest that farmers in Calakmul place a value on (1)

conserving and increasing local forest cover, (2) working in a nursery in order to obtain seedlings, and (3) receiving enough technical assistance to get started with a program.

The third essay uses an application of the discrete-choice contingent valuation method to estimate the willingness of farmers in southeastern Mexico to participate in forest conservation efforts. The estimated values of the marginal effects from a probit model (Cameron 1987) are used to develop welfare estimates. Results suggest farmers are willing to work slightly less than three days per month in order to preserve an area of community forest.

If agroforestry programs are to succeed, it is important to understand precisely what farmers want and what will lead them to adopt new technologies. This will facilitate wider scale dissemination of agroforestry and enable researchers to improve the design of agroforestry systems. In order to accomplish this, economic data must accompany biological data. By learning more about the preferences of farmers in Calakmul, agroforestry will stand a better chance at alleviating poverty and decreasing rates of deforestation.

Essay 1

Econometric Analysis of the Determinants for Participation in an Agroforestry Development Program

Abstract:

The objective of this paper is to empirically test the impact of several determinants on the likelihood of participation in an agroforestry development program. Theoretical determinants of adoption, based on recent work by Gadim and Pannell (1999), Negatu and Parikh (1999), and Caviglia and Kahn (2001) are tested using revealed and stated preference (RP and SP) data. Data for this analysis was collected near the Calakmul Biosphere Reserve in the state of Campeche in southeastern Mexico. One hundred seventy-five farmers were interviewed from January through March of 1998. Results support several hypotheses that factors relating to farmers' managerial abilities, skill development, and personal perceptions affect the likelihood of participation in an agroforestry development program.

1.0. Introduction

A centerpiece of a large number of projects intended to foster sustainable economic progress in rural areas is the adoption of agroforestry and other farming systems that are more in tune with the natural environment than is conventional monoculture. It is curious, then, that the factors influencing adoption have been little investigated. This paper makes an attempt at remedying this omission. In the paper, an econometric model is used to relate the adoption of agroforestry in southeastern Mexico to various factors. Evidence from both revealed and stated preferences for agroforestry is used and compared.

Conventional wisdom suggests that agroforestry systems, capable of providing substantial net economic and ecological benefits to households and communities, should be readily adopted by farmers. Nevertheless, many attempts to promote agroforestry have resulted in poor rates of adoption (Zinkhan and Wear 1992). Studies by Dunn et al.

(1990), Wannawong (1991), Sullivan (1992), Current, Lutz and Scherr (1995) show higher net present values (NPVs) for agroforestry systems when compared to monoculture systems, yet farmers in developing countries show low rates of adoption. When adoption occurs, many farmers eventually abandon the new agroforestry system of production in favor of more traditional systems with lower NPVs.

Why is this the case? Mercer and Miller (1998) suggest that shortcomings in our understanding of the contribution of risk and uncertainty to agroforestry adoption may explain the low adoption rates. Negatu and Parikh (1999) suggest that farmers' perceptions regarding new technologies make a difference. Ghadim and Pannell (1999) present theoretical results, which show learning over time to be a significant factor.

Using farm-level data, collected in southeastern Mexico from January through March of 1998, this paper empirically tests whether various factors related to (1) farmers' personal perceptions, (2) skill development, and (3) managerial abilities enhance the likelihood of participating in an agroforestry development program.

1.1 Agroforestry Adoption

For the farmer, investing in agroforestry entails undertaking an activity with an uncertain outcome. The incentive behind planting trees on farms is to diversify outputs, reduce the uncertainty associated with droughts, and increase cash income (Scherr 1995). However, planting trees is labor intensive, returns are not immediate, and tree planting may be a new activity for the farmer. Therefore, even though farmers are presented with information pertaining to the long-term benefits of planting trees, they may not adopt due to the lack of relevant information they possess and the set of skills they have for agroforestry.

“Peasant skepticism about innovation is thought to be largely related to imperfect knowledge of innovations and agronomic practices appropriate to them” (Ellis 1988). For subsistence farmers, uncertainty has a seriously inhibiting effect on production, for they cannot afford to suffer setbacks, which might mean deprivation or even starvation. Innovations, i.e. agroforestry, often introduce more uncertainty to the farmer than traditional methods of production. This uncertainty inhibits the diffusion and adoption of innovations, which could potentially improve the output and incomes of peasant farm families (Low 1974). However, Schultz (1964) argued that farmers with greater human capital are better able to utilize new technology. According to Blaug, (1972), education improves one’s ability to capitalize on opportunities:

“the better educated are generally more flexible and more motivated, adapt themselves more easily to changing circumstances, benefit more from work experience and training, act with greater initiative in problem-solving situations, and, in short, are more productive than the less educated, even when their education has taught them no specific skills.”

1.2 Theoretical Model of Adoption Choice

The theoretical model of the farmer household’s decision to adopt agroforestry follows the adoption framework from the seminal work of Griliches (1957). The adoption of a new farming technique is treated as a dichotomous choice. According to Mansfield’s (1971) additions to Griliches’ model (1957), the diffusion of a new, superior technology is expected to increase slowly at first, then rapidly as information about the technique spreads, and then slow down as the percent of farmers that have adopted the new technology approaches 100. The adoption of new farming technologies have

historically been slow in developing countries because of market failures, capital and/or income constraints, risk averse behavior, and/or an inability to adopt the new techniques (Caviglia and Kahn 2001) (Casey et al. 2001).

Following Caviglia and Kahn (2001), I use a model of household utility maximization to explain farmer adoption behavior because farmers are both consumers and producers of goods. And, since farming households in developing areas often operate under multifaceted market failure (for example, markets are limited by transportation, consumers and producers hold imperfect information, and there are missing markets for native products), I use an expected utility maximization framework to represent choices made under market uncertainty. Again, this follows directly from the theoretical model developed in Caviglia and Kahn (2001). Utility is derived from the household's consumption of goods, C , and a group of other factors, Z .

Following the work of Adesina and Zinnah (1993) and Caviglia and Casey (2001), the family utility maximization model is based on the expected value of the non-observable underlying utility function that ranks the preference of the i th family according to the chosen technology. The non-observable underlying utility function is represented by: $E [U_{it} (C_i (H_i, T_i), Z_i)]$, where E is the expectations operator, t represents the technology choice ($t=1$ when agroforestry is employed on the lot and $t=2$ when slash-and-burn agriculture is used exclusively), and i indicates the individual household.

Consumption is derived from observable farm and household characteristics, H , (such as lot size, and age and education of the household heads), and from observable technology characteristics, T , (such as yield, income, and the labor-leisure ratio) where the technology refers to the agricultural method chosen by the family. The choice of

technology therefore determines farm yield, family income, and the labor and leisure that the family can afford. Input and output levels of agricultural production will differ according to the farm technique. Although the utility is unobservable, the relation between the utility derived from a specific technology is a function of the vector of the observed farm and technology characteristics included in the utility measurement.

The family chooses between $E[U_{i1}]$ and $E[U_{i2}]$ depending upon which technology yields the greatest expected utility. The utility ranking of the chosen technology is therefore estimated from the vector of observable farm and technology characteristics as follows:

$$E[U_{it}] = \alpha F_i(X_i) + e_{it}; \quad t = 1,2 \text{ and } i = 1 \dots n \quad (1)$$

where e_{it} is a normally distributed disturbance term.

The i th family will choose to use slash-and-burn agriculture if $U_{i1} < U_{i2}$,² or if the latent variable $Y^* = U_{i1} - U_{i2} < 0$ and will choose agroforestry when $U_{i1} > U_{i2}$, or if the non-observable latent variable $Y^* = U_{i1} - U_{i2} > 0$:

$$\begin{aligned} Y_i &= 1 \quad \text{if } U_{i1} > U_{i2}, \text{ Agroforestry adopted} \\ Y_i &= 0 \quad \text{if } U_{i1} < U_{i2}, \text{ Agroforestry NOT adopted} \end{aligned} \quad (2)$$

The probability that the farmer household adopts agroforestry (the probability that Y_i equals one), is a function of the independent variables:

$$\begin{aligned}
P_i &= \Pr(Y_i = 1) = \Pr(U_{i1} > U_{i2}) \\
&= \Pr[\alpha_1 F_i(X_i) + e_{i1} > \alpha_2 F_i(X_i) + e_{i2}] \\
&= \Pr[(e_{i1} - e_{i2}) > F_i(X_i)(\alpha_2 - \alpha_1)] \\
&= \Pr[v_i > F_i(X_i)\beta] \\
&= F_i(X_i\beta)
\end{aligned} \tag{3}$$

where X is an $n \times k$ matrix of explanatory variables, and B is a $k \times 1$ vector of coefficients to be estimated.

The probability that the i th household adopts agroforestry is therefore the probability that the utility gained from slash-and-burn agriculture is less than the utility gained from the adoption of agroforestry (the cummulation distribution function of F for i evaluated at X_i). If ϵ_i is normal, F will have a cumulative normal distribution, and if ϵ_i is uniform then F is triangular (Caviglia and Kahn 2001). For the purpose of this analysis, ϵ_i is assumed to be normal, making the estimation of the probability possible using a probit model.

The second stage of the model involves the estimation of the extent of adoption once the decision is made to adopt agroforestry by the i th family. Evaluating equation 4, the functional form of F is specified with a Tobit model where ϵ_i is an independently normal distributed error term with a zero mean and constant variance (Adesina and Zinnah 1993, Caviglia and Kahn 2001).

$$\begin{aligned}
Y_i &= X_i\beta & \text{if} & & i^* = X_i\beta + v_i > A \\
Y_i &= 0 & \text{if} & & i^* = X_i\beta + v_i < A
\end{aligned} \tag{4}$$

Y_i is the probability of adopting agroforestry, i^* is a non-observable latent variable, A is a non-observable threshold value, and X are the same independent variables used to explain the extent of adoption decision.

1.3. Empirical Procedures

1.3.1. Data

The data for this research were collected in the State of Campeche, in the southeastern corner of Mexico near the buffer zone of the Calakmul Biosphere Reserve. I collected all of the data with assistance from ICRAF and funding from the USFS. The reserve extends over 723,185 hectares (1.7 million acres) and its forests are contiguous with those of the Peten in Guatemala and the northwest forest of Belize. In 1993 UNESCO's Man and the Biosphere program accepted Calakmul into its international network of biosphere reserves. The innovative premise behind the biosphere reserve is to link conservation with human activities and rural development.

The majority of people in Calakmul practice slash-and-burn agriculture and all are basically poor, subsistence-type farmers. Poverty rates have continued to increase in the region over the last ten years due to migration from other areas of Mexico and the general lack of agricultural knowledge inherently found in urban migrants. In addition, the natural resource base has been degraded with the increase in population and more intensive use of the land.

Table 1 lists each of the communities surveyed, the total population in each community, the number of people interviewed, and the number and percentage of farmers interested in agroforestry.

