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**Land Titles, Tenure Security and Resource use  
Among Small Farmers in the Brazilian Amazon**

## **Abstract<sup>1</sup>**

Policies endorsed by major institutions predict that environmental degradation can be reduced by providing farmers with secure title to the land they work. This study tested hypotheses derived from the tenure security thesis by using 261 interviews with small farmers in the Brazilian Amazon to compare the behavior of titled and untitled landholders. Ordinary least squares and logistic regressions techniques were used to test the statistical association between possession of land title and various land use decisions. The models controlled for such variables as distance to market, time in residence, as well as the social and background characteristics of the landholders. The findings show that, other things being equal, titled farmers were more likely than untitled farmers to use credit and fertilizers, and to refrain from exploiting timber. They were also more likely to purchase cattle, and to deforest at a higher rate. We conclude that, even though possession of title promotes behavior consistent with the tenure security thesis, it should not be assumed that land titles necessarily lead to positive environmental results. The results have important implications for the environmental consequences of migration and land settlement in frontier areas.

Keywords: Brazil; Amazon; property rights; land titling; deforestation; cattle ranching.

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**Among Small Farmers in the Brazilian Amazon Abstract**

**I. Introduction**

Persistent reports of continued high rates of deforestation in the Brazilian Amazon<sup>2</sup> have intensified the search for policy instruments to curb the destruction of primary forests. High on the list of attractive policy options is the idea that providing land titles to farmers will effectively reduce the rate of forest clearing, and will promote forms of economic production that are friendlier to the natural environment.

Land titling policies are conceptually derived from the more general "property rights paradigm." According to the property rights paradigm, the lack of secure land tenure means that farmers cannot be sure that they will reap the benefits of their own restraint and investment. Under such circumstances, untitled farmers are expected to prefer current consumption over long-term investments, and to mine their land and timber resources rather than engage in sustainable production strategies. If these expectations are correct, then an effective way to reduce deforestation and environmental degradation is to eliminate uncertainty by providing clear land titles and enforcing the associated property rights.

The property rights paradigm has commanded growing attention among resource economists and policy makers the world over (World Commission 1987: 129; Durning 1989; World Bank 1989:20), even though its main predictions have rarely been subjected to empirical test.<sup>3</sup> Indeed, the popularity of the property rights model stands in striking contrast to the paucity of quantitative research on the topic (Feder et al. 1988:3). The fact that environmental policies are fervently endorsed on the basis of weak empirical confirmation, implies an urgent need to determine precisely if, how, and to what extent legal owner of land actually affects small farmer performance.

This study tests the expectations derived from the property rights paradigm using interviews with 261 randomly selected small farmers located in the Brazilian Amazon.<sup>4</sup> The findings provide novel insights into the various ways in which the possession of legal title influences the investment strategies and resource use decisions that, in turn, lead to deforestation and land degradation. Given the relevance of these outcomes to critical issues such as sustainable development, biodiversity, river siltation, greenhouse gas emissions and global climate change, the results we present here have scholarly and policy implications that extend well beyond the Amazon.

## **II. Tenure Security, Investment Strategies and Resource Use: Overview**

The emphasis on land titling policies is an obvious choice for reducing land degradation in developing countries, where land tenure is frequently unclear, unspecified, disputed, or nonexistent (Wachter 1992:8). Moreover, the process of providing land titles, even though it may be burdened by inefficient bureaucracies, is eminently attractive from a public policy standpoint. The strategy relies on existing laws and agencies, and does not require the introduction of "exotic" concepts or procedures, as in the case of pollution quotas and carbon vouchers. Moreover, the provision of land titles has parallel social and political benefits by virtue of meeting the expectations of rural landholders, promoting the emergence of a disciplined land market, and quelling land conflicts that often occur in places where land claims are contested by competing groups (see Schmink and Wood 1992).

