EVALUATION OF PAYMENTS FOR ECOSYSTEM SERVICES IN THE VALLEY REGION OF BOLIVA

by

Cassie Ann Hoffman
Dr. Jeffrey R. Vincent, Advisor
May 2009

Master's Project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment of Duke University

Abstract:

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Market based mechanisms are proliferating around the globe as a means to offer direct economic incentives for protecting and conserving ecosystem services. Among the ecosystem services being marketed, payments for watershed services (PWS) are the most difficult to establish clear service provision. Most PWS use a land-based compensation method, assuming that specific land management practices will result in the desired watershed services. Past evaluations of financial benefits for PWS service providers have suggested that payments have been relatively insignificant when compared to income or opportunity costs of market participants.

This report explores whether the payment employed in a PWS implemented by the non-governmental organization Fundación Natura in the Los Negros watershed of Bolivia offers significant incentive to conserve forest cover and has the ability to meet landowners' opportunity cost of alternative uses of land. Since 2003, upstream farmers have enrolled parcels of land and been compensated $3 per hectare per year for conserving forest cover. In 2008, sixty-two farm surveys were completed and their location geo-referenced in the Los Negros watershed to determine annual net farm income per hectare as a measure of marginal opportunity cost to land. Opportunity costs were modeled using biophysical characteristics of farm parcels, economic parameters of the market and distances to roads. The model was used to map opportunity costs across the watershed.

The economic model predicted significant variation in opportunity cost across the Los Negros watershed with a range of US $0 to $8493 per hectare. The majority of landowners were overcompensated with 75% of the area in conservation carrying opportunity costs of US $0 per hectare. Other areas are significantly under-compensated at the current compensation rate and could be under the highest threat of deforestation. While increased cost effectiveness could be achieved and more meaningful incentives offered to landowners by differentiating compensation, consideration should be given to non-financial benefits of the PWS, such as strengthened property rights, as well as the political costs of price differentiation.

Approved:

________________________________ ________________________________

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And lastly, the sincerest gratitude to my eternally supportive parents.

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INTRODUCTION

Market based mechanisms are proliferating around the globe as a means to offer direct economic incentives for protecting and conserving environmental services. Many view these markets as an opportunity to ensure the provision of these services over more traditional command and control measures while leveraging willingness to pay for environmental services in a competitive supply and demand scenario. In developing countries where top-down federal environmental management policies have been poorly implemented and weak states have inhibited enforcement and monitoring compliance with environmental laws, environmental service markets provide an opportunity to promote environmental stewardship on a local and relevant scale.

Potential exists for environmental service markets to create a self-sustaining and permanent conservation mechanism, but start-up and implementation of these projects has been slow and encountered many challenges. These markets encompass a broad range of activity, and even the criteria of what defines a payments for environmental services (PES) scheme is somewhat contentious. Sven Wunder offers the most formal definition of PES as voluntary contingent transactions around a well-defined environmental service (or a service-producing land use) between at least one buyer and one seller (Wunder, 2005, p. 9). The most commonly bought and sold environmental services include biodiversity conservation, watershed protection, carbon sequestration, and preservation of landscape beauty (or some combination of more then one service[1])

[1] This is the concept of "bundling" environmental services; a buyer can purchase more then one environmental service with one payment.

(Landell-Mill, Natasha, 2002, p. 4). The wide spectrum of market activity has resulted in a diverse collection of ongoing and proposed projects in developed and developing countries, yet few schemes entirely embody the criteria of a PES presented by Wunder. Furthermore, there is an extensive list of concerns plaguing these new efforts including, but not limited to, lack of efficiency, high transaction costs, lack of additionality, leakage and inadequate consideration of equity and fairness when intervening in the livelihoods of the world's poor (Landell-Mill, Natasha, 2002, p. 4 and Wunder, 2007, p. 52).

Among the environmental services being marketed, payments for watershed services (PWS) are the most controversial and difficult to establish clear service provision. Provision of better water quality or flow regulation (water quantity) are the most commonly sold watershed services, but the science linking the conservation of forest cover and watershed services provision is convoluted and highly dependent on context, vegetation cover and specific trees species. There is mild consensus that high altitude cloud forest is the exception to this debate. This specific forest type has the ability to increase dry season flows through increased water yields from cloud interception, but even this effect may be smaller then originally perceived (Roertson and Wunder, 2005, p. 35-36 and Porras, Grieg-Gran and Neves, 2008, p. 91). Due to prohibitive cost or time constraints, most PWS schemes have not established a hydrological baseline before implementing a market. In developing countries, where supply of watershed services has not been fully substantiated, market implementers have relied on local perception and belief that upstream land conversion and management is responsible for water quality and quantity downstream.

While there are concerns over the provision of watershed services for buyers, how to compensate service stewards is complex and measuring and attributing the provision of watershed services is difficult. Of the fifty ongoing PWS identified by Porras et al. in a 2008 review of payments for watershed services in developing countries, all schemes employed a land-based compensation method, assuming that specific land management practices would result in the desired watershed services instead of directly paying for the services provisioned. There are four main land management practices being compensated for watershed services: (1) improved land, agricultural, and ranching practices, (2) conservation and protection of existing ecosystems, (3) reforestation, and (4) rehabilitation of degraded ecosystems (Porras et al., 2008, p. 2). Compensation in PWS has proven to be less direct and monitoring less straightforward then other environmental service markets.

In rural, agricultural communities, PWS that restrict natural resource extraction and use by encouraging protection and conservation of ecosystems have the potential to negatively impact livelihoods of environmental service providers. Past evaluations of financial benefits for PES service providers have suggested that payments for market participants have been relatively insignificant when compared to household income, 1.2-30% of average household incomes, and/or the cost of participating in the scheme, 2-20% of opportunity costs (Porras et al., 2008, p. 77-79). There is the possibility that participation in environmental service markets provide other non-financial benefits such as capacity building, gaining a reputation as an environmental steward, strengthened property rights and increased social organization, but are difficult to quantify and compare across markets. It is also conceivable that land management behaviors or land enrolled in conservation bears little cost to the watershed service provider or adds little additionality to the watershed service provision because a substantial threat to forest integrity does not exist. Understanding landowners' motivation to participate in a PES is critical to its success.

Study Objectives

With limited resources to achieve important environmental goals, conservation interventions must demonstrate additionality, cost effectiveness and economic efficiency. The onus rests on those implementing a conservation scheme to prove that their intervention improves on the baseline of environmental protection and provides a better outcome then the counterfactual of no intervention (Ferraro and Pattanayak, 2006, p 482). One performance indicator of a PWS is whether the opportunity cost of land, the forgone opportunities from alternative use of resources, for an environmental service provider are met by the compensation for participating in the scheme. Measuring opportunity costs does not replace program evaluation, but does provide a measure of the cost effectiveness of the scheme and signals whether the PWS legitimately incentivizes conservation. For environmental service providers, this means that the compensation must at least meet and ideally exceed the benefits from an alternative land use (Engel, Pagiola, and Wunder, 2008, p. 664).

In transitional landscapes with tropical forest cover, the most common alternative land uses to maintaining forest cover are agriculture and raising cattle. Returns to agriculture and thus opportunity costs are differentiated according to following parcel characteristics:

- Biophysical: soil suitability, elevation, slope, climate conditions, vegetation cover
- Accessibility: distance to roads, rivers and markets
- Tenure security
- Availability of new technologies and other inputs

(Nepstad, Bali Reports 2007, Chomitz, Alger, Thomas, Orland and Villa Nova, 2005, Grieg-Gran, 2006)

Sven Wunder identifies PES as "best suited for scenarios of moderate conservation opportunity costs on marginal lands in settings with emerging, not-yet realized threats"; it is clear that if a realized or potential threat does not exist, there is no additionality to the PES (Wunder, 2005, p. 21). In use-restricting PES schemes, opportunity costs to conservation are deemed as returns to alternative land uses. Forested areas with high opportunity costs will be under the greatest threat of conversion to agricultural uses while those lower returns face less significant threats of deforestation. Returns to these alternative land uses vary greatly from year to and are usually determined by market actors outside of the PES area. These external pararmeters can greatly affect the ability of the payment to cover an environmental service seller's opportunity cost from year to year.