Table 1 Ejidos surveyed

EJIDO	Population	Number surveyed	Percentage surveyed	Interested in Agroforestry	Interested in AF %
Ley de Fomento	44	15	34	11	73%
Felipe Angeles	24	10	41	9	90%
11 de Mayo	57	17	30	16	94%
La Guadalupe	84	22	26	11	50%
Josefa Ortiz	34	13	38	12	92%
El Refugio	30	12	40	12	100%
Carmen II	58	16	28	13	81%
Castellot	20	13	65	12	92%
Heriberto Jara	54	9	17	8	89%
Centauro del Norte	60	10	17	9	90%
20 de Junio	57	11	19	9	82%
Nueva Vida	40	10	25	9	90%
16 de Septiembre	14	8	57	6	75%
Alvero Obregon	NA	5	NA	2	40%
Narciso Mendoza	NA	4	NA	3	75%
Total		175	NA	142	82%

Individual farmers were interviewed during the period from January 1998 through March 1998. Farmers were asked about their current farming methods, experience with tree harvesting, and their interest in participating in an agroforestry development program. A total of 175 farmers were interviewed in 15 different communities. Of the 175 farmers, 142 expressed interest in agroforestry as a potential production strategy for at least part of their farm. Of these 175 farmers, 57 are currently using agroforestry on their farms.

1.3.2. MODEL SPECIFICATION

In order to test the hypothesis that farmers with greater human capital are more likely to adopt agroforestry I estimate the following model of agroforestry adoption.

$$Y = a + b H_i + b S_i + b R + e \quad (5)$$

H_i is the vector of determinants expected to influence the adoption decision. H_i includes variables to measure the amount of formal education (ED), the level of forestry related experience (EXP), the number of hectares currently cultivated in trees (HAAF), whether the farmer thinks he has been successful in previous attempts to cultivate trees (SURV), the amount of time a farmer has been practicing agroforestry (TIME), and to identify those who have been exposed to agroforestry through formal forestry-related development programs (EXPOSE).

The vector S_i contains socioeconomic characteristics of the farmers. S_i includes variables to measure income (INC), the age of the household head (AGE), the size of the farm (FARM), the number of years the farmer has been at the present location (YEARS), whether or not there is an adequate natural seed source available to the farmer (SEEDS), family size (FAM), area in crop production (CROP), and the distance from the household to the agricultural fields (DIST).

R is a dummy variable used to stratify the sample based on general rainfall patterns. Actual data for rainfall were unavailable so based on several conversations with local extension agents it was determined that the Southeast area received more rainfall than the Northwest and the sample was stratified based on this difference in rainfall.

Table 2 contains a description of how each variable in the model is measured along with means, minimum and maximum values and standard deviations. The dependent variable for the SP model is equal to 1 if the farmer says yes he will participate and 0 if he says he is not interested. For the RP model it is equal to 1 if the farmer is currently using agroforestry and 0 if not. Finally, for the Tobit model, Y equals the number of hectares of agroforestry.

Table. 2: Variables Included in Model Specifications

Variable name and Description	Mean	Standard Deviation	Min.	Max.
HAAF: The number of hectares currently planted in an agroforestry system.	0.38	0.65	0	3
ED: A categorical variable to differentiate between farmers who have not completed primary school, those who have completed primary, those who have completed secondary, and those with more than secondary school.	0.51	0.72	0	3
SURV: Farmers who say they are happy with their current plantation receive a one and those who are not pleased with their current plantation receive a zero.	.31	-----	0	1
EXP: Farmers who had agricultural experience before coming to Calakmul and have since obtained some forestry experience received a 1 and all others a 0.	0.17	-----	0	1
EXPOSE: If a farmer has participated in an agroforestry program he receives a 1, and all others 0.	0.46	-----	0	1
INC: Total income from the sale of agricultural and forestry related products.	11,363	12,269	0	63,600
STRAT: Dummy variable differentiating the NW zone and SE zone.	0.39	-----	0	1
FARM: Size of the farm, including agricultural land, forestland, the homesite, etc.	49.1	25.1	0	120
YEARS: The number of years farmer has been living at the present location.	11	6.4	0.3	36
SEEDS: Dummy variable indicating whether or not the farmer thinks the local forest is a good source for seeds and seedlings. 1 if yes, 0 if no.	0.53	-----	0	1
DIST: The distance the farmer actually has to travel to get to his fields.	2.9	2.3	0	10
BOYS: The number of male children living at home.	2	1.8	0	8
CROP: Hectares of cropland.	3	2.1	0	18
TIME: Years since implementing an Agroforestry system.	1.2	1.9	0	7
HARV: 1 if the household harvests timber; 0	.16	.37	0	1

otherwise.				
BURN: Hectares burned for agricultural.	17	13	0	95
AGE: Age of the household head.	38	13	16	74
FAM: Total number of people living in the household.	6	4	0	14

1.4. EMPIRICAL RESULTS

Table 3 summarizes the main characteristics of farmers in Calakmul and compares those indicating they would participate with those not interested in agroforestry.

Table 3. Study Sample Characteristics

Characteristic	Total N=175	Yes N=142	No N=33
Agroforestry (hectares)	0.38	.43***	.13
Education	.506	.552*	.303
Survival	0.31	0.35**	0.15
Experience	.17	.19	.09
Exposure	.46	.50**	.31
Income (pesos)	11363	10787	13859
Total farm area (hectares)	49	49.8	46
Years	10.9	10.9	10.9
Seeds	0.53	0.55	0.39
Distance	2.9	2.9	2.9
Boys	2	2	2
Crops (hectares)	4.8	4.8	4.9
Time	1.2	1.3**	.6
Harv	.16	.17	.12
Burn	17	9.8	12
Age	38	37.7	40.7
Fam	6	6	6

Each of the characteristics was tested for significant differences in means.

*** significant at .01, ** significant at .05, and * significant at .10

Before proceeding to the regression results from the estimation, it can be seen from table 3 that there are significant differences between farmers who are interested and those who are not interested in agroforestry. Farmers who say they are interested currently have more trees planted, they have more education, and are more likely to have been exposed to agroforestry through a development program and are happier with their current tree plantations. Additionally, they planted their first trees an average of 1.3 years ago, opposed to seven months ago for those not interested.

Table 4 provides the results from the stated preference (SP) and revealed preference (RP) equations. Stated preference refers to the method of directly asking an individual farmer whether they are interested in participating in an agroforestry program and revealed preference refers to the revealed behavior of those currently using some form of agroforestry on their farm. Signs of all variables are as theory predicts, except for income. Traditional economic theory predicts that per capita income will play a positive role in the adoption of new technologies. Results from Dercon (1998) and Rosenzweig & Binswanger (1993) support this theory. However, there is also contradictory empirical evidence. Caviglia and Kahn (2001) show that information and education are more important factors in the adoption decision than is income. Shakyia and Flinn (1985) find similar results and I also find the coefficient on income is not significantly different from zero.

Table 4. RESULTS OF PROBIT ESTIMATIONS

STATED PREFERENCE			REVEALED PREFERENCE		
Number of obs = 175			Number of obs = 175		
chi2(15) = 30.02			chi2(9) = 25.86		
Prob > chi2 = 0.011			Prob > chi2 = 0.0021		
Log Likelihood = -68.24			Log Likelihood = -97.153		
Pseudo R2 = 0.18			Pseudo R2 = 0.12		
ADOPT	Coef.	Mar.Eff.	ADOPT	Coef.	Mar.Eff.
HAAF	1.47*** (.68)	.29	CROP	.174** (.121)	.06
ED	.434*** (.22)	.08	ED	.393*** (.295)	.13
SURV	.539** (.32)	.11	BURN	-.329 (.793)	-.11
EXP	.875** (.47)	.12	FARM	-.003 (.007)	-.001
EXPOSE	.178 (.28)	.03	EXPOSE	.754*** (.366)	.25
INC	-.00001 (.00001)	-.000001	YEARS	-.005 (.030)	-.002
STRAT	.299 (.29)	.06	AGE	.011 (.014)	.003
FARM	.008 (.005)	.001	FAM	-.046 (.068)	.015
YEARS	.015	.003	INC	-.00001	-.000004

SEEDS	(.02) .241	.05	_cons	(.0001) -.226	-----
	(.28)			(.996)	
DIST	-.015	.003			
	(.06)				
BOYS	-.024	-.005			
	(.07)				
CROP	-.032	-.006			
	(.06)				
TIME	-.238	-.05			
	(.15)				
HARV	-.288	-.06			
	(.44)				
_cons	-.118	---			
	(.49)				

Of the 175 farmers interviewed, 142 said they were interested in agroforestry as a production strategy. The SP model, with a chi-square of 30.02 with 15 degrees of freedom, is significant at .01% implying the independent variables, taken collectively, influence being interested in participating in an agroforestry program. Accordingly, the model predicts 82.9% of the responses correctly and has a pseudo r-square of .18.

Several of the determinants are positively correlated with the decision to adopt. The variable (HAAF) is significant at the .01 level as is education level (ED). The subjective measure of tree planting success (SURV) and forestry experience (EXP) are also positively related to the decision to adopt and significant at the .05 level. The variables (HAAF) and (EXP) can be interpreted as measures of informal specific on-the-job training. We can compare this to (EXPOSE), which is a measure of formal general training. Formal training is not as important as specific on-the-job. Since farmers with more informal on-the-job training are more likely to be interested in agroforestry, it may be possible to identify and use these farmers to informally teach others about tree planting. This should enhance the likelihood of adoption by other farmers. Additionally,

(ED), the level of education supports the theory that those with education are more likely to be interested as they can more readily handle uncertainty.

Of the 175 farmers interviewed, 57 are currently using agroforestry. This accounts for 32% of the sampled population. The equation relating the actual adoption of agroforestry (RP) to various factors is well specified. A chi-square of 25.86 with 9 degrees of freedom is significant at the .002 level, implying the right-hand side variables, taken collectively, do influence the decision to adopt agroforestry. Additionally, a pseudo r-square of .12 with 72.16% of the responses predicted correctly suggests the model is well specified. There are three significant variables, all of which are positively correlated with the adoption decision. They are exposure to agroforestry through an extension agent (EXP), level of education (ED) and amount of cropland in cultivation (CROP). ED and CROP are significant at the .05 level and EXP at the .01 level. The acquisition of information from an extension agent and educational attainment are two factors that may reduce the uncertainty associated with adopting agroforestry and improve the chances for adoption.

In addition to the decision whether or not to use agroforestry, there is also the decision of how much to plant. A Tobit model is used to estimate the extent of adoption. Here, the dependent variable is the number of hectares of agroforestry currently planted. The extent of adoption model has a pseudo r-square of .488, which is very high for a small sample cross sectional data set. Also, the null hypothesis of all variables being equal to zero can be rejected at the .001 level. In the decision of how much to plant, the level of education (ED) is negative and significant at the .10 level. Two other variables are also negatively correlated with the amount of acres under cultivation and these are

(STRAT) the location of the community and (YEARS) the amount of time the farmer has lived in the present location. The only variable that is positively related to the extent of adoption is the amount of time since inception of the agroforestry system (TIME). This makes sense as farmers will have had more time to increase the size of plantings. Also, the coefficient on (TIME) is .53, suggesting that an increase of 1 year leads to another hectare of planted trees. For example, someone who planted trees in 1996 will have one less hectare than someone who got started in 1995.