The economic theory of property rights, although quite complex in its more rigorous formulations, rests on a few simple but far-reaching propositions. Property rights refer to the rights of individuals or groups to use resources. It is not the resource itself which is owned, but rather a bundle of rights to use a resource (Alchian and Demsetz 1973:17). When the particular resource in question is land, the general notion of property rights is more narrowly defined in terms of land titles -- documents or legal notes that certify that some individual or group has property rights over a certain piece of land. To "own land" usually means to have the right to till or mine the land, to withhold it from production if the owner wishes, and to rent or sell the land to someone else (Alchian and Demsetz 1973: 17). Exclusive property rights give rise to

incentives for investing in land conservation, such as the ability to prevent reduction of future income streams, to increase future income streams, or to enhance the value of land as a capital asset. For such incentives to come into play, property rights must include transfer rights and rights to obtain income from the asset, since the value of the land can be realized only by renting or selling it (Wachter 1992:17).

Expressed in its most general form, the rationale for the property rights approach is that the insecurity caused by the lack of clear and enforced land ownership promotes the unsustainable use of resources by discouraging long-term investments (Wachter 1992). Without clear and enforced property rights, everyone is afraid others will reap the fruits of one's own restraint or investment. Restraint may take the form of postponing the harvest of high-grade timber. Investments may be made in the form of allocating labor and capital to the construction of irrigation works or land conservation measures. Economic agents who cannot be sure of receiving the benefits of their efforts do not have as strong an incentive to work and to invest compared to a situation in which the fruits of labor may be captured by others. Under conditions of uncertainty resource use and investment decisions regarding land cannot be made with the long term in mind. Planning horizons will be short term, and oriented to maximizing immediate profitability (Johnson 1972). With increases in uncertainty, investment incentives are reduced and current consumption is preferred (Feder 1987:17-18).

When the lack of secure land tenure fosters intense competition for land, such as occurs in some frontier places, there is a strong incentive to "mine" the available nutrients. Mining refers to the unsustainable extraction of nutrients through cropping, logging and ranching. This process differs from agriculture (and silviculture) because it requires that new land be constantly brought into production as nutrients are extracted. Once nutrients are depleted below a profitably extractable level, the activity must relocate to a new area. To keep a plot of land continuously productive requires the maintenance and replacement of nutrients.

Secure property rights, on the other hand, give small farmers an incentive to care for the resources at their disposal and use them in a "socially optimal" manner. If rights to property are clearly defined and fully and exclusively assigned, then users are expected to have the incentives

to maintain and invest in natural resources at their disposal (Alessi 1987:25). In such circumstances the management unit is well-defined as a single individual who can act in a unified and authoritative manner, thereby fulfilling key axioms advanced by the model (Larson and Bromley 1990). Similarly, tenure security is thought to promote longer-term investment decisions with respect to a wide range of factors. The latter include the construction of fences, the choice of crops to be planted (annuals vs. perennial) and the methods to be used (e.g., agroforestry), the use made of timber reserves, the amount of land cleared, the rate at which land is converted to pasture, as well as the investment of labor and capital in land conservation, such as the construction of terraces, windbreaks, drainage facilities, irrigation works and reforestation efforts.

Many land conservation measures thus need an investment of capital, which, in turn, requires access to credit. The lack of clear title inhibits the mortgaging of land to banks or other sources of institutional credit. By verifying the existence of an asset that can be used for collateral, a legally recognized title to land is expected to facilitate the farmer's access to cheaper, and to longer-term and more extensive credit, especially when credit is sought from lenders who do not have a personal or detailed knowledge of the borrower (Feder 1987:18).

Compelling as these arguments may be, the ability of titling initiatives to achieve environmental goals has been questioned by critics who doubt the feasibility and effectiveness of land titling projects in rural areas of developing countries. The critique presented in the next section summarizes the content of the on-going debate in the field. The review underscores the real-world contingencies that influence investment strategies and resource use in the Amazon, and calls attention to key conceptual and methodological issues relevant to the empirical analyses presented in this study.