This report analyzes the ability of compensations to influence landowner behavior in a PWS in the Los Negros watershed in the valley region of Bolivia. This PWS currently compensates landowners the equivalent of US$3 per hectare per year through in-kind payments for primary cloud forest and grassland. Utilizing a geospatial econometric model to map opportunity cost of forest conservation to agriculture for landowners in the Los Negros watershed, these modeled costs will be used to gauge the significance of compensation and its ability to incentivize forest protection and conservation.

The objective of this report is to produce an opportunity cost map of smallholder agriculture in the Los Negros Watershed dependent on spatial differentiation of environmental and economic variables across the landscape. This map will allow conservation managers to understand the geographical variation of opportunity costs and determine if individual landowners' opportunity costs are being met. The map can also serve as a reference if and when the payment amount is renegotiated. Section one of this report describes the evolution of watershed management and payments for ecosystem services in Bolivia and gives background on the study area and PWS under investigation. Section two details the theoretical framework of opportunity costs and modeling land rents and explains the methodology and data used in this report. Finally, section three reports results from the modeling exercise, compares current compensations with the opportunity cost map produced, and discusses the implications for PWS in the Los Negros watershed.

SECTION ONE

Background

The Bolivian landscape spans twelve eco-regions and a diverse terrain from the northeastern Andean mountain range to the dry forests of eastern lowlands. This array of different ecosystems hosts extremely rich and biologically diverse forests (Robertson and Wunder, 2005, p. 9). As a low-income country in South America with relatively low population density, economic growth has been sluggish, and the country has increasingly relied on its natural resources for national income. Rising deforestation rates have been slow to manifest, and the country has approximately 50% of its surface area covered with forests. As threats[2] to these forests grow, the Bolivian federal and municipal governments have supported environmental policies and innovations to protect its forests: twenty-one national protected areas encompassing 15% of Bolivia's land area, the first debt-for-nature swap, and more recently, payments for ecosystem services (Robertson and Wunder, 2005, p. 10-11). Adoption of PES in Bolivia requires overcoming the common perception in rural Bolivia that "nature is a gift from god" and skepticism of the marketization of nature. Despite this obstacle, payments for ecosystem services has gained footing in Bolivia, and nine PES were operating and eight were in the proposal stage in Bolivia in the year 2005 (Robertson and Wunder, 2005, p. 13).

The Bolivian federal government has typically had a weak capacity to provide assistance to the poor in rural areas, manage natural resources to serve the needs of their citizens,

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[2] The increase in soya bean cultivation has been the largest industrial threat. Although rural migration is more diffuse, aggregate effects can pose serious threats as well.

and enforce laws with environmental objectives. Decentralizing the capacity and resources to pursue these objectives to municipalities has been more effective in most cases. While local municipalities in Bolivia frequently do not have the regulatory power to enforce environmental laws, they do have institutional capacity to assist in PES implementation. In 1994, the Bolivian federal government adopted the Law of Popular Participation that included a series of reforms to increase the efficiency of public spending and decentralize disbursement authority. Municipalities gained considerable autonomy and fiscal power, including the responsibility for local water supply, sanitation, and ability to play a role in watershed management. This initiative came after years of relatively ineffective top-down integrated watershed management from the federal government (Asquith and Vargas, 2007, p. 16-17).

Bolivia is largely dependent on its natural resources for national income as export commodities and subsistence. Subsistence agriculture with the inclusion of one to three cash crops to take to market is common in rural areas. These agriculture communities depend on water availability and resilient irrigation networks to sustain their livelihoods. Political and economic realities hinder responsible and adept watershed management. The context of watershed management in the Eastern lowlands of the country is such that:

- Clear, documented land tenure is rare.
- High levels of poverty persist with a GDP per capita of $1101 in 2006 (United Nations, 2009).
- Rural inhabitants are largely dependent on agriculture and extensive cattle grazing for subsistence and income.
- Downstream communities are completely dependent on upstream water sources.

- There is steady stream of migrants from Western Bolivia making illegal land claims and establishing tenure by cultivating the land.

- Regulation and management are embroiled in complex local decision-making structures.

(Asquith et al., 2007, p. 10)

Although these realities create a challenging atmosphere for responsible resource management, PES schemes are being implemented in Bolivia using *de facto* property rights with varying success. Some claim that the greatest contributions of these PES schemes have been spillover effects, increasing community cooperation, environmental education and awareness, and warding off new land claims by migrants, yet full evaluation of additionality and conservation costs have generally been overlooked. To ensure environmental integrity and service provision instead of another false development scheme handed down from the industrialized countries, PES in Bolivia must be scrutinized more thoroughly.

Study Area

The non-profit and non-governmental organization (NGO) Fundación Natura Bolivia initiated a payment for environmental services scheme for watershed management and biodiversity in the Los Negros valley in 2003. The Los Negros valley is approximately 26, 900 hectares in area and is located in the valley region of a mid-elevation transitional zone in the Santa Cruz department. The headwaters of the Los Negros river begin in the 637,000 ha Amboró National Park, home to at least 127 species of mammals, 105 species of reptiles, 73 amphibian species and more then 800 bird species (Asquith et al., 2008, p.

676). The watershed borders the park boundary and lies in its buffer zone. The primary upstream population center, Santa Rosa del Lima, lies 35 kilometers from the downstream community of Los Negros.

Characteristics of the Los Negros Valley	
Total Area	26, 900 ha
Major Population Centers	
Upper Watershed: Santa Rosa de Lima Palmasola Sivingal	• 1,328 inhabitants • Higher rainfall • Rain-fed production of maize and beans common • Extensive cattle grazing • Average annual income: 8000 Bolivianos (US$ 1100)
Downstream: Los Negros	• 2,970 Inhabitants • Mostly irrigated agriculture with major crops: tomatoes, onions, potatoes and carrots • 2 -3 harvests annually • Major markets Santa Cruz de la Sierra and Cochabama • Average annual income: 11, 400 Bolivianos (US$ 1426)

Table 1. Characterization of Los Negros Valley Communities
Source: Asquith, 2008, p. 676

Inhabitants of the Los Negros watershed earn their income primarily through agriculture with different crops dominating depending on the varied agroclimatic conditions of the different areas of the watershed. Farmers depend on the Los Negros river as a water source for irrigation, but the downstream Los Negros community has significantly more irrigation infrastructure, farming is more intensive, and more institutional capacity exists to monitor water resources. Water is generally abundant upstream in Santa Rosa del Lima and Palmasola, but seasonal scarcity plagues the downstream community.

It is a common perception in the downstream community that seasonal scarcity has become increasingly more acute, and Los Negros residents claim that water flow has decreased by 50% in the last 25 years. They frequently attribute this decrease in hydrological flows to deforestation upstream, land use change, more upstream water consumption, and inefficiencies in water distribution. Asquith et al. (2008) offer rough numbers from a hydrological modeling exercise using national level data that states annual upper watershed deforestation rates of 0.8% would decrease dry-season flow in Los Negros in by 75% over 10 years (Asquith et al., 2008, p. 676 – 680). These numbers need more refinement, and Asquith acknowledges the shortcomings of using national data for micro-analysis. As previously acknowledged, no functioning PWS that has been reviewed has sufficiently established a hydrological baseline. The NGO is currently and continually collecting hydrological data in the Los Negros watershed, but beyond local perceptions, they are hedging on studies suggesting that high altitude cloud forest increase dry season flows, even if marginally (Bruinjezeel, 2004).