Table 5. Tobit Estimates

Number of obs = 175		
chi2(10) = 160.79		
Prob > chi2 = 0.0000		
Log Likelihood = -84.267		
Pseudo R2 = 0.4882		

HAAF	Coef.	Std. Err.
-----+		
ED	-.2008*	.116
EXP	-.132	.201
EXPOSE	.105	.160
INC	-6.48e-06	6.89e-06
STRAT	-.4706***	.181
FARM	-.0002	.003
YEARS	-.0408***	.014
DIST	.044	.038
SEEDS	.202	.170
TIME	.530***	.051
_cons	-.408	.291
-----+		
_se	.705 .069	(Ancillary parameter)

57 uncensored observations		

1.5. Conclusion

This paper offers evidence on the relationship between human capital investment and investment in agroforestry. The primary question is whether farmers with more human capital are more likely to be interested in agroforestry. The empirical results lead to the conclusion that investment in human capital, by subsistence farmers in Southeastern Mexico, does lead to a higher probability of adoption/investment in agroforestry. Specifically, (1) informal specific on-the-job training, (2) formal training and (3) formal education improve the likelihood of adopting agroforestry.

These findings, supported by both the revealed behavior and stated interest, also suggest that low rates of adoption can be improved through the use of public policies improving access to education, providing exposure to information about agroforestry from other farmers, and ensuring careful implementation of initial rural development programs. This is an extremely important point. The evidence provided by the variables HAAF, ED, EXP, EXPOSE and SURV suggests that farmers who have more education, more training and previous successes are more likely to invest. Of course this makes sense, but it also highlights the impact of previous development programs on the implementation of new or current programs. We may have new information pertaining to the benefits of agroforestry but we may also have to overcome failed efforts in the past in order to implement new strategies. Therefore, working closely with farmers in order to improve their comfort level / confidence with new systems being offered, or analogously, reducing the uncertainty of investing in a new system of production, is an important component of the development process. Table 6 contains a summary of the significant variables from all three estimations.

Table 6. Summary of significant variables

Stated Preference	Revealed Preference	Tobit Model
HAAF (+) .05	Education (+) .05	Education (-) .10
Education (+) .05	Exposure (+) .01	Strata (-) .01
Survival (+) .05	Cropland (+) .05	Years of AF (+) .01
Experience (+) .10		Years in present place (-) .01

Agroforestry practitioners can improve the odds of successfully implementing agroforestry by providing continuing education and training to farmers. Perhaps most important is the role to be played by farmers who have already successfully implemented agroforestry systems. These farmers need to be identified and allowed to participate actively in the dissemination of information and the on-the-job training of new adopters of agroforestry technologies.

Agroforestry has been presented as a sustainable alternative to current methods of production in the tropics. If it is to succeed, the accompanying investments in the human capital of farmers through extension programs and on-farm training must be a part of the overall implementation strategy for agroforestry practitioners.

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Chapter 2

Choice Modelling of Farmer Preferences for Agroforestry In Calakmul, Campeche, Mexico

Abstract

The main objective of this paper is to apply choice modeling to agroforestry for the purposes of valuing the nonmarket benefits associated with agroforestry systems. A model for the ex-ante economic analysis of agroforestry systems is developed. Data for the analyses were collected using a discrete choice experiment with farmers in the State of Campeche in southeastern Mexico. The survey design followed the conjoint methodology for collecting stated preference data in a discrete choice framework, and the analyses of the responses are modeled in a random utility framework, operationalized as a logistic regression of the choices made by each individual farmer. Results lead to the conclusion that benefits from agroforestry, such as conserving forest resources and providing diversified outputs are important characteristics that farmers look for when considering alternative production methods. Numerous farmers expressed interest in developing a nursery in their community and a willingness to work in the nursery in order to obtain the seedlings for developing agroforestry systems.

2.0. Introduction

Economic studies of agroforestry require careful analyses of the priorities of the target audience in order to identify appropriate indicators, types of analysis, and data requirements (Current et al. 1995). Priorities for economic studies should be (1) understanding and (2) quantifying farmers' management and exploitation of agroforestry systems. In addition, finding cost-effective methods are needed to describe, explain, and predict agroforestry impacts, adoption potential, and sustainability (Avila in Sullivan 1992).

In order to address these concerns and more fully understand the behavior of farmers in relation to their potential use of agroforestry, a choice modelling experiment (CM) is used to assess the value farmers have for different agroforestry systems and the individual attributes that make up each system. CM is chosen over other nonmarket

valuation methods, such as contingent valuation (CV), for several reasons. First, Kahn (1996) criticizes contingent valuation as being too narrow and only allowing for single attribute valuation. CM addresses this issue by allowing for the valuation of entire systems and for the derivation of part-worth utilities for each of the individual attributes of the agroforestry system, i.e. conservation, shade for animals, product mix, etc. Second, as Opaluch (1993) points out, it is easy to develop "scores" for systems by simply using the coefficients on individual attributes and multiplying by a specific level of the attribute. Finally, CV estimates may be biased upwards because of "yea-saying" and a lack of consideration for substitutes (Stevens et al. 1997).

2.1 Agroforestry

Agroforestry is a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, seeks to diversify and sustain production for increased social, economic and environmental benefits for land users at all levels. Simply put, agroforestry is using trees on farms (ICRAF 1997). Compared to single output systems, agroforestry systems have a number of advantages as reported by landowners in certain areas. Owners have reported financial, as well as non-financial benefits (Zinkhan and Wear 1992). Some of the sources for the increased financial benefits are (1)more intensive use of the available land, (2)reduction in time between cash flows and (3)sharing of costly resources, such as fertilizer and herbicides between multiple outputs. In addition to these financial benefits, agroforestry is also considered to be more compatible with society's ecological and environmental goals than conventional agriculture (Zinkhan and Wear 1992). Agroforestry, in this respect, may contribute to (1)increasing species diversity,

(2) reforestation, (3) reducing the use of chemical agents on the farm, and (4) improving soil fertility and stability, hence making a claim to being more sustainable than traditional monoculture agricultural systems.

Agroforestry systems capable of providing substantial economic and ecological benefits to households and communities should be readily adopted by farmers. Nevertheless, many attempts to promote agroforestry have resulted in inadequate rates of adoption (Zinkhan and Wear 1992). Most often, farmers are reluctant to adopt new methods and those who have adopted agroforestry systems have been quick to abandon them, despite the fact that agroforestry systems have been shown, time and time again, to provide substantial financial and economic benefits. Studies continue to show higher net present values (NPVs) for agroforestry systems when compared to monoculture systems, yet the statistics for farmers in developing countries show low rates of adoption, and in cases where adoption does occur, many farmers eventually abandon the new agroforestry system of production in favor of other systems (usually a traditional system) with a lower NPV. One of the potential reasons for this behavior is that agroforestry practitioners are assuming what the farmer values, i.e. output, and what he may really value are things such as flexibility of planting schedule, availability of plants, how many days he has to work during a certain time of the year, or even that he simply likes certain species and does not like others.

If agroforestry programs are to succeed, it is important to understand precisely what farmers want and what will lead them to adopt new technologies. According to ICRAF's (1997) vision and plan of action, "we also need to understand the processes that lead farmers to adopt or reject a new technology and we need feedback from users. This

will facilitate wider scale dissemination and enable our researchers to improve the design of agroforestry systems (ICRAF, 1997)." In order to accomplish this, economic data must accompany biological data.

2.2 Economics of Agroforestry

Economic questions pertaining to agroforestry development were little explored before 1980. In the past 20 years, there has been some progress in conceptual and methodological developments, however, a bibliography containing 2 0 entries reveals that applied field research on agroforestry economics is still underdeveloped (Swinkels and Scherr 1991, in Sullivan 1992). Additionally, evidence presented by Mercer and Miller (1998), Casey et al. (2001) and Caviglia and Kahn (2001) exhibit the need for more empirical work in the area of adoption behavior.

Hosier (1989), states that agroforestry programs must be economically attractive to farmers if they are to be successful, and follows that statement with, "a positive on-farm economic analysis provides a necessary, but not sufficient, indication of the successful introduction of an agroforestry project." Wannawong (1991) points out a very important aspect of agroforestry development in that, often the challenge in development projects is to quickly employ limited trial data in order to identify ecologically sound systems that are financially attractive and socially acceptable so that they will be adopted by subsistence farmers. Scherr (1995) reiterates the point made by Hosier (1989), stating, "Profitability is a necessary, but not sufficient criteria for investing in agroforestry, farmers also have environmental objectives, which focus on things such as protecting productive resources and improving the overall human habitat of a community." The

preferences of subsistence farmers can be revealed by analyzing actual behavior and by conducting interviews to obtain information about future plans and preferences for future production methods. According to Scherr (Sullivan 1992), the use of NPV analysis must be supplemented by more holistic analytical techniques, such as whole-farm budgeting, to properly assess the potential for farmer adoption of alternative agroforestry systems.

Each of the above references is an indicator that we are missing pieces of information when it comes to understanding the economics of agroforestry. This study aims at providing a better understanding of farmer preferences for agroforestry and the characteristics that make up agroforestry systems by deriving welfare estimates (part-worth utilities) for these characteristics using CM.

2.3 Study Area - The Calakmul Biosphere Reserve

Campeche, Mexico, located on the Yucatan Peninsula in southeastern Mexico, is the home of the Calakmul Biosphere Reserve (CBR). The CBR extends over 723,185 hectares (1.7 million acres) and its forests are contiguous with those of the Peten in Guatemala and the northwest forest of Belize. There are two core areas of the reserve, located in the north and south. These core areas comprise 32% or 227,869 hectares of the total reserve. In 1993 UNESCO's Man and the Biosphere program accepted Calakmul into its international network of biosphere reserves. The innovative premise behind the biosphere reserve is to link conservation with human activities and rural development. Today, the CBR is considered one of the most important sites for biodiversity conservation in Mexico (Ericson, 1996).

A total of 286 species of birds and 29 species of raptors have been identified in the CBR. Twenty-one percent of the birds have been identified as migratory species that breed in the U.S. and Canada. Five of the six feline species found in Mexico are found in Calakmul, including, the mammal most revered by the ancient Maya, the jaguar. In addition, an estimated population of 125 to 180 jaguars reside in the southern nucleus of the reserve.

The forest in Calakmul is a mature, disturbed tropical forest. It is transitional between the northern dry, scrub forest of Yucatan and the southern rain forest of the Peten. At least six types of vegetation occupy large portions of the biosphere reserve. Population in the area is increasing due to migration mostly from the neighboring states of Tabasco, Chiapas, and Veracruz. In 1960 Campeche was one of the least populated states in Mexico with a population density of 2.9 persons per square kilometer. By 1990, this number reached 9.41 persons per square kilometer (Ericson, 1996). There are approximately 200 ejidos in close proximity to the CBR. An ejido is an area of land granted to a group of people by the Mexican Federal government under Mexico's unique land tenure system. Ejidatarios have usufruct rights to their individual property, but the land is owned by the community and can only be sold by the entire community. The climate in Calakmul is tropical. There are two distinct seasons: wet and dry. The wet season normally occurs during the months of June to October with the dry season occurring during the months of November through May. Rainfall tends to increase from north to south, yet patterns from year to year and location to location are highly irregular. This increase in population and the creation of the biosphere reserve place even more pressure on an already substantially degraded resource, i.e. the tropical forests

surrounding the CBR. Therefore, the importance of developing stationary systems of production is growing. Potentially, agroforestry is a sustainable option in Calakmul, but only if farmers are interested in the systems and programs being offered.