### III. Critique

The effect of land titling on resource use may be offset by socioeconomic conditions. As with any investment, decisions to adopt land conservation measures, or to postpone the harvest of valued timber, is determined by the stream of benefits and costs, the time period over which these benefits and costs occur and the discount rate applied to them (the rate at which future costs and benefits are depreciated). In developing countries the discount rate may be particularly high due to poverty (Durning 1989: 25). Hence, if conservation measures incur net costs to the farmer at the beginning and produce net benefits only after a long time period, poor people will not be able to adopt them (Wachter 1992:19). If individuals apply sufficiently high discount rates, short time horizons and poverty-induced environmental degradation may result even if farmers have secure title to their land. This line of reasoning underpins the assertion that rural poverty is a principal driver of deforestation in the region.

Critiques of the view that private property represents a superior form of tenure vis-à-vis resource management have also been prompted by the recognition that lands in non-private property arrangements, such as common property among indigenous groups, are not automatically more likely to be degraded (Larson and Bromley 1990). Beaumont and Walker (1996) extended such reasoning to situations relevant to small farm production in tropical frontiers by addressing the alleged superiority of title lands in the presence of off-farm labor opportunities, variable discount rates, and alternative preference configurations. They found that, under certain economic conditions, untitled farmers may behave in a manner less degrading to the resource base compared to titled farmers with title. They conclude that the superiority of private property with respect to land management is an outcome that may obtain in some situations but not necessarily in all cases.

The presumed effects of land titling is entirely contingent on the assumption that the property rights associated with the possession of a formal title are recognized and enforced. Formal title signals to purchasers that the land claim is safe and that any exchange will be recognized and enforced by government (Alston, Libecap, and Schneider 1994:3). Compared to developed countries, the capacity of the state in Brazil to provide tenure security is reduced by

the limited ability to maintain an accurate land registry, and by the equally limited capacity to ensure protection from eviction, even when boundaries are properly recorded and formal titles conferred.<sup>5</sup> Both problems are severe in the Brazilian Amazon, notably in places characterized by intense and often violent conflicts over land, such as the southern half of the state of Pará (Schmink and Wood 1992).

In other regions of the Amazon – such as newly settled areas where land is cheap and plentiful, where population density is low, and where markets are poorly developed – there may be little incentive to engage in productivity-enhancing investments. Once soil fertility begins to decline, it is both possible and more rational to clear new lands than to invest in fertilizers and other land improvements. Additionally, in circumstances where land is readily available, *de facto* claims may not imply the degree of tenure insecurity found in places where there is competition for land resources and the price of land is on the rise. This observation is supported by historical analyses that show that the demand for "tenure services" occurs only with the emergence of higher land rents (Alston, Libecap, and Schneider 1994). For these reasons, an open frontier is not an appropriate site to test the tenure security hypothesis since everyone is equally secure in their land claims whether they have title or not.

The final observation concerns the relationship between tenure security and deforestation. Many analysts have noted that the absence of tenure security can promote deforestation by prompting landholders to clear the forest in order to establish claim to land, and by making it rational for farmers to mine the resources over which they have no long-term control. While these relationships have been observed in many places, especially in frontier regions (e.g., Schmink and Wood 1992), it does not follow that providing tenure security will necessarily reduce the rate of deforestation, which may actually increase. The latter is likely to occur if the provision of secure land titles – through its effect on investments, and by facilitating access to credit – leads to an increase in agricultural productivity. Unless smallholders adhere to a subsistence strategy, an increase in profitability will (other things being equal) lead farmers to expand their agricultural land use. Put another way, the increased productivity of forest-derived land also increases the opportunity cost of land, thereby promoting deforestation.

#### **IV. Site Selection, Sample Design, and Survey Instrument**

Empirical studies that seek to test hypotheses derived from the property rights framework have been hampered by a formidable methodological challenge (Feder et al. 1988 is an exception). The problem stems from the fact that farmers with and without titles systematically differ in terms of associated variables such as wealth, education and the quality of land they cultivate. Correlated attributes further include different cultural traditions and cognitive dispositions, as well as differences in ability to manipulate bureaucratic institutions. The latter are pertinent to negotiating concessions from bankers, extension agents, and people involved in the sale, transport and storage of agricultural commodities. Systematic differences of this sort introduce selectivity biases in any attempt to isolate the independent effects of titling on investments and resource use. Unless such confounding variables are controlled for, the statistical associations found between tenure security and resource use cannot be taken to imply causality.