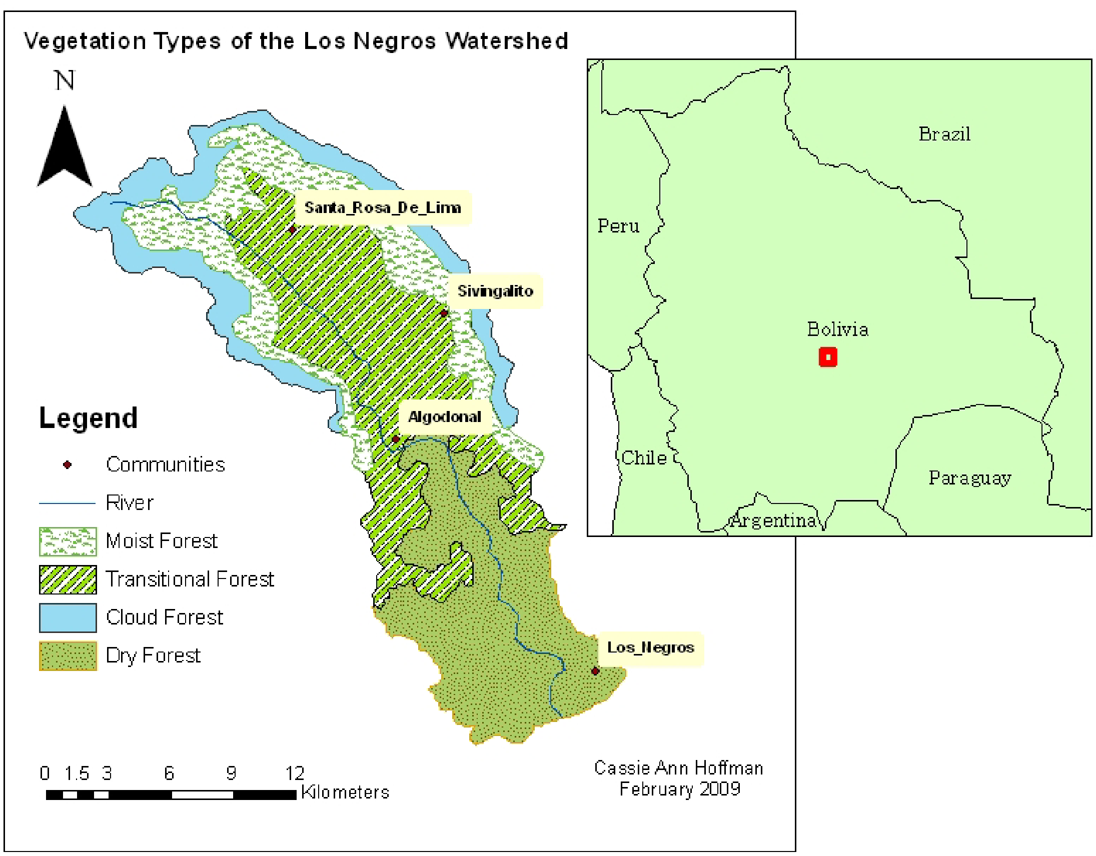

Figure 1. Vegetation types of the Los Negros Watershed.

In mid 2003, after a series of negotiations, five upper watershed landowners entered the PES scheme and offering to protect 592 ha of land of varying types of vegetation. The downstream community was hesitant to pay for hydrological services and watershed management at first, skeptical of the ability to monitor and ensure conservation actually took place. The initial financial backing for the project came from the United States Fish and Wildlife Service for payments for biodiversity. Watershed services were later "bundled" with biodiversity payments. The upstream forests provide both environmental services (watershed protection and biodiversity), but receive funds from entities willing to buy one or both services. Today, the scheme receives funding predominantly for watershed services. The local municipality of Pampagande is contributing funds for the PES for watershed services with the number of downstream farmers contributing to a water fund growing annually. Today, forty-six farmers are being compensated for protecting 2774 ha of land of which 1334 ha is threatened cloud-forest habitat of eleven species of migratory birds (Asquith et al., 2008, p. 675).

Annual contracts allow the landowners who choose to participate in the PES to decide which plot to enroll and the length of the contract at an established annual payment rate. During the start up period of the PES in mid-2003, upstream and downstream representatives negotiated a compensation package of one artificial bee box, valued at 275 Bolivianos or US$ 30 in 2003, for ten hectares of conserved forest cover for a contract length of one year. This translated into a rate of US$3 / hectare / year. Whilesome may deem the compensation method inflexible, PES participants who have enrolled less then ten hectares typically increase the length of the contract to meet the going rate.[3]

While the PES initially compensated all forest types at the US$3 / ha /year rate, today only primary, non-degraded grasslands and primary, non-degraded cloud forest are compensated at the premium, but additional types of vegetation are included in the scheme on a sliding scale (see Table 2 for details). The compensation is hypothetically a conditional and ongoing payment; the one contract infraction that has occurred resulted in suspension from the PES for one year. The bee box could not be reclaimed for political reasons. The most recent landowners to enroll land in the program have requested barbed wire in place of bee boxes for payment. Very few landowners hold government-approved titles, but locally approved signed purchase contracts and agreement on property lines among neighbors are accepted as proof of ownership among community residents. Parcels enrolled in the conservation scheme are monitored and inspected annually (Asquith et al., 2008, p. 675-678 and Vargas, 2004, p. 3).

[3] In a hypothetical situation, an environmental service provider agrees to conserve 5 hectares. To enable his/her ability to receive the entire bee box as compensation, he/she would agree to enroll 5 hectares of land for 2 years. 5 hectares x US$3/ha/year x 2 years = US$30

Conservation Parcel Distribution of the Los Negros PES system						
2007	*Primary forest without any previous or current intervention*		*Grassland without intervention*	*Old growth forest currently subject to cattle grazing*		*Secondary Forest*
	Cloud Forest	Moist Forest		Temporary	Permanent	
	US$ 3/ha	US$ 2.25/ha	US$ 3/ha	US$ 2.25/ha	US$ 1.5/ha	US$ 1.5/ha
0-1 ha	-	2	2	1	-	5
1-10 ha	8	6	4	4	-	7
10-20 ha	11	5	3	5	1	-
20-50 ha	10	-	-	7	1	1
> 50 ha	11	3	-	5	-	-
Total hectares enrolled	1334.98	528.17	70.27	749.26	46.05	45.52

Table 2. Payment schema for PES in Los Negros SOURCE: Asquith, 2008, p. 678

Individual households deforest approximately 1-1.5 hectares of forest per year per household and generally lack the capacity (labor and capital) to increase this rate. Migrants from the West introduce new threats and new labor to the area. Since 2003, residents have deforested between 95-140 ha or 2.5-3.5% of the cloud forest surrounding the community of Santa Rosa (Asquith et al., 2008, p. 676-678). With deforestation rates as low as 1-1.5 ha per household per year, it is quite probable that landowners participating in the PES are enrolling parcels that would not have been deforested. Remote areas and parcels with steep slopes are typically under less serious threat of deforestation and less apt for cultivation and grazing. Conversely, many consider remote areas to be the most vulnerable to clearing by landless migrants, because they have the weakest ownership claims.

SECTION TWO

Methodology

Theoretical Framework

If land is considered a resource in a Ricardian rent context, benefits or returns from the most valuable alternative land use represent opportunity cost. The Ricardian approach states that economic rent or returns to the most valuable land use will be influenced by the differential advantages and characteristics of the land that affect productivity (Ricardo, 2002, p. 34-35). Potential rent from the land use yielding the highest return from a parcel of land will be equal to commercial rent and dependent on land characteristics and farmgate prices of inputs and outputs for production. In this framework, the annual commercial rental value of a parcel of land is equal to its annual net revenue while the parcel's selling price is determined by discounting the flow of future net revenues (Naidoo and Adamowicz, 2005, p. 492). Either annual land rent or land price will serve as an appropriate proxy for opportunity cost depending on the time continuum.

When motivating landowners to conserve forest cover on private land, their land opportunity cost of the highest value alternative land use must be met to motivate conservation (Borner and Wunder, 2008, p. 498). In developing countries, the most common alternative land uses include agriculture (smallholder and mechanized) and ranching whose profits are influenced by land characteristics (soil quality, agroclimatic variables), proximity to markets, and infrastructure. Various econometric models have been employed to represent theses relationships and modeled spatially as geographical information systems capabilities, satellite imagery and data availability have improved.

Hedonic price models have been used to regress land prices on climate and soil properties and distances to roads (Chomitz, Alger, Thomas, Orlando, and Vila Nova, 2005, Vera-Diaz, Kaufmann, Nepstad, and Schlesinger, 2008) as well as econometric models that explain observed land rents using economic and biophysical variables (Mendelsohn, Nordhaus, and Shaw, 1999 and Bateman, Lovett and Brainard, 2002). Some models have incorporated the probability of conversion to a specific land use using a multinominal logit regression to determine the most *likely* alternative use before calculating the opportunity cost of a particular land parcel (Naidoo and Adamowicz, 2006) while Chomitz and Gray (1996) employed a production function to model potential rent for parcel of land as well as the probability of conversion to a particular land use.