2.4 Choice Modelling

Choice modelling experiments are most common in the marketing and applied decision research literature (Adamowics 1994), yet the case for their use in economic analysis has been presented by McFadden (1986) in Adamowics (1994). Developments in the past 20 years by Louviere and Hensher (1982) and Louviere and Woodworth (1983) now allow for choice experiments, which meet the necessary and sufficient conditions to satisfy the statistical requirements of multinomial logit (MNL) choice models (Louviere 1988). These discrete choice experiments provide the respondent with several different products or services and simply ask the respondent to identify the most-preferred alternative in the choice set. Unlike traditional rank-order or rating methods, this method does not require any assumptions to be made about order or cardinality of measurement (Louviere 1988). A more important advantage of discrete choice conjoint methods is that one can estimate choice models directly from choice data, and thus avoid the potentially unrealistic ad hoc assumptions about choice behavior that are implied by rating and/or ranking a single choice (Louviere 1988). Additionally, the inclusion of a “no choice” option, together with an opportunity cost attribute allows for estimates of conditional and absolute value (Rolfe et al. 2000). These value estimates can then be used to derive Hicksian welfare measures (McConnell 1995).

Underlying the CM technique is the theoretical foundation of the random utility model (RUM). The RUM describes the utility associated with a given choice as being comprised of a systematic component and a stochastic component. The systematic component is observable to the researcher and the stochastic component is known only to the individual (Rolfe et al. 2000). Utility can be described by the following equation

$$U_{ij} = V_{ij} + e_{ij} \quad (1)$$

The observable component (V_{ij}), can be disaggregated further into the attributes of the relevant good (Z_{ij}) and the characteristics of the individual (S_i).

$$U_{ij} = V(Z_{ij}, S_i) + e_{ij} \quad (2)$$

The choice among alternatives is a function of the probability that utility associated with one alternative is higher than other alternatives in the given choice set (Rolfe et al. 2000).

$$P = \text{Prob } V_{ij} + e_{ij} > V_{ih} + e_{ih}; \text{ for all } h \text{ in the choice set, } j \neq h \quad (3)$$

Assuming the utility function follows a linear path in the parameters and that the error terms are gumbel distributed leads to the convenient closed-form solution, the multinomial logit (MNL) (McFadden 1974).

$$P = \exp(\lambda V_{ij}) / \sum \exp(\lambda V_{ih}) \text{ for all } h \text{ in choice set} \quad (4)$$

The MNL model generates results for a conditional indirect utility function of the following form:

$$V_{ij} = \lambda (B + B_1 Z_1 + B_2 Z_2 + B_n Z_n + B_a S_a + B_b S_b + B_m S_j) \quad (5)$$

Where B_1 to B_n and B_a to B_m are the vector of coefficients attached to the vector of attributes Z and individual characteristics S . Welfare estimates can be derived using the following formula:

$$CS = -1 / \alpha (\ln \sum \exp V_{i0} - \ln \sum \exp V_{i1}) \quad (6)$$

Where CS is the compensating surplus welfare measure and α is the marginal utility of income (Rolfe et al, 2000). Now, the marginal value of any change within a single attribute can be represented by the ratio of coefficients for eq. 5 and eq. 6 reduces to:

$$W = -1(B_a/B_\$) \quad (7)$$

$B_\$$ is the coefficient on the price variable. This is the part-worth, which effectively is the marginal rate of substitution between income change and the attribute in question.

Most recently, applications of CM have been used to estimate the non-use values of rainforest in Australia (Rolfe et al. 2000), and improvements in water quality (Farber et al. 2000). Choice modelling experiments are particularly useful for valuing environmental commodities, as environmental programs may have several features and it is quite useful to divide the program into its different components to assess people's willingness-to-pay for each program attribute (Johnson et al. 1995). The same is true for agroforestry.

2.5 Using the Choice Modelling technique to value agroforestry systems

Agroforestry systems are composed of many different components and provide numerous benefits, some market and some nonmarket. It is useful to know how farmers perceive the benefits of each of the components, which may be things such as shade for animals, soil fertility, watershed control, risk spreading, labor flexibility or windbreaks. Choice modelling has the advantage of permitting the valuation of both the agroforestry system as a whole and the various attributes of the system. The technique allows respondents to evaluate tradeoffs among multiple attributes, encouraging respondent introspection, and facilitates consistency checks on response patterns (Johnson et al. 1995).

The experimental design phase of any choice modelling experiment is perhaps the most important element of the study. Opaluch (1993) states, “If the experiment is not well-thought out from the beginning and precision is not taken in designing the survey instrument, then the information will be useless to the researcher.” There are several stages to this process, summarized in the following 4 steps:

1. Pre-information stage.
 2. Designing and testing the conjoint question.
 3. Pretesting the survey instrument.
 4. Implementation of the survey.
-

If the overall objective is to analyze potential agroforestry systems for their adoption potential and their value, or worth, as production strategies, it is important to develop systems that not only address physical problems of production, but do so in such

a way that farmers will actually consider implementing them within an overall production strategy. Numerous agroforestry projects have failed simply due to the lack of attention to the socioeconomics of the situation. Hence, it is important to understand the existing social, economic, and ecological conditions in the area under question. To this end, relevant background material should be obtained and synthesized. A thorough secondary data retrieval and assessment at the beginning of the process will enhance the overall quality, uniformity, and efficiency of the evaluation (Mercer 1993). This alone, however, is not sufficient and local land-use professionals as well as the farmers themselves need to be included in this process.

Therefore, key informant interviews and focus groups need to be conducted with local agricultural and forestry extension people. In addition to this, focus groups and informal interviews with farmers are highly recommended at this stage of the process in order to determine if local extension people and farmers view local problems the same way.

To this end, it was necessary to develop a list of key questions for debate in the focus groups. In this study, the list consisted of the following questions to prompt some insightful debate with, both, farmers and technical experts.

Table 1. Questions for local farmers and extension agents

- | |
|--|
| <ol style="list-style-type: none"> 1. What are the main limits to production? 2. What are some ideas to improve production? 3. What things should be considered when implementing a new system? 4. How can agroforestry address questions 1-3? |
|--|

Lack of water resources, lack of transportation, pestilence, lack of technical training, and the rigidity of tree delivery from local nurseries were some of the problems

identified by both farmers and technical experts. When exploring and considering the implementation of new and/or additional production systems some of the key variables identified were: meeting self-consumption needs, consistent production over time, i.e. minimizing variance in output, and immediate returns to labor, i.e. high discounting by farmers. Farmers saw agroforestry as a way to diversify outputs and combine short-term returns, i.e. crops with long-term investment such as timber producing trees.

The focus groups provided a cumulative list of what I considered to be the most important characteristics for evaluation by the farmers. I now had 17 potential attributes for farmers to evaluate as components of an agroforestry system. I categorized each of the attributes as (1)Essential, (2)Secondary, and (3)Non-essential. This allowed the research team to more efficiently choose which attributes to include in the initial testing of the conjoint question. Table 3 lists these attributes and their rating.

Table 2. Preliminary attributes for agroforestry systems

ATTRIBUTE	IMPORTANCE
Labor	Essential
Time for Production	Essential
Value of Production	Essential
Non-market benefits	Essential
Flexibility of Planting	Essential
Weeding Schedule	Essential
Pest Control	Essential
Price of Wood	Secondary
Capital Accumulation	Non-essential
Investment of Excess Labor	Non-essential
Technical Assistance	Essential

Location of Trees	Non-essential
Additions to System	Non-essential
Planting Densities	Essential
Overall Goal of System	Non-essential
Place of Establishment	Non-essential
Types of Products	Essential

This list was then narrowed to the following eight attributes: Labor, Time for Production, Value of Production, Non-market benefits, Flexibility in Planting, Weeding Schedule, Pest Control, and The Price of Wood. The next step required combining these attributes into potential agroforestry systems. This was done using the Breton-Clark Conjoint Design software. Fractional factorial designs were used to construct sets of choices. The use of orthogonal fractional designs ensures that each of the separate alternatives is independent across sets (Louviere and Woodworth 1983). A result is that, the odds of choosing alternative A in relation to alternative B is constant regardless of what other alternatives are present. It has been shown that a 2^N factorial design can be used to put N choice alternatives into choice sets such that the parameters of MNL models, estimated from choices made in response to the design, will be near optimal in statistical efficiency (Louviere and Woodworth 1983). Also, Louviere and Woodworth (1983) note that orthogonal main effects designs ensure independence across all alternatives. That is, the attributes of agroforestry system A will be independent of those in system B, as long as the design is orthogonal.

Once a list of potential systems was developed, the next step was to determine if the systems made sense to the farmers. At this point, the survey was ready for testing.

Our survey consisted of 36 total questions and was broken into five sections. Section 1 contains general socioeconomic questions. Section 2 is concerned with farming activities in general. Section 3 asks the producer about tree planting activities. Section 4 is the conjoint experiment, and section 5 concludes with a contingent valuation question and closing comments. The survey instrument was specifically designed to facilitate thinking about production strategies from the general to the specific, with final emphasis on planting trees on farms. This is the appropriate time in the development of the survey to answer such pertinent questions as: (1)do the farmers understand the question? (2)how many attributes can be included in each system?, (3)how many choices will each farmer make before becoming tired and disinterested?, and (4)how do farmers seem to make their choices, do they consider the whole system or do they focus on one or two characteristics?

At this stage, I discovered: (1) the farmers did understand the question, (2) eight attributes seemed to be a lot of information to evaluate at once, so we narrowed this to five attributes, (3) seven or eight choices appeared to be the limit for the farmers, (initially I tried 15). The literature pertaining to this question says up to 20 choices can be made, but in this particular context of interviewing primarily illiterate farmers, 20 choices could not even be considered. And (4) the farmers seemed to consider the entire system and to not just focus on one all important attribute.

Table 3. Attributes and levels for choice modelling survey

ATTRIBUTE	LEVEL 1	LEVEL 2	LEVEL 3
Labor Requirement	Low	medium	High
Technical Assistance	One year	Three years	Five years
Forest Conservation	No impact	Improved in future	Worse in future
Plant Availability	Work in nursery	Pay for delivery	Look in forest
Products from System	Timber and crops	Fruit, tim, and crops	Timber only

In the choice modelling experiment, the five attributes listed in Table 4 were combined at varying levels to create the hypothetical agroforestry systems. For example, a system may include the following attributes: three years of technical assistance, you must pay for seedlings, the system will increase forest cover in the future, and you will produce fruit, timber and crops.

Figure 1 – Example of Choice Question

Please Choose System A or System B	
A	B
medium	Low
3 years assistance	1 year assistance
pay for seedlings	work in nursery
increase forest cover	the forest will be the same
produce fruit, timber and crops	produce timber and crops

Since the dependent variable in conjoint analysis only takes on discrete values, i.e. 1 or 0, an OLS estimating procedure is inappropriate (MacKenzie, 1990). Therefore, the choice of an agroforestry system is estimated as a logistic regression. The equation estimated is:

$$\text{Choice} = \alpha + b(\text{labor}) + b(\text{assistance}) + b(\text{prod1}) + b(\text{prod2}) + b(\text{plant1}) + b(\text{plant2}) + b(\text{cons1}) + b(\text{cons2}) \quad (8)$$

In the above equation, **labor** is the number of days to implement the agroforestry system. **Assistance** is the number of years for which you will receive technical assistance. **Prod1** is a system that produces timber and crops. **Prod2** is a system that produces fruit, timber and crops. **Plant1** means the farmer will work in a nursery in order to obtain seedlings. **Plant2** represents the system whereby the farmer must pay for the

delivery of seedlings. **Cons1** is the variable for keeping the environment the same, and **Cons2** represents improving the environment.