These methodological observations have important implications for the design of this project. In order to compare the investment and resource use strategies of titled and untitled small farmers, it was essential to maximize the comparability of the two groups. In effect, we had to identify a research site where we could find two populations of small farmers -- one titled, one not -- that did not significantly differ from one another along other dimensions. Ideally, the two groups would be drawn from the same socioeconomic stratum, and would be located in geographical proximity, thereby occupying the same agroclimatic and marketing environment. Equally important to the research site was to select a place situated in a context that, in contrast to an open frontier, local markets had emerged and land values had increased, thereby providing the incentives to conserve resources and to invest in land.

The site that met most of these conditions was the Uruará colonization project, located several hundred kilometers to west of the town of Altamira, along the Transamazon Highway. The Uruará colonization project began in the mid-1970s, and is today one of the more successful small farmer settlements in the state of Pará. Using maps provided by the INCRA colonization agency, we randomly selected a total of 261 farms sites. In the summer of 1996, a team of nine

researchers spent approximately one month in the field applying the questionnaires and collecting secondary data.

### Survey instrument

The survey data collected provided information on: (a) the land manager's background characteristics (age, sex, years of school completed, place of origin, urban background, and previous experience as a land owner, length of residence on the lot); (b) the labor force available to the household (age and sex of household members); (c) land improvements (fertilizers, fences and corrals); (d) land use decisions (annual crops, perennial crops, and investments in pasture and cattle); (e) distance to the main road; (f) deforestation and reforestation efforts; (g) access to credit, and (h) the wealth status of the household.

Wealth status is a proxy measure based on the capital goods and consumer durables in the household. All respondents were initially assigned a value of 0, which served as the reference category. Then, if a household owned a gas stove or chainsaw, it was placed in the Wealth 1 category. If a household owned a television, refrigerator, generator, satellite dish, or motor cycle, it was placed in the Wealth 2 category. Finally, the household was placed in the Wealth 3 category if it possessed a car or tractor. Typically, properties in the higher order categories possessed the goods that defined the lower categories. The indicators serve as indirect measures of wealth and monetary resources, and were calculated at the time of the interview and upon arrival in the colonization project.

The key independent variable was title status, of which there are several types. In this study the variable is coded 1 (0 otherwise) if the respondent gave a positive answer to the question "Do you have a title for this lot?" As such the variable can include both definitive and provisional forms of titling.<sup>6</sup>

### Comparability of Titled and Untitled Farmers

Evidence of the comparability of titled and untitled farmers is presented in Table 1. The data show no statistically significant differences between the two groups in terms of age at the time of arrival (a proxy measure of experience in the labor force), and with respect to the number

of years of school completed by the head of household. Two additional measures of human capital – previous experience as a land owner, and previous experience in an urban place – similarly evidenced no significant differences. Equally, if not more important, is the finding that titled and untitled farmers showed no differences in terms of the wealth they possessed when they arrived in the colonization project. On the basis of these findings we conclude that farmers in Uruará were drawn from the same socio-economic background, and that the probability of possessing a title was not selective of landholders with higher levels of educational attainment, or higher levels of initial wealth.<sup>7</sup>

Table 1

In contrast to the human capital measures, we nonetheless observe statistically significant differences between titled and untitled farmers in terms of place of origin. The latter is potentially important in the analysis of investment strategies and resource use because of the somewhat unique cultural traditions of those from the northeastern Brazil, the poorest and most populous region of the country.

Similar differences were observed in terms of distance to the main road and length of residence: titled farmers are closer to the road and have been in the area a longer period of time. These two variables are themselves related to each other due to the spatial process by which lands were settled. Colonists who arrived years ago, when the project first began, claimed lots that were located on or near the road. Those who arrived later claimed lots at successively further distances, as the agricultural frontier moved outward from the Transamazon. Latecomers were thus more likely to be further from the road, except in those cases where nearer lots were acquired through purchase or exchange.