Whether a hedonic price model or production function, these econometric models are typically reduced form functions, modeling economic relationships, not technical ones. Assuming a profit-maximizing individual, annual economic rent to land (a short-run profit function) is written

$$\text{Max } \pi \text{ (p, w, x, E)} = \text{max pq} - \text{wx} \quad \text{subject to q} = \alpha x^{\beta} E^{\gamma} \tag{1}$$

(Coelli, Timothy J., D.S. Prasada Rao, Christopher J. O'Donnell and Geroge Battese, 2005, p. 32 and Vincent, Jeffrey R., 2008, p. 12)

where annual profit (π) is equal to total revenue (quantity produced, q, at price, p) minus total costs of fixed and variable inputs (input, x, at price, w) subject to the Cobb Douglas production function which imposes a multiplicative relationship on the inputs (both variable and environmental, *E*).

A farmer makes decisions about what to grow, how much to grow, and the number of necessary of inputs in response to market prices of inputs and outputs and the available fixed environmental inputs available on their land. This means that profit can be modeled using explanatory variables that are exogenous (*w*, *p*, *E*) to the farmer's decisions. Price data can be difficult to observe and some studies have used distance to markets as an explanatory variable to proxy for prices of inputs and outputs. It is assumed that prices will increase for inputs and decrease for outputs as the distance from a population center to a farm increases. This assumption is generally true, but may not hold for price of labor that is provided locally. Distance to markets may not be entirely exogenous to farm location if roads have been built specifically to serve agricultural communities (Chomitz and Gray, 1996, p. 491).

Economic Modeling

The land rent model assumes the productivity of any given parcel of land will be a function of land characteristics as well as the exogenous economic parameters of the market. Observed annual economic rents from farms are determined by:

$$\pi = f\,(p, w, E) \tag{2}$$

With observed input and output prices, and environmental variables, annual economic rents are modeled:

$$\pi_i = \beta_0 + \beta_1 E + \beta_2 w + \beta_3 p \ldots X_i\beta_n + \varepsilon_i \qquad (3)$$

where π_i is annual profit in US$ per hectare of the *i*th farm ($i = 1, \ldots n$), *E* is a vector for agroclimatic or environmental input variables, *w* is a vector for the prices of input variables, *p* is a vector for the price of output variables, X_i is a vector of other independent variables and ε is an error term.

If distance is modeled as proxy for prices, the model takes the following form:

$$\pi_i = \beta_0 + \beta_1 E_{1i} + \beta_2 D_{2i} \ldots X_i\beta_n + \varepsilon_i \qquad (4)$$

where D is a vector for distance measures (farm to road, farm to market, etc.).
A goodness of fit criteria is employed through the backwards stepwise approach. If distance and environment inputs are explanatory variables, annual returns per hectare can be predicted across the entire study region where coverages of environmental variables are available and the location of roads and markets are know. Modeled profits serve as an upper bound on opportunity costs if owners incur benefits from the standing forest (Chomitz et al., 2006, p. 299). Because environmental variables and distances are assumed to be exogenous, the predicted annual returns per hectare are determined by land characteristics rather then the returns to any given farm.

Assumptions and Other Caveats

Annual net farm income was calculated using cash-flow analysis[4]. This study excluded returns to standing forests[5] and any timber harvested from land conversion. Neither was

[4] Total revenue minus total costs, including changes in stocks. See Appendix 2.

predicted to significantly skew calculated income or seriously undermine opportunity costs as timber is not harvested or used commercially in the area. Economic returns for farmers were calculated over the past year (between 2008 and the beginning of 2009, depending on when the survey was implemented) and reflect output and input prices from the time frame. These prices have tendency to shift and fluctuate over time and significant price changes will affect the ability of the PES in meeting opportunity costs of landowners' alternative land use through time.

This model assumes that farmers are seeking to maximize profit and are not seeking other objectives such as to establish land tenure or to reflect other preferences, such as a benevolent desire to conserve forests. It also omits other preferences and characteristics of the farmer that may contribute to annual net profits such as entrenched farming knowledge and experience, risk aversion and access to community knowledge or extension agents (Bateman et al., 2002, p. 230). Prices are deemed exogenous in a small, open economy (Kaimowitz and Angelsen, 1998, p. 15), and annual farm incomes are modeled by sequentially adding the following explanatory variables: biophysical variables, distances to roads and markets, and finally prices of inputs and outputs. As previously stated, the one exception to inclusion of only exogenous variables in the model may be labor prices as it is difficult to assume that a perfectly competitive labor market exists in rural areas of Bolivia. If prices are truly exogenous, there will be little variability in price observed in the region and will not be statistically significant.

[5] Use of forest resources was included in the survey administered, but non-response was frequent and reported extracted resources were either very small amounts or hard to standardize. The most common forest extracts were wood for fuel and fruit for consumption.

It should be noted that utilizing a land value that reflects the highest use value may overstate opportunity costs, especially if there are significant barriers (capital or labor constraints) to realizing the highest value use option. It has been argued that a more appropriate approach models the discounted stream of returns from the most *probable* land use (Pirard, 2008, p. 514) which is utilized in the Paraguay study by Robin Naidoo and Wiktor L. Adamowicz (2006). The multinomial logit regression technique employed in econometric modeling in previous papers was ruled out for this report because of a small sample size and the prevalence of one predominant land use: smallholder agriculture, with many farms utilizing both extensive cattle grazing and agriculture to generate income.

Land prices are not used as a dependent variable for a number of reasons. The market in the Los Negros watershed is not well documented nor perfectly competitive which can obscure land prices (Wunder, 2005, p. 70 and Grieg-Gran, 2006, p. 4). While many community members do not hold government title, there is a local official who authorizes and records land purchases. Despite this phenomenon, a large number of land transactions occur without exchanging money or amongst family members. Annual farm income was used to model marginal opportunity costs. It is useful to determine the annual marginal opportunity costs to the alternative land use as current PES contracts in the Los Negros Valley are not permanent conservation easements. Contracts exist for varying amounts of time, but one year is the minimum. The opportunity cost derived from this methodology is for annual income and comparable to the $3 / hectare / year paid annually to PES participants conserving cloud forest.

Data

The preparation of an opportunity cost map for the Los Negros watershed integrates ecological and economic modeling, and environmental endowments of land are viewed as production inputs. This methodology requires two main data inputs:

- Geo-referenced annual net farm income (or economic rents)
- Continuous geospatial data for biophysical and agro-climatic variables and road and river maps for the study region.

Annual net farm incomes were derived from primary data collected during the summer of 2008 and the beginning of 2009 through an in-person survey of farmers in the Los Negros watershed. Sixty-two individuals owning or renting land in the Los Negros watershed were surveyed concerning forest and land use, production inputs and outputs, local markets and prices, and personal characteristics, and sixty of the surveys were used for statistical modeling. The survey instrument was adopted from a similar opportunity costs study in Colombia and a focus group was conducted in Santa Rosa de Lima in July of 2008 to adapt the survey and gather information and attitudes about the conservation program. As a result of the focus group, redundant questions were removed, the survey was shortened appropriately, and an emphasis placed on input decisions.

Farms of the individuals surveyed were geo-referenced using a geospatial positioning system (GPS) and their locations are exhibited in Figure 2. The surveys were completed primarily in five population centers in the watershed (Santa Rosa de Lima, Palmasola, Sivingalito, Valle Hermoso and Los Negros) and have a tendency to be close to rivers and towns. Although the survey was not implemented randomly[6], it managed to achieve a rather wide spread upstream and relatively representative sampling of the five different land covers in the region (see Table 3). Although the study could have benefited from a larger sample, those surveyed represent approximately 1.5% of the sampling frame.