The total population for sampling consists of all the communities participating in CONSEJO, which is the regional council for development in Calakmul. Considerations at this point revolved around the basic question of whether it is more important to cover a larger area and less people in each community, or to concentrate on fewer communities and more people in each one. This decision should depend on local circumstances and the resources available to your survey team. I decided to conduct the survey in a minimum of 20% of the communities and to interview a minimum of 20% of the population in each community. Ejidos were randomly selected from two strata. One strata consisted of ejidos in the northwest region and the other in the southeast. The rationale here is that there is more rainfall to the southeast and rainfall should impact the choice of a production system. Also, within each ejido, a completely random sample of individuals to interview was selected from the ejido register in each community. All of this took place from August to January 1997. The results of a basic MNL model were estimated using STATA, with results found in table 7. Before moving on to the CM results, I first report results from the survey on the general characteristics of the farmers of Calakmul.

2.6 General Characteristics of a Farmer from Calakmul

Individual farmers were interviewed during the period from January 1998 through March 1998. A total of 176 farmers were interviewed in 15 separate communities. Table 5, below, contains a summary of the main characteristics of farmers in Calakmul. There are rather large standard deviations for most of the variables. One farmer may be

in his late 50s, no longer have children at home, and may have lived in his present location for over 15 years. The next farmer may be in his 20s, with 8 or 9 children living at home, and may have moved to the region within the past year or two. Also, interesting to note, on average, farmers in Calakmul keep over 56% of their total land area in primary forest cover. Also, on average, when farmers arrived at their present locations, approximately 22% of the primary forest had already been cleared (roughly 10 hectares), meaning these farmers, on average, have only cleared 11 hectares, or an additional 24% of the total land area.

Table 5. Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Age	38	13.7	16	74
No. of kids	4	2.9	0	12
Years in present place	11	6.4	.3	36
Distance to fields (km)	2.8	2.3	0	10
Total area (ha)	49	25	0	120
Forested area (ha)	28	24	0	95
Hectares in AF	0.37	.65	0	3
Hectares in trees	1.2	2.4	0	15
Original forest area (ha)	39.7	26.8	0	120
Harvest Trees	16%	---	---	---
Experience with agriculture and forestry	17%	---	---	---
Area in Milpa (ha)	4.8	4.1	0	36
Agricultural and forestry related Income (npesos)	11,363	12,269	0	63,600
Participation in development programs	43%	---	---	---

n = 176

A typical farmer in Calakmul is 38 years old with 4 children living at home. He has lived in his present ejido for 11 years and walks almost 6 kilometers daily to and from his field. This farmer has access to almost 50 hectares and currently keeps almost 30 hectares forested. In addition, he has about 5 hectares under “milpa” production (corn, beans, squash) and an annual income from sales of agricultural and forest products of \$11,363 Npesos or \$1,420 U.S. dollars (8.5Npesos/US\$, 1998). Farmers in Calakmul derive income from various agricultural and forestry related activities. Table 6 displays

the types of crops that are cultivated and allows us to see what the cash crop components are for the typical farmer in Calakmul. Lastly, of all the farmers we interviewed, forty-three percent had participated in some type of forestry related development program, but when asked if they had any forestry experience on their own parcelas, in addition to their agricultural practices, only 17% responded in the affirmative.

Table 6. Breakdown of sources of Agricultural and forestry related Income

CROP	NPESOS (mean)	MAX
Picante(pepper)	5249.05	49000
Maiz(corn)	1946.90	18000
Frijol(bears)	411.63	10000
Chihua(squash)	1244.88	21600
Ganado(cows)	348.29	14000
Madera(wood)	881.70	40000
Chicle(chicle)	274.12	10750
Frutas(fruit)	9.65	600
Puercos(pigs)	665.05	15000
Miel(honey)	330.81	14400

n=176; Minimum = 0 for all categories

2.7 Choice Modelling Results

Two simple models, including only the attribute levels, and a full model that also includes socioeconomic variables are estimated. The first simple model includes (Labor) and (Assist) as continuous variables and the second simple model includes them as discrete variables. Therefore, I will refer to the models as 1) simple-continuous, (SC) 2) simple-discrete (SD) and 3) full. Most attributes in the model are statistically significant at conventional levels and signs are as expected except for the labor variable.

Unfortunately, the probability that an individual will choose a particular system increases with increasing labor costs¹. Needless to say, this was not expected and precludes the

¹ I hypothesize that farmers interpreted the cost variable as a “quality/output” variable. They may have interpreted more work-days as more output or higher quality for the system. The only way to test this hypothesis will be to return to Calakmul and re-interview each farmer.

development of welfare estimates. In spite of this, however, I can still rank alternatives based on the part-worths. Again, the part-worths relate how important each attribute-level is relative to the others. This allows for comparison between individual levels of attributes and the derivation of scores for agroforestry systems, based on combinations of individual attribute levels. Even though I am unable to derive welfare estimates, I still have useful comparative information. Referring to equation 7, I can still look at the marginal tradeoff between two attribute levels as each of the coefficients represents the “part-worth” (Louviere 1988) of that level of the attribute. For example, if the coefficient on A is .5 and the coefficient on B is .25, then A is “worth” twice as much as B.

Table. 7 Multinomial Logistic Regression Results

	Simple discrete	Simple continuous	Full Model
Variable	Coef	Coef.	Coef.
Constant	-1.38*** (.138)	-1.91*** (.174)	-2.41*** (.311)
LABOR	-----	0.006** (.003)	.006** (.002)
High	.211* (.128)	-----	-----
Low	-.08 (.106)	-----	-----
ASSIST	-----	.117*** (.032)	.118*** (.032)
1 year	-.223** (.114)	-----	-----
5 years	.227** (.111)	-----	-----
Prod1	.207 (.122)	.241** (.121)	.246** (.121)
Prod2	.571*** (.107)	.602*** (.107)	.609*** (.107)
Plant1	.555*** (.106)	.552*** (.106)	.557*** (.106)
Plant2	.119 (.122)	.171 (.121)	.172 (.121)
Cons1	.297** (.122)	.288*** (.122)	.289*** (.122)
Cons2	.825*** (.109)	.822*** (.108)	.829*** (.109)
Forestry Experience	-----	-----	.152** (.068)
Farm hectares	-----	-----	.007* (.003)
Age	-----	-----	.004 (.004)
# of kids	-----	-----	-.029 (.019)
Years on lot	-----	-----	.013 (.008)
Forest area	-----	-----	-.006 (.004)
Tree planting	-----	-----	-.015 (.018)
Education	-----	-----	-.042 (.069)
Previous experience	-----	-----	-.098 (.071)
Honey cultivators	-----	-----	-.288 (.234)
Participation	-----	-----	.098 (.099)
Harvesting trees	-----	-----	-.145 (.136)
N =	2182	2168	2168
Chi2 (10)	158.33***	(8) 161.27***	(20) 181.65***
Log Likelihood	1379.6	1369.4	1359.2

The simple-discrete model allows for a fuller inspection of the labor and technical assistance variables. Using the missing dummy variable as a baseline, it is possible to determine if there are significant differences in preferences for the other levels of the attribute.

In the full model, the two additional variables that influence the choice decision are the amount of forestry experience and the total area of the farm. Both of these variables are positively related to choosing an agroforestry system. The rest of the socioeconomic variables hypothesized to influence the choice decision are not significantly different from zero.

2.7.1. Labor

Farmers exhibit negative utility for working 5 or 10 days (LOW) and positive utility for working 40 or 50 days (HIGH). The difference between LOW and MEDIUM (20 or 30 days) is not significant, but farmers do exhibit significant differences in their preference for HIGH vs. MEDIUM. Again, it is possible that farmers interpreted this variable as a “quality” or “output” attribute, and not the cost of the agroforestry system.

Labor	Part-Worth
Low	-0.08
Medium	0.00
High	0.211*

2.7.2. Conservation

An especially interesting and important result is the part-worth of the environment attribute. Improving the environment, described in the experiment as increasing forest cover (BETTER), is the most important attribute level of all those

included in the model. And, the result is robust across all three specifications. Farmer preferences for improving forest cover (BETTER) compared to keeping the environment the same (SAME) are almost four times as strong, and both of these options are significantly preferred to the option of reducing forest cover (WORSE).

Environment	Part-Worth
Worse	0.00
Same	0.297***
Better	0.825***

2.7.3. Extension Assistance

All technical assistance coefficients are significant at the .05 level. From a policy perspective this is an important variable. There is a significant difference between receiving one of technical assistance and the baseline of 3 years. Not surprisingly 3 years is preferred to 1 and 5 years is preferred to 3.

Technical Assistance	Part-Worth
1 year	-0.223**
3 years	0.00
5 years	0.227**

2.7.4. Production

As expected, more product diversity is better. There is no significant difference between timber only and timber and crops, but the option of all three products is preferred to the others. Since the timber only option and the timber with crops option are not significantly different, yet the addition of fruit to the system is significantly preferred, we can interpret this as a strong preference for fruit trees as part of an agroforestry system. This result makes intuitive sense, because fruit trees provide an intermediate return, whereas timber trees are a long term investment.

Products	Part-Worth
Timber & Crops	0.207
Fruit, Timber & Crops	0.571***
Timber	0.000

2.7.5. Seedling delivery

In terms of plant availability, the most preferred option is to work in a nursery and receive seedlings. Again, from a policy perspective, this is important and valuable information. This result supports the on-going efforts in the Yucatan aimed at developing small nurseries.

Plant Availability	Part-Worth
Work in nursery	0.555***
Pay for delivery	0.119
Collect from forest	0.000

2.8. Conclusion

In order to address concerns related to the behavior of subsistence farmers with respect to their use of agroforestry, a CM experiment was used in order to assess the importance of five characteristics of agroforestry systems. These characteristics were (1) cost, (2) conservation of forest resources, (3) method of obtaining seedlings, (4) years of technical assistance, and (5) diversity of outputs. CM was chosen in order to address issues concerning multiple attributes, substitution, and the development of reliable “scores” (Opaluch 1993). The initial attempt to derive welfare estimates was thwarted due to problems with the cost characteristic, but all other characteristics are still useful and comparisons can still be made between all the other attribute levels.

If a CV study had been conducted, we would have been left without any useful information. Not all is lost with a CM study and perhaps this is one of the greatest

benefits of CM. The time and effort that went into the experiment still provides useful information pertaining to the relative value of system attributes. Although these values are not absolute values, they are comparable and allow for policy choices to be determined based on actual tradeoffs, i.e. working for seedlings vs. paying for them or 3 years of technical assistance vs. 5 years. Again, we do not have a willingness-to-pay estimate for having a nursery or receiving three years of assistance, but we know a nursery is preferred to the alternative of paying for seedlings and five years of assistance is preferable to three.

The primary question of this paper was, how do farmers value the individual characteristics of agroforestry systems, especially the characteristics not valued in the market, i.e., forest conservation, availability of seedlings, and technical assistance. Results suggest that farmers in Calakmul place a value on (1) conserving and increasing local forest cover, (2) working in a nursery in order to obtain seedlings, and (3) receiving technical assistance.