The fact that distance to the main road and length of residence in the area were associated with titling status poses potential problems for studies (like this one) that seek to determine if the possession of a land title influences investment strategies and resource use in a manner that is independent of distance and time. The problem would be fatal to the analysis if, say, all titled farmers were close to the road while all untitled farmers were distant. It would be equally fatal if all titled farmers were oldtimers while all untitled farmers were newcomers. Fortunately these

scenarios did not characterize the population of small farmers in Uruará. As noted in Table 2, both titled and untitled farmers are represented at varying distances from the main road, and within varying periods of time since arrival in the colonization site. A sufficient number of both title and untitled farmers are therefore present the various distance and time categories, thereby permitting valid comparisons.

Table 2

Two additional features of the Uruará site are pertinent to the comparability of titled and untitled landholders, each of which bolsters the appropriateness of the research site. The first concerns the size of lot. Unlike rural areas in other places – where the size of holding varies widely with such factors as wealth and family size – in the case of the colonization project the land distribution policy meant that the vast majority (84 percent) of farmers held exactly 100 hectares of land. Variations from officially prescribed minimum were relatively small, due to illegal subdivisions on the one hand, and to the acquisition of portions of neighboring lots on the other. The notable consistency in lot size meant that the land endowment was virtually constant for the majority of the respondents in the sample. The effect is to remove from the data set systematic differences that could potentially affect farmer behavior.

Finally, it is worth noting that all of the respondents in our sample were part of an official colonization project, a factor that has potentially important implications for the degree of tenure security experienced by titled and untitled farmers. Without implying that the INCRA personnel were thoroughly efficient in carrying out their mandate, the presence of federal agents in the area nonetheless meant that lots were systematically allocated to colonists, and that there were officials in the vicinity prepared to hear complaints and resolve conflicts. As a result, the level of tenure security was relatively high, even for those who did not have title to the land. In a methodological sense, circumstances such as these strongly favor the null hypothesis of no difference between titled and untitled farmers. The fact that we find differences between the two groups anyway suggests that our findings are robust.

## V. Findings

The overview of the property rights paradigm suggests 9 hypotheses that can be tested with the data set at hand. Specifically, we hypothesize that, compared to individuals without title to land, those who possess title (1) will have greater access to credit, (2) will be more likely to apply fertilizers, (3) will deforest less land, (4) will invest in perennial crops, and (5) will be more inclined to leave valuable trees standing as well as (6) engage in reforestation. Greater access to credit among titled farmers is also expected to (7) promote the purchase of cattle, and to (8) finance associated investments in pasture, fences, and corrals. Finally, (9) we predict that the possession of title will have a positive effect on long-term investments that is independent of access to credit.

### Credit, Fertilizer Use, and Deforestation

Tests of the first three hypotheses are presented in Table 3. In the first column, access to credit is the dependent variable. Because credit is dichotomous (yes=1; not=0), we use logistic regression. For each independent variable, we present both the regression coefficient and, for ease of interpretation, the odds ratio (shown in parentheses). The findings indicate that the possession of a land title has a very strong effect on the probability of obtaining credit. After controlling for other measures in the equation, titled farmers are three times more likely to have received credit compared to untitled farmers (as indicated by the odds ratio of 3.0). Other statistically significant variables are Northeast origin, wealth 3, distance from the main road and length of residence on the lot.

Table 3

The observed relationship between land title and access to credit is a significant finding for a number of reasons. The provision of rural credit – often on special terms and at subsidized rates – is one of the primary institutional mechanisms by which the state can achieve rural development goals. The effectiveness of development plans that rely on credit instruments thus depend on assumption that farmers have access to credit which, as the results here show, is greatly enhanced by the possession of formal title. The provision of titles thus plays a key role in

the state's ability to shape the incentives that affect the production and land use decisions made by small farmers.