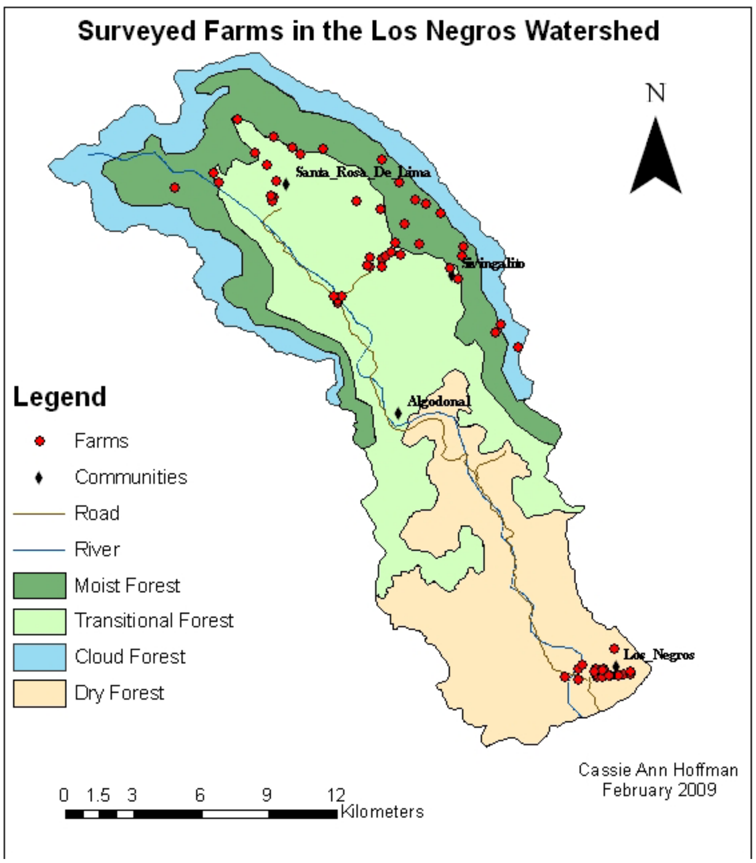

Figure 2. Locations of farms of individuals surveyed July-November of 2008.
X and Y coordinates taken using a GPS units.

The majority of the data for analysis using a geographical information system (GIS) was available from a 2006 Spatial Hydrological study conducted by the Centro do

[6] Random sampling was difficult due to time and staff constraints along with a general mistrust of outsiders by significant portion of watershed residents.

Levantamientos Aeroespeciales y Aplicaciones SIG (CLAS – Center for Aerospatial and GIS Applications) and the Fundación Natura Bolivia geospatial database. Discrete values for biophysical variables for each farm were determined from the GIS data.

While there is variation in the predominant crops from the top to the bottom of the watershed, the aggregate group of farms is treated as a homogeneous group and farms are not classified due to the primary output (milk, soy, or otherwise). It is generally observed that farmers engage in risk mitigation, diversify farm activity, and utilize a number of different production activities to generate farm income. This is certainly true in the upper part of the watershed where most farmers cultivate between two to three active crops, while mono-cropping occurs more frequently downstream.

The purpose of this study requires specific and highly detailed information for individual farms to determine geographic variation of opportunity cost in the Los Negros watershed. To this end, an in-person survey was conducted to achieve micro-observations instead of aggregate data at municipal level. Secondary data from the Santa Cruz agricultural department was utilized to reference numbers and accuracy of prices reported by survey respondents and to ensure responses were within a reasonable bound. Because landowners/renters frequently cultivate land that is dispersed among different parcels that are not necessarily contiguous, a single GPS point was taken at a parcel currently being cultivated. GIS data was available at a 50 m by 50 m resolution, and it is assumed the majority of one landowner's property would fall in a 50 by 50 m area or in the adjacent GIS pixel.

Descriptive Statistics for Biophysical Variables				
Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Annual Humidity Deficit (mm)	403.75	221.95	132	793
Annual Surface Drainage (mm)	120.3	64.42	40	300
Annual Interception by Vegetation (mm)	145.02	14.61	107	160
Elevation (m)	1574.43	252.9	1241	2039
Annual Precipitation (mm)	745.68	41.08	699	848
Annual Percolation (mm)	35.38	29.93	0	79
Erosion (t/ha/year)	11.73	14.41	0	76
Slope (Degrees)	9.95	6.94	0.453	31.71
Annual Evapo-trasnspiration (mm)	462.22	63.3	396	612

Variable	**Category**	**Frequency**	**% of Total**
Land Cover	Dry Forest	10	16.67
	Transitional Forest	26	43.33
	Irrigated Crops	9	15
	Cloud Forest	7	11.67
	Moist Forest	8	13.33
Aspect	Northeast Facing	11	18.33
	Northwest Facing	5	8.33
	Southeast Facing	17	28.33
	Southwest Facing	27	45
Texture	2	44	73.33
	3	16	26.67
Geomorphology	2	4	6.67
	3	15	25
	5	23	38.33
	9	11	18.33
	10	7	11.67

Note: n = 60
Table 3. Descriptive statistics for biophysical variables

Descriptive Statistics for Explanatory Variables				
Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Farm Gate Income per Hectare (US$/ha)	523.41	1949.88	-5118.39	9889.11
Farm Area	2.26	1.63	0.25	6.25
Distance to River (m)	911.63	1079.21	0	4175
Distance to Road (m)	1890.17	1553.94	50	4975
Distance to Market (km)	152.78	14.85	130.47	167.27
Price of corn (US$/metric ton)	182.61	6.18	176.18	195.75
Price of beans (US$/metric ton)	1005.09	75.43	838.92	1067.06
Price of peas (US$/metric ton)	360.58	31.61	340.24	412.47
Price of potato (US$/metric ton)	427.87	93.41	284.12	539.71
Price of tomato (US$/metric ton)	460.48	287.95	167.79	848.71
Price of fertilizer (US$/kg)	8.72	5.26	3.08	16.88
Price of chemicals (US$/Kiloliter)	28.46	18.52	6.38	54.78
Price of seeds (US$/ha)	930.57	1334.56	37.14	2951.82
Price of a day's labor (US$)	5.91	1.03	4.92	7.43

Note: $n = 60$

Table 4. Descriptive statistics for prices of inputs and outputs and distance variables

Results

Linear ordinary least squares regression was used to model annual net revenues for farms based on their biophysical attributes and distance to markets. These independent variables were fit to the model sequentially: biophysical attributes, distances, and finally prices. Since survey respondents provided prices for different outputs and inputs, they were included in the model last to see if they had any explanatory power after distance to roads had already been accounted. Input and output prices did not have significant p-values (many with p-values > 0.6) and excluded from the model. A backwards stepwise approach was used in modeling, and goodness of fit was an important criterion along with meaningful and logical coefficients for economic and biophysical variables. A quadratic form was used for a number of the agro- climatic variables to include the notion of a physiological optimum when modelling. The physiological optimum providing the greatest yield is predicted to be at the intermediate value of the quadratic terms[7] (Kaufmann and Snell, 1997, p. 181). It was anticipated that a number of the biophysical variables would be highly collinear. The model had relatively good explanatory power ($R^2 = 0.5434$ and Adj. $R^2 = 0.3318$) considering annual net farm revenues were regressed only on the available biophysical coverages and geographical information systems data. Heteroskedasticity was present in the model, and a robustness correction was made. Explanatory power is distributed relatively well among the variables, and no one variable dominates the model.

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[7] This the point at which the negative linear term and positive quadratic term cancel one another out. If $y = c + bx = ax^2$, $-b/a$ equals the physiological optimum.