Agroforestry has been presented as a sustainable alternative to current methods of production in the tropics, i.e., “slash & burn.” If agroforestry is to succeed, the accompanying investments in the human capital of farmers through extension programs and on-farm training must be a part of the overall implementation strategy for agroforestry practitioners. In addition, agroforestry projects must be designed and targeted to meet specific needs of farmers. These needs are not limited to income, but encompass characteristics such as forest conservation, a certain amount of technical support, diversity in outputs, and flexibility in seedling delivery. In spite of the lack of welfare estimates in this particular application, CM experiments should prove useful in

choosing these characteristics and then, determining the value farmers have for these them. Hopefully, this information can facilitate the successful implementation of agroforestry in the tropics.

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Essay 3

The Value of Forest Conservation: “Willingness-to-Work” (WTW) to Protect Local Forest Resources in Calakmul, Campeche, Mexico

Abstract

Tropical forests cover a mere 7 percent of the Earth’s land surface, yet almost half of the world’s biota are found exclusively in these forest ecosystems (Wilson 1988). The repercussions of tropical deforestation are, therefore, extensive in terms of losses in biodiversity. This paper uses an application of the discrete-choice contingent valuation method to estimate the willingness of farmers in southeastern Mexico to participate in forest conservation efforts. The estimated values of the marginal effects from a probit model are used (Cameron 1987), to develop welfare estimates. Results suggest farmers are willing to work slightly less than three days per month in order to preserve an area of community forest. Additionally, a Turnbull estimator is used for developing a lower-bound, as suggested by Haab and McConnell (1997).

3.0 Introduction

Tropical forests cover only 7 percent of the Earth’s land surface, yet almost half of the world’s biota are found exclusively in these forest ecosystems (Wilson 1988). The repercussions of tropical deforestation are, therefore, extensive in terms of losses in biodiversity. During the 1980s, tropical deforestation occurred at an annual rate of 0.9% (Shyamsundar and Kramer 1996). According to a recent FAO report, the rate of deforestation in tropical countries was 10% less for the 1990s than for the previous decade. In spite of this recent slow-down, the loss of tropical forests continues to be a global concern. Over 55% of global deforestation occurring since 1980 took place in only seven countries; Brazil, Mexico, Venezuela, Malaysia, The Democratic Republic of Congo, Bolivia, and Indonesia (Abramovitz 1998). This research is about tropical deforestation in Mexico. The paper uses an application of discrete-choice contingent

valuation (CV) to estimate the willingness of farmers in southeastern Mexico to participate in conservation efforts.

3.1 Parks and Preservation

One response to concerns about deforestation has been the creation of Parks and Reserves. The creation of parks and biological reserves protects forest by prohibiting human disturbance other than scientific and perhaps limited recreational activity. Throughout the 1990s, the creation of Biosphere Reserves and Ecological Parks in the tropics has increased substantially (www.wri.org). Biosphere Reserves are areas of terrestrial and coastal ecosystems which are internationally recognized within the framework of UNESCO's Man and the Biosphere (MAB) Programme. Collectively, they constitute a World Network. They are nominated by national governments and must meet a minimal set of criteria and adhere to a minimal set of conditions before being admitted into the World Network. Each Biosphere Reserve is intended to fulfill three basic functions, which are complementary and mutually reinforcing: a conservation function - to contribute to the conservation of landscapes, ecosystems, species and genetic variation; a development function - to foster economic and human development which is socio-culturally and ecologically sustainable; a logistic function - to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

A key component, in regards to the effectiveness of parks and reserves, are the people living near the boundaries of the park. Most often, these areas are inhabited by poor, subsistence farmers. In order for tropical forest conservation efforts to be

successful, local individuals must be willing and able to participate in the development and implementation of conservation programs.

The rest of the paper is structured as follows. Section 2 describes the current situation in Mexico with emphasis on the state of Campeche. Section 3 develops the theoretical framework. Section 4 discusses issues related to CV design. Section 5 estimates the model and presents results and a discussion of these results. And, Section 6 concludes with a brief summary.

3.2.0 The Study Area - Mexico

Mexico ranks fourth in the world after Indonesia, Brazil and Colombia in terms of biodiversity (Toledo 1988). Mexico has the highest diversity of reptiles in the world, the second greatest mammal diversity and holds 8.7% of the world's amphibian species, 11% of reptile, bird and mammal species and 14% of all fish species. Furthermore, 32% of Mexico's terrestrial vertebrates and 40-50% of her plant species are endemic (Alcérreca et al. 1988; Flores-Villela and Gerez 1988). This biological richness results from great habitat variation and diverse ecological regions, complex topography, climate, geology and geographical location. Ecosystems throughout Mexico range from deserts to mangrove swamps and tropical rainforests.

Current estimates of rates of deforestation in Mexico range from 400,000 to 1,500,000 hectares per year, or about 2 percent of total forest cover in the country (Barbier and Burgess 1996). These estimates, however, do not account for large geographical differences in rates of deforestation throughout Mexico. Rates of deforestation vary substantially over geographic regions with the largest losses occurring

in tropical evergreen forests, located almost entirely in the southeastern part of the country (Cairns et. al 1995, Table 1). According to Deininger and Minten (1999), the rate of deforestation throughout the 1980s in Southeast Mexico was four times that of the global rate. In the 1990s, estimates of annual deforestation rates for all of Mexico were 1.2% according to FAO (www.fao.org) and 0.9% according to WRI (www.wri.org).

Table 1. Deforestation in Mexico by Region

Region	Deforested Area 1980-1990 (1,000 ha)	Annual rate of deforestation (%)
Northwest	1,474	1.92
Pacific Center	2,669	2.98
Pacific South	5,561	3.75
Southeast	3,662	3.81
Total for Mexico	19,198	2.94

Source: Table 2 in Deininger, Klaus W. and Bart Minten (1999), Poverty, Policies, and Deforestation: The Case of Mexico. Economic Development and Cultural Change, 13 313-344.

In this same time period, Mexico has increased its Parks and Reserves system dramatically². The number of biosphere reserves has almost doubled and the land area protected by these reserves has increased almost six-fold (table 2). One of the largest biosphere reserves in Mexico is the Calakmul Biosphere Reserve (CBR), located in the state of Campeche.

Table 2. Biosphere Reserves in Mexico

Year	Number of Reserves	Area (000 ha.)
1990	6	1,288
1994	10	5,393
1999	11	6,688

(www.wri.org)

3.2.1 The Calakmul Biosphere Reserve

Campeche, Mexico, located on the Yucatan Peninsula in southeastern Mexico, is the home of the Calakmul Biosphere Reserve (CBR). The CBR extends over 723,185

² The numbers in table 2 only account for biosphere reserves and not all types of parks and reserves.

hectares (1.7 million acres) and its forests are contiguous with those of the Peten in Guatemala and the northwest forest of Belize. There are two core areas of the reserve, located in the north and south. These core areas comprise 32% or 227,869 hectares of the total reserve.

In 1993 UNESCO's Man and the Biosphere program accepted Calakmul into its international network of biosphere reserves. The innovative premise behind the biosphere reserve is to link conservation with human activities and rural development. Today, the CBR is considered one of the most important sites for biodiversity conservation in Mexico (Ericson, 1996). A total of 286 species of birds and 29 species of raptors have been identified in the CBR. Twenty-one percent of the birds have been identified as migratory species that breed in the U.S. and Canada. Five of the six feline species found in Mexico are found in Calakmul, including, the mammal most revered by the ancient Maya, the jaguar. An estimated population of 125 to 180 jaguars reside in the southern nucleus of the reserve.

The forest in Calakmul is a mature, disturbed tropical forest. It is transitional between the northern dry, scrub forest of Yucatan and the southern rain forest of the Peten. At least six types of vegetation occupy large portions of the biosphere reserve. Table 3 summarizes the types of forest, canopy height, and common tree species found in each of the ecoregions.

TABLE 3. Ecosystems in Calakmul

Forest type	Canopy height	Common Species
Tropical semi-evergreen medium-height	15 to 30 meters	Chicozapote, Ramon, Mahogany, Guaya
Tropical subdeciduous medium-height	15 to 30 meters	Cedar, Tsalam, Amapola
Tropical semi-evergreen low	15 meters	Kanatzin, Chechen, Granadillo

Tropical subdeciduous low	15 meters	Cocoite blanco, Tzalam, Jobo
Thorn Forest	8 to 12 meters	Logwood, Chechen blanco, Guaya
Savannah	Grasses with infrequent trees	Nanche, Jicaro

(Ericson, 1996)

Population in the area is increasing due to migration mostly from the neighboring states of Tabasco, Chiapas, and Veracruz. In 1960 Campeche was one of the least populated states in Mexico with a population density of 2.9 persons per square kilometer. By 1990, this number reached 9.41 persons per square kilometer (Ericson 1996). There are approximately 200 ejidos in close proximity to the CBR. An ejido is an area of land granted to a group of people by the Mexican Federal government under Mexico's unique land tenure system. Ejidatarios have usufruct rights to their individual property, but the land is owned by the community and can only be sold by the entire community. This land tenure system plays an important role in the contingent valuation experiment.

3.3 Farmer Willingness to Work (WTW)

The primary question of this paper is whether farmers are interested in conserving forests and if they are, how much they are willing to contribute to efforts to conserve forested areas. Following Whitehead et al. (2000), the assumption is made that farmers will answer the contingent valuation question based on the value they place on the forest. I consider a utility function that depends on a consumer composite good, X , and nonmarket forest goods and services, F .

$$(1) \quad u = u(X, F)$$

Utility is increasing in X and F and twice differentiable. The utility maximization problem can also be stated as the dual problem of expenditure minimization. Minimizing

household expenditures, PX , subject to the utility constraint, $u = u^*(X, F)$, yields the following expenditure function:

$$(2) \quad e = e(P, F, u^*)$$

where P is the market price of the consumer good and F is the current level of protected forest. If the farmer is presented with the opportunity to add to F , i.e. preserving more forestland, the willingness to pay for this additional forest protection is the difference in two expenditure functions

$$(3) \quad WTP(F) = e(P, F', u^*) - e(P, F, u^*)$$

Numerous approaches have been suggested for estimating the appropriate WTP value for use as a welfare measure. In this case, I am interested in the farmer's willingness to work (WTW), because the tradeoff is not money, rather it is the number of days a farmer would be willing to work in order to contribute to forest conservation. In this particular instance, the probability of a yes response to a single bound question depends on the probability that WTW, with a random error, is greater than the number of work-days, (BID).

$$(4) \quad \Pr(\text{YES}) = \Pr(\text{WTW} + e > \text{BID}).$$

It is assumed that e is normally distributed and since the yes/no response to the number of workdays is a discrete, (non-continuous), variable, a standard probit model is employed to estimate (Whitehead et al 2000). For any individual in the sample, we can observe the choice of yes or no, and therefore define a discrete economic variable y as the outcome

$$\begin{aligned} Y &= 1 && \text{if the individual says yes} \\ Y &= 0 && \text{if the individual says no} \end{aligned}$$

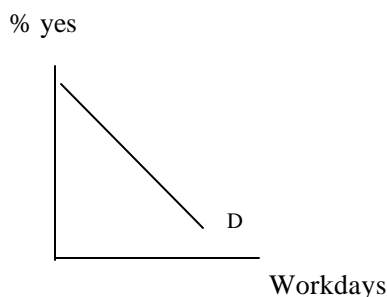
Since we assume the individual is maximizing utility, $Y=1$ when the individual derives more utility from working to preserve an area of forest than from not working the specified number of days per month (BID). That is,

$$\begin{aligned} U_f &= \text{utility from working in the forest preserve} \\ U_n &= \text{utility from using this time for leisure} \end{aligned}$$

Then,

$$\begin{aligned} Y &= 1 \quad \text{if } U_f > U_n \\ Y &= 0 \quad \text{if } U_n \geq U_f \end{aligned}$$

The outcome of the choice is random because the researcher cannot predict with certainty the outcome of a randomly selected individual. The choice of whether or not to work to preserve forests is a function of both observable and unobservable characteristics of the individual farmer. In order to determine the probability (pr) that a randomly selected farmer chooses $Y = 1$, the probit model is appropriate as it is a nonlinear (in the parameters) statistical model that achieves the objective of relating choice probability (Pr), to explanatory variables in such a way as to keep the probability in the [0,1] interval (Griffith et al. 1993). Again, the probit is chosen over other statistical models due to 1) the discrete nature of the Y variable and 2) an assumption of normally distributed error terms. The probability of a yes response should decrease with increases in the number of work-days, (BID). Again, BID is the number of days that the farmer is asked to work for forest conservation in the contingent valuation scenario (see equation 4).