One of the most important decisions a farmer confronts is whether to adopt the use of fertilizers. In the context of the Brazilian Amazon, the use of fertilizers is the strongest indicator of a farmer's attempt to invest in land rather than mine the natural fertility of the soil. The extent to which the use of fertilizers is a realistic expectation in the Amazon – a place that is known for its poor soils – is an issue that goes to the heart of a lively debate about the sustainability of agriculture and the future of deforestation in the region. Those who advocate the greater use of fertilizers claim that it is economically feasible, and that deforestation can be slowed by increasing the productivity of land via the use of fertilizers (e.g., Faminow 1998; Serrão and Falesi 1978). According to this line of reasoning, farmers would limit the use of additional forests if they could get more production out of the lots that they have already cleared. Others, such as Fearnside (1999) questions these arguments on the grounds that the cost of fertilizers in the region is prohibitive. Fearnside goes on to argue that there is little reason to think that the use of fertilizers to enhance soil productivity will reduce deforestation. Farmers, he contends, will continue to clear land so long as it is profitable for them to do so. Indeed, by increasing yields, and therefore profits, the use of fertilizers is likely to increase rather than reduce the quantity of land farmers deforest.

We can address key elements of this debate by using, as a dependent variable, whether or not farmers in Uruará use fertilizers (Yes=1; No=0). The findings presented in second model indicate that, other things being equal, the use of fertilizers is strongly associated with title status. Farmers who possess title to their land are 2.5 times more likely to use fertilizer, as indicated by the odds ratio corresponding to the title dummy variable. The only other variable that reaches statistical significance is distance to the main road, which shows a negative sign. As distance from the road increases, the probability of using fertilizers declines.

The next step is to introduce credit into the equation, and to test whether there is an independent effect of land title on fertilizer use once we control for access to credit. If the coefficient for the title dummy becomes statistically insignificant, we can conclude that the title

effect observed in the Fertilizer 1 equation is a relationship that operates through the farmers' access to credit, and that having a title per se does not influence land investment decisions. The findings shown in the last two rows of the Fertilizer 2 equation clearly indicate that title status remains statistically significant, even after controlling for access to credit. Net of the effects of the other variables in the equation, farmers with title are twice as likely to apply fertilizers to their land. Although the title effect is reduced somewhat (the odds ratio falls from 2.5 in the Fertilizer 1 equation, to 2.0 in Fertilizer 2), the results indicate that both access to credit and possession of a title have a strong positive effect on the likelihood that a farmer will apply fertilizers to his/her land.

The last two models presented in Table 3 explore the effects of land title and access to credit on the number of hectares that a farmer has cleared. Because the variable is measured in hectares, we switch from logistic to ordinary least squares regression. Contrary to the expectation that the higher degree of tenure security provided by the possession of a land title will lead to lower levels of deforestation, the Deforest 1 equation shows that farmers with title have deforested a greater number of hectares. On average, titled farmers have deforested 7.33 more hectares than untitled farmers, as indicated by the unstandardized regression coefficient. Adding credit to the equation does not eliminate the title effect, as noted in the Deforest 2 equation. The Deforest 2 equation further shows that access to credit substantially increases the number of hectares cleared by 10.86 hectares. Moreover, by comparing the magnitude of the standardized Betas (in parentheses), we can conclude that access to credit exerts a stronger influence on deforestation than any of the other variables in the equation (Beta of .253 is the largest value in the column).

The results in the last column of Table 3 further show that both distance to the main road and length of residence in the area show a relationship with the number of hectares cleared. Similarly, farmers in the highest wealth category (Wealth 3) have deforested a larger number of hectares. Contrary to the notion that poverty promotes deforestation, the findings from this study in Uruará shows that deforestation increases as wealth rises.

We can now return to the debate about the effects of fertilizer use on deforestation in order to address the often-cited notion that increases in the use of fertilizers, by boosting agricultural production, is one way to slow the rate of deforestation. In contrast to the Fertilizer 1 and 2 equations, where the use of fertilizers was the dependent variable, now we introduce the use of fertilizers as an independent variable to predict the number of hectares cleared. The results (not shown) indicate that the use of fertilizers exerts a positive and statistically significant effect on deforestation. Net of the effects of the other independent variables (including title status and access to credit) the use of fertilizers is associated with an increase in deforestation of 6.04 hectares. The findings are consistent with Fearnside's (1999) contention that the use of fertilizers tends to promote rather than reduce deforestation.