Best-Fitting Model for Annual Net Returns per Hectare	
Variable	**Coefficient (t-statistic)**
ln_area_data	-926.0736 (-3.32)
deficit	-16.05718 (-1.83)
deficit_sq	0.0219852 (2.24)
aspect_ne	-1428.686 (-2.42)
land_cvr_2	1944.999 (3.64)
geom_10	2380.592 (2.73)
elevate	-8.092879 (-0.59)
elevate_sq	0.0044183 (1.02)
intercept	-1029.042 (-2.42)
intercept_sq	4.050315 (2.49)
evapo	-113.993 (-2.50)
evapo_sq	0.1125482 (2.37)
inv_distance	200.8667 (4.63)
precip	-267.6067 (-2.16)
precip_sq	0.1753675 (2.16)
erosion	114.2801 (2.27)
erosion_sq	-1.42176 (-2.76)
ln_slope	-559.9987 (-1.33)
constant	196298.3 (2.97)
R squared 0.5434 F-Statistic 0.0000	Adj R squared 0.3318

Note: $n = 60$

Table 5. Summary Statistics of econometric modeling of annual net revenue of farms surveyed in the Los Negros Watershed.

ln_area_data = natural log of area of the farm
deficit = annual humidity deficit

deficit_sq = square of annual humidity deficit
aspect_ne = dummy variable for areas with a northeastern facing slope
land_cvr_2 = dummy variable for drylands with livestock grazing
geom_10 = dummy variable for foothills
elevate = elevation (meters)
elevate_sq = square of elevation
intercept = annual interception by vegetation
intercept_sq = square of annual interception by vegetation
evapo = annual evapo-transpiration
evapo_sq = square of annual evapo-transpiration
inv_distance = inverse of distance of farm to main road
precip = precipitation
precip_sq = square of precipitation
erosion = erosion
erosion_sq = square of erosion
ln_slope = natural log of slope

The size of the farm in hectares was negatively correlated with annual net farm income per hectare most likely to due to the nature of farming in the upstream and downstream communities. Water availability and land is more abundant in the upstream community, and farming is more extensive. Farmers downstream practice intensive farming, employ more inputs, and have access to more irrigation infrastructure. Because farmers are able to produce more from smaller plots, a hectare of land is more productive downstream and hence has a higher rent.

The northeast aspect was the only significant slope direction. West facing slopes tend to be warmer and receive sun during the warmest time of the day (afternoon). This can be an explanation for why eastern facing properties may have lower returns. But northeastern slopes should have at least a partial solar aspect in the southern hemisphere that would typically be positively correlated with crop productivity. The dummy variables for foothills and the land use / land cover classification of dry shrubbery with grazing livestock have positive coefficients and could be areas that are easier to clear for agriculture, easier to travel to, and most likely have rolling slopes. Areas less prone to erosion yield higher returns, and erosion is negatively influences annual net farm income per hectare. This is most likely a result of increased loss of soil for cultivation and increased difficulty for plants to establish themselves.

Inverse distance variable to roads is also positively correlated with annual farm returns. The inverse transformation indicates that those farms that are closer to the road will receive higher returns to agriculture. This may be realized by paying less for transportation of goods to market or prices for outputs are higher and for inputs lower if the farm is closer to a road (Vera-Diaz, Kaufmann, Nepstad and Schlesinger, 2008, p. 423 and Chomitz and Gray, 1996, p. 491). Accessibility to roads and markets is important to farm profitability as would be expected.

Four biophysical variables, including both their linear and quadratic terms, were significant: annual precipitation, annual evapo-transpiration, annual humidity deficit and annual canopy interception. Referring to the notion of physiological optimums, none of these variables exhibit this optimum within the observed range of values for the surveyed farms. As these biophysical variables increase, they contribute negatively to farm income at a decreasing rate. All four biophysical variables are interconnected and critical to creating a biophysical environment suitable for cultivation.

High levels of evapo-transpiration and canopy interception can decrease the amount of available soil moisture for crop productivity, but this may be reflective of the current land cover rather then production capability. Annual humidity deficit should and is negatively correlated with annual net farm income per hectare, because it represents the deficit in humidity needed for potential evapo-transpiration relative to evapo-transpiration that actually occurs. Annual humidity deficit represents a lack of available moisture that would result in plant growth. Too much precipitation, and specifically heavy rains, can keep plants from absorbing nutrients, negate the application of fertilizers or pesticides and make plants more prone to diseases. Unfortunately, only annual mean values for these biophysical variables were available, and it is most likely that all four fluctuate greatly over the course of year. The watershed is located in a sub-tropical region that has dry and rainy seasons; extreme values (minimums and maximums) usually have more explanatory power then mean values and more influence on crop productivity.

After an acceptable and best-fit model was chosen, annual net farm returns were predicted for the entire study area using the fitted model, the available biophysical coverages and calculated distances to road. Predicted negative opportunity cost values were trumped to zero and the resulting opportunity cost map is exhibited in Figure 3.

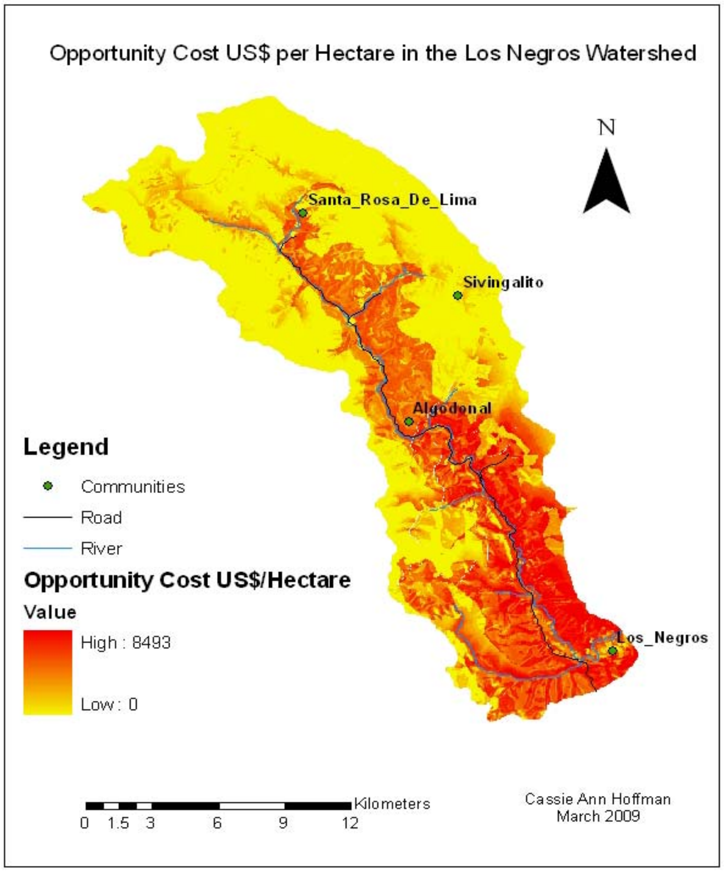

Figure 3. Opportunity Cost of land in the Los Negros Watershed valued at US$ per hectare

The opportunity cost map shows a range of values from $0 to $8493 US dollars per year per hectare. The values vary greatly over the study area, but the highest net returns per hectare are clearly in the southern, downstream region of the watershed. As would be expected, returns are higher in areas closer to the river and road, both as a result of access to the market and water for irrigating crops. A significant area of the upstream region carry $0 opportunity costs. The map should be interpreted with context and knowledge of region, and extreme values observed with caution.

Opportunity Cost US$ per Hectare				
Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Upstream of Watershed	857.05	1292.31	0	6740
Downstream of Watershed	3320.2	1677.07	0	8493
Cloud Forest	56.6	229.07	0	3203
Parcels in Conservation	243.93	633.73	0	4327
Los Negros Watershed	1585	1808.74	0	8493

Table 6. Summary Statistics of Opportunity Cost to land in for specific communities or parcels.

Predicted mean returns to agriculture are almost four times greater in the downstream region then upstream region, most likely as a result of higher incomes earned downstream, intensive agriculture and higher productivity per hectare. Surface area with cloud forest has the lowest mean opportunity cost value of US $56.6 per hectare, well below the mean value for the entire watershed (US $1585 per hectare) and mean upstream value (US $857.05 per hectare).