FIGURE 1 – Demand Curve of Forest

and the estimated equation is

$$(5) \quad \text{Pr}(\text{YES}) = Xb + e$$

where b is a vector of the probit coefficients and X is a vector of explanatory variables including the number of workdays (WTD). Mean WTW is then estimated at the means of the independent variables using the procedures developed by Cameron (1987).

3.4 The Contingent Valuation Experiment

Several issues arise in determining the appropriate format for the contingent valuation question. Two important decisions are: (1) the use of open-ended or closed questions and (2) the use of willingness to accept or willingness to pay as a value measure. The most popular design for estimating WTP is the dichotomous choice closed question (Whitehead 2000). In addressing the issue of WTA vs. WTP, this paper introduces a third choice, willingness to work, (WTW). An explicit discussion of the WTP vs. WTA argument can be found in Shyamsundar and Kramer (1996). The decision to use WTW, which is a measure of willingness to pay with time instead of money as the medium, was based on several considerations. First, these farmers earn less than \$1200 annually and exist primarily in a subsistence setting with incomplete markets. Second,

these farmers are familiar with the concept of community service. Life in these villages is based on community and spending time helping neighbors or working on communal projects is very common. Therefore, the concept of working to protect a public or community forest was not an unusual idea. Lastly, the ejido system does not permit the sale of land. In any other land ownership context, this question would have to be addressed as a WTA question. This would simply entail asking the farmers to sell their land for money, but the cultural and legal complexities of the ejido system do not present such a simple alternative.

3.4.1 The Survey

The survey question was designed in order to elicit the willingness of farmers to participate in efforts to conserve an area of forest within the community³. Considerations in the development of the survey included (1) being sure to convey that no products could ever be taken from the forest, (2) the forest was communal, e.g. public, and (3) the requirement of working to insure the protection of the forest. The use of the CVM in this context is very different from conducting a standard mall-intercept, mail, or telephone survey. The length of the survey and the amount of time to complete the survey were important considerations, as was the total amount of information presented to the respondent. Therefore, the simplicity of the survey, in this context, is, perhaps, the most important feature. The question of how best to elicit reliable information in the simplest of contexts was the main issue in designing the CV experiment. To this end, focus groups with local farmers and extension agents, as well as informal conversations with several

³ The survey question was part of a larger survey looking at farmer's agricultural practices and preferences for agroforestry.

extension agents were used. In addition, the question was pre-tested on a sub-sample of farmers. In the end, choices were made in terms of (1) explicitly defining the commodity, (2) explicitly defining the tradeoff, and (3) using reminders of constraints for the sake of simplicity. However, the goal was not necessarily to estimate a dollar amount for a specified increase in forest area, but rather to gain some insight to the farmers' willingness to contribute to conservation efforts. Therefore, the following question was asked of 176 farmers.

“Suppose your ejido is considering a new program for conserving an area of communal forest. In the forest area, there will be no extraction of wood, plants, chicle, nothing. This area is only to protect plants, animals, water and air quality for the future. However, it will be necessary for each member of the community to work X number of days each month in the forest. Are you willing to do this?”

Participants were randomly assigned to one of seven bid levels, ranging from one day per month to seven days per month. Individual farmers were interviewed during the period, January 1998 through March 1998. Farmers were also asked about their current farming methods, experience with tree harvesting and their interest in participating in an agroforestry development program. A total of 176 farmers were interviewed in 15 different communities.

3.5 Estimation and Results

Non-parametric estimate of willingness-to-work (WTW)

The yes/no response to the number of workdays is first analyzed by looking at the percentage of yes responses to each workday level (Table 4).

Table 4. Data Structure

Bid Amount (Days)	Sample Size	# “yes” responses	% “yes” responses
1	26	25	96
2	26	21	81

3	28	22	78
4	28	17	60
5	25	13	52
6	24	10	42
7	23	11	47

The percentage of yes responses follows the expected pattern decreasing at each interval from 96% at 1 day to 42% at 6 days. However, the percentage of yes responses to 7 days then increases to 47%. This may be due to the small sample (personal conversation with John Whitehead, UNC-Wilmington) or the psychological effect of translating seven days to one week and thinking one week is not much time (personal conversation with Bob Turner, Colgate University).

The Turnbull estimator is a distribution free, maximum likelihood approach. It has been exploited by Haab and Mc Connell (1997) and others to deal with the possibility of negative willingness to pay in discrete choice CV surveys. The Turnbull empirical distribution estimator is simple to use and is an effective way to estimate a lower bound on willingness to pay from single or double-bounded discrete choice contingent valuation data. For example, if respondents are asked will you pay an amount C_j where $j = 1 \dots m$ and $C_j > C_k$ for $j > k$ then P_j is the probability that a respondents willingness to pay is in the interval C_{j-1} to C_j (Haab and McConnell 1997). And,

$$(6) \quad P_j = P(C_{j-1} < W < C_j) \quad \text{for } j = 1, \dots, M+1$$

Alternatively, the cumulative distribution function (cdf) is written

$$(7) \quad F_j = P(W < C_j) \quad \text{for } j = 1, \dots, M+1 \quad \text{where } F_{M+1} = 1$$

A simple procedure for calculating the P_j s by hand is summarized in 4 steps:

1) For $j = 1 \dots M$, calculate $F_j = N_j / (N_j + Y_j)$, where N is the No response and Y is a yes response

- 2) Start with $J = 1$, If $F_{j+1} > F_j$ then continue, but if $F_{j+1} < F_j$, then pool cells j and $j+1$ into 1 cell with boundaries C_j, C_{j+2}
- 3) Continue until cells are pooled sufficiently to allow for a monotonically increasing cdf
- 4) Calculate the pdf as the step difference in the final cdf.

Using this nonparametric approach I derive a WTW of 4.6 days per month, which provides an indication of what to expect from a properly specified probit model. Since the PDF for 7+ is .45 and the Turnbull (PDF*lowBid) is 3.15 (table 2), which accounts for approximately 75% of the willingness to work, it makes sense to truncate the distribution and eliminate responses beyond 6 days. This leaves a lower-bound estimate of 1.46 or about a day and a half.

Table 5. Turnbull Empirical Distribution Function Estimates

Bid Range	Turnbull CDF	Turnbull PDF	(PDF*lowBid)
0-1	.04	.04	0
1-2	.19	.15	.15
2-3	.22	.03	.06
3-4	.40	.18	.54
4-5	.48	.08	.32
5-6	.55	.07	.35
6-7	Pooled	Pooled	-----
7+	1	.45	3.15
			4.61

3.5.1 Estimated Equation

Using a Probit model, the yes/no response to the WTW question was regressed on a number of explanatory variables thought to influence the decision to participate in a forest conservation effort. There are three categories of explanatory variables, (1) cost variables, (2) socioeconomic variables, and (3) environmental attitude variables. Cost variables include the number of workdays (BID), and the distance from the house to the farm (DISTANCE). Socioeconomic variables designed to account for heterogeneity in

the population include (INCOME), number of children living at home (KIDS), a dummy variable to differentiate between those with and without primary level of education (EDUC), the number of years living at the current location (YEARS), whether farmers think they have a good seed source in their forest (SEEDS), farmers who live in an area with higher annual rainfall (STRATA), and farmers who have forestry related experience (EXP). Environmental attitude variables include acres of trees planted on the farm (TREES), survival rate of current tree plantations (SUCC), participation in conservation and development programs (PART), and hectares of forest remaining on the farm (FOR). A description of each variable with mean values, standard deviations, minimum and maximum values is found in table 6.

Table. 6: Variables Included in Model Specification

Variable name and description	mean	Stand Dev.	min	max
Response: 1 if yes, 0 if no	0.665	0.47	0	1
Bid: number of workdays	3.9	1.9	1	7
Distance: The distance the farmer actually has to travel to get to his fields.	2.9	2.3	0	10
*Strata: Dummy variable 0 if NW zone and 1 if SE zone.	.39	.49	0	1
Kids: number of children living at home	4	2.9	0	12
Education: dummy for those who have completed primary school.	.39	.49	0	1
Years: The number of years farmer has been living at the present location.	10.9	6.4	.3	36
Income : Total income from the sale of agricultural and forestry related products.	11363	12269	0	63000
Experience : Farmers who had agricultural experience before coming to Calakmul and have since obtained Some forestry experience received a 1 and all others a 0.	.17	.37	0	1
Trees: The number of hectares currently planted in an agroforestry system.	1.3	2.5	0	15
Forest: Hectares of forest on the farm	28	24.7	0	95
Success: Farmers who say they are happy with their current plantation receive a one and those who are not pleased with their current plantation receive a zero.	.31	.46	0	1
Seeds: Dummy variable indicating whether or not the farmer	.53	.5	0	1

thinks the local forest is a good source for seeds and seedlings. 1 if yes, 0 if no.				
Participate : If a farmer has participated in any forestry-related program he receives a 1, and all others 0.	.46	.5	0	1

The estimated equation is:

$$Y = B + B1(\text{COSTS}) + B2(\text{SOCIOECONOMIC}) + B3(\text{ENVIRONMENTAL ATTITUDE}) + e$$

$$B1 = (\text{Bid, distance})$$

$$B2 = (\text{Income, , strata, kids, education, years, seeds, Experience})$$

$$B3 = (\text{Trees, success, participate, Forest})$$

3.5.2 Results

STATA was used for all estimations and testing for multicollinearity of right hand side variables for all models. In order to learn more about the demand for forest conservation, several simple models are estimated to explore the BID variable and its effect on the yes/no response. The simplest of all models assumes the population is completely homogeneous and uses only the cost variable (BID) to predict the yes/no response. This simple model supports the hypothesis that respondents behave rationally when presented with changes in cost. The coefficient on BID is negative and statistically significant at the $p=.001$ level. Although the sign is as expected, this coefficient does not represent the marginal effects as do OLS coefficients. The marginal effect of BID, evaluated at the mean of 3.9 days, is -.099. If the number of workdays increases from 3.9 to 4.9, the probability of a yes response decreases by 9.9% and if the number of workdays decreases to 2.9, the probability of a yes response increases by 9.9%.