#### Land Title and Perennial Crops

The tenure security associated with the possession of formal title to land is expected to influence the choice of crops planted. Annual crops, such as rice and beans, can be harvested within a short period of time, and can provide sustenance to the family through direct consumption. Others, such as cacao and pepper, take an average of three years to become productive and provide sustenance to the family indirectly by selling the commodities on a market. Cacao and pepper are especially good indicators of longer time horizon investments since both commodities commanded relatively high prices in the three to five year period before the survey in 1996.<sup>8</sup>

#### Table 4

The findings presented in Table 4 offer little support for the hypothesis that the possession of a land title was associated with a greater likelihood of farmers opting for perennial crops. For both pepper and cacao, the effect of land title was not statistically significant. The coefficients for other variables, however, provide some insight into additional factors that affect land use. Access to credit was positively associated with pepper, as was the number of adults in the household. The latter was also statistically significant in the case of cacao. The association between adult members and these two crops was undoubtedly related to the fact that both cacao

and pepper are relatively labor intensive economic activities. The findings in Table 4 indicate that a consistent predictor of farmer investment in perennial crops was the supply of labor in the household rather than the possession of a land title.

#### Land Titles and Cattle Ranching

The proportion of land converted to pasture is another key indicator of land use decisions. The labor and capital that a landholder devotes to clearing forest for pasture can be considered a long time horizon investment, at least among those farmers who intend to purchase animals and to invest in the infrastructure required to raise cattle, such as building fences and corrals.<sup>9</sup> The first two equations in Table 5 indicate that both the possession of a land title and access to credit have positive and statistically significant effects on the number of hectares of pasture and the number of head of cattle on the lot. Of the two variables, access to credit has a larger effect: on average, landholders who have access to credit have 10.6 more hectares of land in pasture. Nonetheless, the continued significance of the title variable is noteworthy inasmuch as the finding is consistent with the tenure security hypothesis. Other significant predictors of both pasture and cattle are the dummy variable for Wealth 3 and distance to the main road. Related investments in fencing (measured in meters) and corrals (Yes=1; No=0) are significantly associated with credit, but not with the dummy variable for title.

Table 5

The findings in Table 5 point to a critical feature of the property rights paradigm that is rarely made explicit. When the framework is invoked to promote titling initiatives in the interest of environmental goals, only rarely is it recognized that the provision of title can have effects that are also detrimental to the environment. The observation that the possession of a formal title stimulates the conversion to pasture and the purchase of cattle is arguably a case in point. Most observers would agree that the expansion of cattle ranching in the Amazon is not a desirable environmental goal.

### Harvesting Timber and Reforestation

In contrast to the dubious environmental merits of cattle ranching, there is little doubt that slowing the rate of timber extraction and increasing investments in reforestation are among the unambiguously positive outcomes predicted by the tenure security thesis. Titled farmers, who are more certain than their untitled neighbors of their ability reap the future benefits of current restraint, are expected to harvest timber more selectively, and to reserve a larger proportion of high grade stock for later use. Similarly, titled farmers, by virtue of their longer planning horizon are more likely to engage in reforestation efforts that can take a long time to produce a profit. Both variables are particularly discriminating indicators given the vulnerability of valuable trees to poaching, and because the reforestation of species such as mahogany can take up to twenty years to mature. In other words, farmers who forgo the rapid exploitation of forest resources, and who invest their time and expectations in the eventual harvest of seedlings, are truly “banking on the future.”

Table 6

Our measure of restraint is based on an affirmative response (coded 1; 0 otherwise) to the question “Do you still have valuable trees standing on your lot?” Our measure of reforestation is also a dichotomous variable, coded 1 for those who engage in such efforts, 0 if they did not. Analyses of both variables are presented in Table 6. The possession of formal title was significantly associated with the probability of having valuable trees still standing on the lot at the time of the interview, and on the probability of investing in reforestation. The odds ratio for title status is particularly noteworthy in the second model, which shows that titled farmers are nearly fifteen times more likely than untitled farmers to reforest.