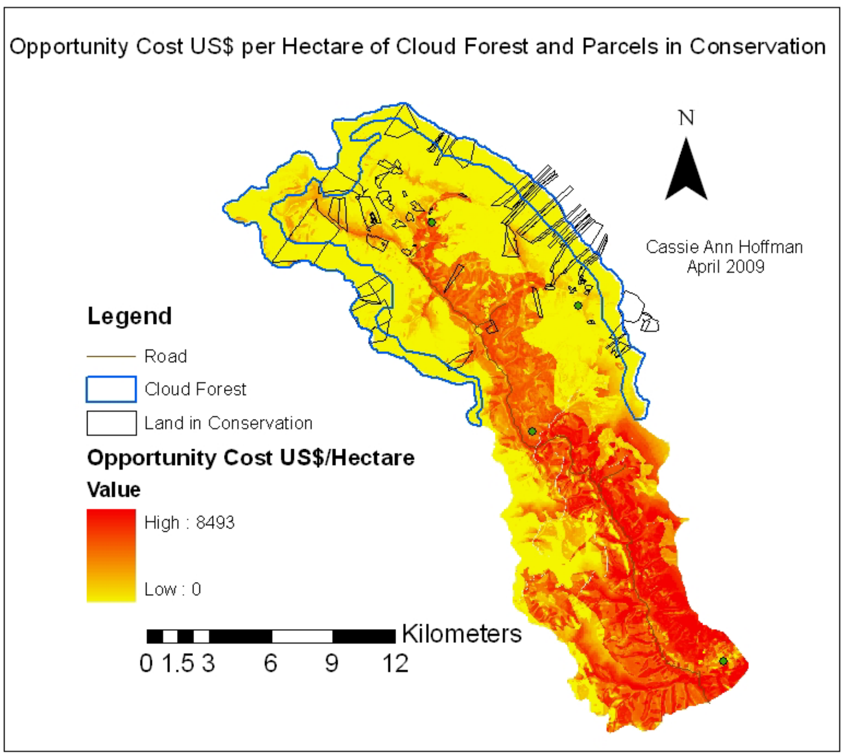

Figure 4. Opportunity Cost of land in the Los Negros Watershed valued at US$ per hectare, highlighting locations of cloud forest and parcels in conservation.

Parcels in conservation also carry considerably lower mean opportunity costs (US$ 243.93 per hectare) then the mean opportunity costs for the upstream region of the watershed. When examining the distribution of opportunity costs of the parcels in conservation, over 75% of GIS pixels of parcels in conservation carry an opportunity cost of US $0. Of the remaining pixels that carry a positive opportunity costs, the majority carry opportunity costs above the PES compensation of US $3 per hectare.

Breakdown of Opportunity Costs for Land in Conservation		
$US	**No. of Pixels**	**% of Pixels**
0	7818	75.95
1-250	529	5.14
251-500	475	4.61
501-750	290	2.82
751-1000	235	2.28
1001-1250	175	1.70
1251-1500	185	1.80
>1500	587	5.70

Table 7. Distribution of opportunity costs of GIS pixels of parcels in conservation.

SECTION THREE

Discussion

The map produced in this study can serve as reference for opportunity costs in the region and demonstrates while some of the parcels in conservation are being compensated below their opportunity costs, many carry an opportunity cost of US$ 0 per hectare and are being overcompensated. Supporting the theory that farmers are enrolling properties with 0 or low opportunity costs, over 75% of the parcels in conservation carry US$ 0 per hectare in opportunity costs. This map demonstrates that farmers upstream do have significant variation in their opportunity costs and suggests that the compensation amount should be reevaluated or renegotiated in light of this information.

Market actors and the facilitating NGO would have to decide if the benefits and increase in cost effectiveness of differentiated compensations would outweigh the political implications[8] and higher transaction costs associated with further differentiation. Compensation differentiation for the type of land cover already occurs in the current PES and introduction of this tiered payment system could offer lessons of how to introduce further differentiation. Unlike the tiered payments due to land cover that is readily observable[9], the opportunity cost map is a modeling exercise, not observable by PES participants. If the variation in opportunity cost map was used to determine payments, it could mean actually retracting payments. Beyond avoiding political malfeasance, it is likely that important reputation and trust building benefits are incurred from offering even token payments. It should also be considered that there are probably a number of reasons why a landholder may not enroll land besides the amount of the compensation: disregard for outside NGO, preferences for cash payments.

For those landowners whose modeled opportunity costs were not met, it is possible that given parcels of land were not under serious potential to be deforested, especially if the farmer does not have the capacity (labor and capital) to do so (Robertson and Wunder, 2008, p. 48). It has been observed by this researcher and suggested in the literature that

[8] Most likely highly negative political implications. Compensating landowners for forest conservation on private land has already caused tension between land owning and landless inhabitants. Introducing differentiation in payment has the potential to create tension among compensated landowners.

[9] It was apparent to this researcher that the tiered compensation for different land covers was not well understood (nor well received for obvious financial reasons) by the PES participants during a focus group held in Santa Rosa de Lima in July 2008.

other benefits from participation in a PES are present: strengthening of property rights, capacity building, reputation building and improvement in social organization (Porras et al., 2008, p. 81-83). Because landowners are currently requesting barbed wire as compensation for new and continuing contracts, it suggests that landowners are trying to secure stronger property rights. Increased community organization was observed and the apiculture society in Santa Rosa was working to create a co-operative and training center in the town. Qualitative observations by the researcher suggest that those participating in the PES are proud to be contributing to conservation of the environment and enjoy the reputation as an environmental steward.

The strong threat from landless immigrants should be considered when evaluating the PES in Los Negros. Although the areas furthest away from towns upstream in the watershed carry lower opportunity costs, they also have the weakest tenure claims and could be most vulnerable to illegal land claims, deforestation and cultivation by landless migrants. In this respect, reinforcing property rights and offering barbed wire as compensation in the PES could be useful to deterring the threat to the forests poised by landless immigrants that is not captured in the economic model.

As Robin Naidoo pointed out in his 2006 opportunity cost study in Paraguay, modeling opportunity costs requires high quality data and a deep understanding of agricultural practices and land use change of the study region to accurately model economic behavior. This should be considered when interpreting and modeling an opportunity cost map. The methodology employed in this report is potentially replicable in other watersheds where

GIS data is available and the capacity to do socioeconomic surveys exists. It is highly recommended that the opportunity cost map be updated at regular intervals[10] to reflect current prices and annual net returns for farms before being used in a policy or a negotiation arena. As Naidoo's comments suggest, qualitative data should be highly valued and complementary to empirical analyses.

Lastly, forest conservation may be achieved by alternatively incentivizing agricultural intensification upstream. Modeling indicates that increased farm size is negatively correlated with annual net returns. Assuming labor and capital supply does not increase significantly in the future, using payments to incentivize intensification may be a simple way to protect forests by decreasing the necessary surface area for cultivation and subsequently area that needs to be deforested.

As of now, the economic modeling performed in this report indicates that many of the plots of land being enrolled in the PES carry little additionality; they were unlikely to be deforested anyway because they carry US $0 opportunity costs. Yet those areas that are most in endanger of deforestation are being severely under-compensated, and the payment in the PES does not meet the opportunity costs of a little under 25% of the areas in conservation by several magnitudes. The US $3 per hectare per year compensation rate is far below the mean of the areas of cloud forest and parcels enrolled in conservation.

[10] Ideally, a map would be updated annually, but minimally every 2-3 years.

CONCLUSION

Geospatial econometric modeling predicted significant variation in land opportunity cost to forest conservation in the Los Negros watershed. Higher opportunity costs were observed downstream where agriculture is more intensive and accessibility to roads and markets is greater. Parcels of land in current in conservation carried the lowest opportunity cost, a significant portion US$0 per hectare per year. Size of farm, aspect, elevation, distance to road, rates of erosion and four biophysical variables: annual canopy interception, annual precipitation, annual humidity deficit and annual evapo-transpiration had significant explanatory power in predicting opportunity costs. These results imply that the potential for more cost effectiveness in the implementation of this market mechanism could be achieved through differentiation in conservation compensation. Yet differentiation of the compensation also carries political and transaction costs that could negate any benefits.

Modeling opportunity costs is a technical process that could benefit from more stakeholder participation in the mapping process. An evaluation of the qualitative benefits and social capital gained from participation in the PES should be fully reviewed. Opportunity costs require context and knowledge of the agriculture, land use, and social norms in the region to be interpreted. The current PES scheme should investigate incorporating new elements of sustainable development that increase the productivity of farming activity upstream and should also be compared to alternative conservation strategies such as command and control.

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***APPENDIX 1*:**

Survey Instrument
(Original Version in Spanish available upon request.)

Survey No. _____

Introduction: Good morning, my name is…. I am performing a survey of the inhabitants of this sector of Santa Rosa (Palmasola, Silvingul, etc.). This survey is part of a study looking to evaluate the compensations of the conservation program of this municipality. The Fundacion Natura is behind the evaluation of this project. With your responses they wish to learn about the variety of agriculture activities and livestock of each property and the conditions of production.