Table 7. Probit Estimates:
 N = 176, $\chi^2(1) = 27.91$, Prob > $\chi^2 = 0.000$
 Log Likelihood = -98.302, Pseudo R2 = 0.1243

response	Coef.	Std. Err.	margin. eff.	mean
bid	-.281***	.055	-.099	3.9
_cons	1.613***	.264	-----	----

Another way to gain information about the effect of the cost on willingness to pay is to make each workday its own discrete variable. Creating and using dummy variables for each BID level requires dropping one of the dummies from the model in order to provide a reference point for the estimated coefficients on the other workday levels. This model drops the seventh day and compares days 1-6 with seven days. There is a statistically significant difference between the probability of a yes response to seven workdays and one workday or two, or three workdays at $p < .01$ level. The difference between responses to five or seven, and six or seven is not significant. The difference between 7 days and 4 days presents an interesting point of departure. The difference in the probability of a yes response is not significant at .01, or .05, but is at .10. It appears that four days may represent some sort of kink in the demand curve.

Table 8. Probit Estimates:
 N = 176, $\chi^2(6) = 30.73$, Prob > $\chi^2 = 0.000$
 Log Likelihood = -96.891, Pseudo R2 = 0.1369

response	Coef.	Std. Err.	margin. eff.
one	1.862***	.525	.375
two	1.020***	.378	.274
three	1.046***	.376	.279
four	.614*	.352	.186
five	.150	.358	.051
six	-.013	.363	-.005
_cons	-.150	.251	-----

Table 9 provides the maximum likelihood estimates of the parameters of the full probit model. The overall goodness of fit for the model is estimated with McFadden's R2 and a value of 0.28 is good for small sample cross-sectional data. Additionally, the chi-sq. of 63.88 with thirteen degrees of freedom allows for the rejection of the null hypothesis of all explanatory variables being equal to zero at the .001 level.

Table 9. Probit Estimates				
N = 176, chi2(13) = 63.88, Prob > chi2 = 0.000				
Log Likelihood = -80.318, Pseudo R2 = 0.2845				
response	Coef.	Std. Err.	marg. eff.	mean
bid	-.310***	.065	-.101	3.9
dist	-.114**	.057	-.037	2.9
succ	.757***	.277	.220	.31
exp	1.092***	.400	.265	.17
forest	.0152***	.005	.005	28.05
strata	.400	.263	.126	.39
trees	.093	.065	.030	1.26
part	.080	.245	.026	.47
seeds	.356	.261	.116	.53
years	-.0005	.020	-.0002	10.9
income	-.00001	.0000009	-.000003	11363
educ	.130	.241	.042	.39
kids	-.033	.040	-.011	4.03
_cons	1.062	.490	-----	

The most important explanatory variable, as expected, is the number of workdays; *BID* is negative and significant at .01. Other variables of significance are *EXP* (.01), *FOR* (.01), *distance* (-.05), and *SUCC* (.01). The distance variable suggests that farmers who live farther from their fields are less likely to be willing to work for a forest

preserve. Perhaps this is due to the extra distance of walking to work, which for some farmers is up to 10 km one-way each day (see table 3). The three variables that are positive and significant tell an interesting story. Farmers with forestry experience, larger areas of forest remaining on their own farms, and previous success with planting trees are more likely to be willing to work to preserve a forest area. These are the environmental attitude variables. These variables suggest that farmers who preserve more of their own land in forest and have been successful at propagating trees on their farms are more willing to work for the preservation of a “public” forest.

Although the signs and magnitude of the probit coefficients are indicative of changes in the probability of a yes response, they need to be re-parameterized in order to determine their marginal impacts and to develop the WTW estimate using Cameron's (1987) technique. Evaluated at the mean for each of the explanatory variables, the marginal effect measures the change in the probability of a yes response of a one-unit change in the explanatory variable. For example, an increase in the bid amount from 3.9 days to 4.9 days, decreases the probability of a yes response by 10 percent. This is consistent with the simple model estimate. For each of the dummy variables the marginal effect is for the discrete change from 0 to 1. For example, farmers with forestry experience are 26% more likely to say yes than those without this experience. Farmers who are happy with their current tree plantations are 22% more likely to respond affirmatively than those who have not been successful, and a one hectare increase in forest area leads to a 0.5% increase in the probability of a yes response.

The final step is to estimate the WTW for a forest preserve.

$$E(WTW) = \hat{\alpha}XB$$

$$B = -(\delta/\alpha)$$

δ = vector of all estimated coefficients

α = the estimated coefficient of the BID variable

TABLE 10 – WTW Estimation

Variable	X	B	XB
Constant	1	3.42	3.42
Bid	3.9	-1	-3.9
Distance	2.9	-.36	-1.04
Strata	.39	1.29	.5
Kids	4	-.11	-.44
Education	.39	.4	.15
Years	10.9	.00016	.002
Income	11363	.00003	.3
Experience	.17	3.5	.59
Trees	1.3	.3	.4
Forest	28	.05	1.4
Success	.31	2.44	.75
Seeds	.53	1.1	.5
Participate	.46	.25	.11

Applying Cameron's (1987) technique, the mean willingness to work is estimated to be 2.74 days per month. This is slightly more than one weekend per month, which does not seem unrealistic. It is even more believable when one considers the importance of community service in Ejido life and the distinct possibility that working with friends on a communal project might even be fun.

3.6. Conclusion

In the past decade, contingent valuation (CV) has been used to value such goods and services as tropical forests (Shyamsundar and Kramer 1996), and research and extension programs (Whitehead et al. 2000). The focus of this paper was to determine farmers' willingness-to-work in order to protect local forest resources. Life in these small villages on the Yucatan Peninsula of Mexico is grounded in community service. Members of the community often donate their labor services to community projects. Hence, subsistence farmers were asked a contingent valuation question, in order to

determine their willingness to work to create and maintain a local forest preserve. Not surprisingly, farmers exhibit a willingness to work for forest conservation and the responses are consistent with economic theory, i.e. costs matter.

The probit model is reasonably well estimated and the WTW is robust across nonparametric and parametric estimations, providing suggestive evidence that the typical farmer is willing to work slightly less than three days per month in order to insure the conservation of local forest resources for future generations. Certainly, there is a need for more research into the use of non-market valuation techniques for valuing environmental resources in this context. The results of this study suggest the CVM may be a useful tool for determining the viability of local participation in forest conservation efforts. Farmers in southeastern Mexico are interested in forest conservation and are willing to contribute to efforts to conserve forest resources.

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CONCLUSION

All of the data collected in Calakmul have been analyzed using several stated preference techniques in order to determine farmer preferences for agroforestry and forest conservation. From July 1997 through March 1998, the survey was designed, tested and administered to 186 farmers. Of the 186 surveys completed, 175 were used in the final analysis. Although each of the three essays are unique, they have common themes and they begin to fill the gaps identified by Mercer and Miller (1998).

Evidence from the choice modeling experiment, which shows that forest conservation is important, is confirmed by the contingent valuation experiment. In the CM experiment the part-worth utility derived from improving forest cover is .82 (which is the highest part-worth of any attribute level) and the mean willingness to work from the CV experiment is 2.74 days per month. Also, the human capital variable representing on-the-job training, i.e. forestry experience (EXP) is positively related to interest in agroforestry in (1) the RP model, (2) the SP model, (3) the choice experiment and (4) is positively correlated with willingness to participate in a conservation program. Perhaps these farmers with more experience have a better understanding of local resources and the importance of conserving forests for future prosperity in Calakmul.

Findings, supported by both the revealed behavior and stated interest, also suggest that low rates of adoption can be improved through the use of public policies improving access to education, providing exposure to information about agroforestry from other farmers, and ensuring careful implementation of initial rural development programs. This is an important point. The evidence provided by the variables HAAF, ED, EXP, EXPOSE and SURV suggests that farmers who have more education, more training and

previous successes are more likely to invest. Of course this makes sense, but it also highlights the impact of previous development programs on the implementation of new or current programs. We may have new information pertaining to the benefits of agroforestry but we may also have to overcome failed efforts in the past in order to implement new strategies. Therefore, working closely with farmers in order to improve their comfort level / confidence with new systems being offered, or analogously, reducing the uncertainty of investing in a new system of production, is an important component of the development process.

Agroforestry practitioners can improve the odds of successfully implementing agroforestry by providing continuing education and training to farmers. Perhaps most important is the role to be played by farmers who have already successfully implemented agroforestry systems. These farmers need to be identified and allowed to participate actively in the dissemination of information and the on-the-job training of new adopters of agroforestry technologies.

Agroforestry has been presented as a sustainable alternative to current methods of production in the tropics, i.e., “slash & burn.” If agroforestry is to succeed, the accompanying investments in the human capital of farmers through extension programs and on-farm training must be a part of the overall implementation strategy for agroforestry practitioners. In addition, agroforestry projects must be designed and targeted to meet specific needs of farmers. These needs are not limited to income, but encompass characteristics such as forest conservation, a certain amount of technical support, diversity in outputs, and flexibility in seedling delivery. In spite of the lack of welfare estimates in this particular application, CM experiments should prove useful in

choosing these characteristics and then, determining the value farmers have for these them. Hopefully, this information can facilitate the successful implementation of agroforestry in the tropics.

Certainly, there is a need for more research into the use of non-market valuation techniques for valuing environmental resources in this context. The results of this study suggest the CVM may be a useful tool for determining the viability of local participation in forest conservation efforts. Farmers in southeastern Mexico are interested in forest conservation and are willing to contribute to efforts to conserve forest resources.

Finally, I want to close this paper by returning to the 4 main points from Mercer and Miller (1998) identified in the introduction. These 3 essays contribute to the literature by using (1) a large sample (n=175), from (2) Latin America, collected by (3) formal survey techniques and (4) utilizing quantitative/multiple regression analyses. The data collection for these analyses was carried out in 1997 and 1998 and the sample was collected using scientific sampling methodologies in order to render the data useable for quantitative statistical analysis. As of 1996, only 16 surveys from papers in *Agroforestry Systems* had utilized these methods and collected a sample of greater than 100. These essays make use of a rather large sample of 175. Additionally, these essays provide 3 new analyses from Latin America looking at farmer preferences for agroforestry and forest conservation. Lastly, the use of Probit and Tobit Models and a Multinomial Logit Model are all in keeping with the recent trend of using increasingly sophisticated techniques to better understand adoption behavior (Mercer and Miller 1998).

Basado en estos caracteristicos, Yo tengo una lista de 8 sistemas de agroforestales y me gustaría saber que piensa probar Usted. Yo describiré dos sistemas potenciales y me dice que sistema que escogería. Por favor, recuerde que puedo escoger ningun sistema, si no le gusta cualquiera de los dos sistemas presentados.

- | | | | | | | | |
|----|---|---|---|----|---|---|---|
| 1) | A | B | C | 5) | A | B | C |
| 2) | A | B | C | 6) | A | B | C |
| 3) | A | B | C | 7) | A | B | C |
| 4) | A | B | C | 8) | A | B | C |

V. PREGUNTA FINAL

Suponga tu ejido considera una programa para conservar bosque communal y en este bosque no hay extraccion de madera, chicle, nada. Este area de conservacion es para proteger plantas, animales, limpia agua y aire y proteger bellas vistas por el futuro.

Es necesario para cada ejidatario trabajar _____ dias por mes en este bosque.

Esta bien para Usted SI NO

SI, es _____ dias por mes esta bien SI NO

NO, es _____ dias por mes esta bien SI NO