It is necessary to make it clear that the information collected from this survey will be treated under complete confidentiality, that is to say, your name will not be given and the information you give will not be associated with your name. Your participation is completely voluntary. You don't have to answer questions that you do not want to. It will take between 20 and 30 minutes of your time to complete. Do you wish to collaborate with me and begin with the first question?

CHAPTER 1: IDENTIFICATION

1.1.How many years have you lived in Santa Rosa (Palmasola, etc.)?

1.2.How many people are there in your home?

1.2a.How many of these people work on the farm?

CHAPTER 2: CHARACTERISTICS OF THE FARM

2.1.What is the total area of your property? ____ ha / other (specify ________)

2.2. How many hectares are cultivated now? ____ ha / other (specify ________)

2.3.How many hectares are currently fallow? ______ ha/other [This does not include forested areas.]

2.4.From what year have your worked on this farm?

2.5.How do you describe or qualify the land you use?
(You can circle more then one)

1. Your Property
2. Renting or leasing
3. Land within your possession
4. Other (specify) ________

2.6. If you were to sell this property, how much would it be worth? [Specify if the land is irrigated or temporal]

2.7. If you are renting land, how much do you pay to rent it?
[Specify if the land is irrigated or temporal]

2.8. Do you have rented any area of your farm to third parties for agriculture or livestock production? (includes renting fields for pasture) YES or NO

- If they answer no to question 2.8, skip to question 2.11 –

2.9.What area of your farm do you have rented or leased to third parties?
ha / % / other (specify) __________ / don't know

2.10.For what amount of money and how much time do you rent this land?
$ ____ per ______ week / month / year

2.11.How much time to reach the village from your farm?
_____ minutes - on foot / on a moto / car / other (specify) __________

2.12.How many hours do you work in the field each week? ______ hours

2.13.Please, we are going to construct a sketch of your farm where you can identify the different uses. (Hand them a piece of paper to draw the sketch).

Read one by one the following items to sketch: - crops - pasture - natural forest - fallow areas - land not suitable for agricultural production - routes - home.

CHAPTER 3: CROPS

In relation to the crops you have on your property, please answer the following questions.

3.1.During the last year, what crops did you have on your farm? (include crops for pasture and fruit gardens)

Answer questions 3.2 through 3.22 for each crop listed in 3.1.

3.2.What is the area this crop occupies? ____ ha / other ______

3.3.How many harvests of ________ did you collect in the last year?

3.4.What was the quantity that you obtained during the last harvest? ___ lb / kg / other __

3.5.How much did you use for your animals? ____ lb / kg / other _____

3.5a.How much did you consume in your home? ____ lb / kg / other _____

3.6.How much did you sell? ____ lb / kg / other _____

3.7.Where did you sell it?

3.8.At what price did you sell it? $ ____ / lb / kg / other ____

3.10.During the last year, how was the harvest compared to a normal harvest?
– better / same / worst -

3.11.During the last year, how many months was this crop under irrigation?

3.12.During the last harvest, what quantity of fertilizers did you apply to this crop?
- gal / kg / other ____

3.13.During the last harvest, what price did you pay for fertilizer? $ ____

3.14.During the last harvest, what quantity of agricultural chemicals did you apply to this crop? (includes pesticides, insecticides) - gal / kg / other _____

3.15.During the last year, how much did you spend on agricultural chemicals? $ ____

3.16.How much did you spend on seeds for this crop during the last harvest? $ _____

3.17.How did you spend on the preparation of the land for this crop? $ _____

3.18.During the last harvest, how many day laborers did you contract to work exclusively with this crop? *(For example, for the laborers for the preparation of the land, planting, application of agricultural chemicals, harvest.)*

3.19.What was the average pay in pesos for day laborer during the last harvest? $ _____

3.20.Did said pay include food? YES / NO

3.21.During the last harvest, did you rent machinery for this crop? YES / NO

3.22.If yes, how much did you pay to rent this machinery? $ ______

3.23 Changes in the land use and crop rotation on your farm. (For each crop/use, ask the following questions; you can refer to the sketch.)

A. For how long has the lot had this current use?
B. What was the previous land use of this lot?
C. For how long was this lot, under this land use?
D. What will be the future use of this lot?

CHAPTER 4: LIVESTOCK ACTIVITIES

4.1.During the last year, which animals did you have?

A - Cows/Bulls for Meat *(includes animals of all ages from calf until adult cow/bull)*
B - Cows for Milk *(includes animals of all ages from calf until adult cow)*
C - Chickens
D – Roosters
E – Pigs
F - Others (specify) _______________
G – None

For each of the following animals that the landowner may possess, ask questions 4.2 – 4.8: baby bulls, calves, cows, bulls, chickens, pigs, other _______ .

4.2.How many did you have a year ago?

4.3.How many did you buy?

4.4.At what price did you buy them? $ ______

4.5.How many did you sell?

4.6.At what price did you sell them? $ _______

4.7.How many do you have today?

4.8.What is the price of these animals today? $ _______ per head / total

About the site where you keep your animals to graze.

4.9.What area of property do you use to graze your livestock? ____ ha / other ____

4.10.Are they in closed areas, open field or both?

4.11.Does your livestock graze only on your property? YES / NO

4.11a.If you use open areas, what is the area your livestock utilizes? Ha / other _____

4.12.During the dry season, do you use the forests to graze your animals? YES / NO

4.13.If you use the forests for pasture, how many animals die in the forest each year?

4.14.If you graze your animals on another person's property, what type of agreement is it? - renting / none / other _______ -

4.15.For what area of pasture is the agreement?

4.16.How many ____ is this area?   _____ ha / other _____

4.17.For how long do you have them in this other property?

4.18.How much do you pay to graze them there?

About the expenses for the maintenance of your animals. Answer question 4.19 – 4.23 for the following animals: livestock, chickens, pigs, and other ________.

4.19.During the last year, how much did you spend on vaccinations and medicines for your _____? $ _____

4.20.During the last year, how much did you spend in food concentrate, supplements, and other nutrients for your ____? $ _____

4.21.How many day laborers did you contract during the last year for the cleaning of the land your animals occupied?

4.22.What was the average pay in pesos for a day laborer during the last year? $ _____

4.23.Did said wage include food?   YES / NO

Products derived from Animals

4.24.During the last year, what products derived from animals were produced on your farm? *(Examples: cheese, milk, eggs)*

4.25.During the last month, what quantity of ___ was produced on your property?
_____ lt / lb / other _____
_____ per day / per week / other time _______

4.26. At what price did you sell _____? $ ______ lt / lb / other ______

CHAPTER 5: USE OF NATURAL RESOURCES

Answer questions 5.1 – 5.3 for each of the following resources: Firewood or charcoal for domestic consumption, Wood, Food items for domestic consumption, Fodder, Plants and Other _____ (specify)

5.1.During the last year, did you extract ____ from natural areas?   YES / NO

5.2. How much ____ did you extract? ____ kg / other _____

5.3.If you were to buy or sell ____ , how much do you think it would be worth per *(read the unit previously marked)*? $ ______ / unit _______

APPENDIX 2:
Example Cash Flow Analysis [in Bolivanos]

SURVEY ID:	6		
INPUTS			
LABOR			
	Paid Labor		3600
	Unpaid Labor		3990.9375
CROPS			
	Fertilizer		1750
	Agro-Chemicals		210
	Seeds		200
	Preparation of the Land		
	Rental of Machinery		140
ANIMALS			
	Animals Bought		
	Vaccines		
	Medicines		
	Supplements		100
	Rental of Pasture		
	Crops Consumed by Animals		330
LAND			
	Rent		
TRANSPORTATION COST TO MARKET			
	Travel Cost		384.75
		TOTAL CASH OUT	10705.6875
		TOTAL CASH OUT w/o unpd labor	6714.75
OUTPUTS			
CROPS			
	Sales		9105
	Crops consumed by Animals and people		330
ANIMALS			
	Animals Sold		5628
	Change in Valuation of Animals		-110
	Milk		
	Cheese		
	Eggs		
		TOTAL CASH IN	14953
NET INCOME			**4247.3125**
NET INCOME w/o unpd labor			8238.25