An assessment of the other variables in the equations indicates that access to credit has no effect on the probability of engaging in restraint or reforestation. The latter, however, is highly correlated with wealth status. Compared to farmers in the lowest wealth category (the reference group), those in the Wealth 1 category are 6.3 times more likely to reforest; those in the Wealth 3 category are 10.7 time more likely to reforest.

## **VI. Summary and Conclusions**

Policy initiatives endorsed by major institutions such as the World Bank predict that environmental degradation can be reduced by providing farmers with secure title to the land they work. This study tested hypotheses derived from the tenure security thesis by using the results of 261 interviews with small farmers in the Uruará colonization site, located in the Brazilian Amazon. By minimizing the selectivity bias that has limited most research on the environmental effects of property rights, the Uruará research site permitted us to compare titled and untitled farmers in terms their investment strategies and resource use decisions.

As predicted by hypotheses derived from the property rights paradigm, analyses of the independent effects of title possession showed that titled farmers were more likely to use credit, apply fertilizers, refrain from exploiting timber, and engage in reforestation (positive environmental outcomes). Other hypotheses found little empirical support, such as the anticipated investments among titled farmers in perennial crops, such as cocoa and pepper. The results further showed that titled farmers were also likely to deforest more land, establish more pasture, and purchase more cattle (negative environmental outcomes).

When the positive outcomes in terms of fertilizer use and reforestation are considered along side the negative outcomes associated with cattle ranching, the juxtaposition compels us to investigate, not only the independent effect that the possession of a title may have, but also the relative magnitudes of the associated results. Although the data required to address the relatively magnitude of the title effects are far from complete in our data set, we can nonetheless draw tentative conclusions from the findings presented.

On the one hand, we noted that, net of the effects of other variables, the possession of title was associated with a 5-hectare increase in the amount of land deforested, and a 4.2-hectare increase in the amount of land converted to pasture. These were not only large effects, but they also applied to majority of landholders in our sample: 87 percent had converted some portion of their lot to pasture. On the other hand, we have also shown that titled landholders were fifteen times more likely to engage in reforestation. In this case, however, the large effect applied to a very small number of the farmers interviewed: only 17 landholders (6.5 percent) engaged in

reforestation efforts. Taken together, these observations suggest that the relatively large effects of title on deforestation and pasture were not likely to be offset by the effects of title on reforestation.

Although the analysis of the comparative magnitude of title effects on various outcomes is more illustrative than definitive, the argument nonetheless points to a critical implication of this study. Among other things, it highlights the fact that, even though the possession of a title to land has a number of outcomes consistent with the hypotheses derived from the property rights paradigm, caution is advised before it is assumed that policies to promote the titling of land held by small farmers will in all cases lead to positive environmental results.

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Table 1

Mean Values of Selected Variables,  
by Title Status

Concept	Variable	Title No	Title Yes	Sig. of Difference
		(1)	(2)	(3)
Human capital	Age at arrival (yrs)	36	36	n.s.
	Years of school completed (yrs)	1.8	2.2	n.s.
	Previous land owner (%)	25.8	33.3	n.s.
	Previous urban residence (%)	17.2	13.7	n.s.
Wealth	Wealth index at the time of arrival	1.4	1.5	n.s.
Cultural background	Northeast origin (%)	72.0	58.9	.04
Location	Distance to road (kms.)	25.9	12.2	.01
Time	Length of residence on lot (yrs.)	7.9	13.4	.01

Source: 1996 survey.

Table 2  
 Distribution of Titled and Untitled Farmers  
 by Distance to the Main Road and Length of Residence in the Area

		Title No	Title Yes	Total
Distance to road	0 to 15 kilometers	42	137	179
	> 15 to 30 kilometers	52	46	98
	> 30 kilometers	51	19	70
	Total	145	347	347
Length of residence	0 to 5 years	27	32	59
	> 5 years to 10 years	36	29	65
	> 10 years	27	106	133
	Total	90	167	257

Source: 1996 survey.

**Table 3**

Access to Credit, Use of Fertilizers, and Deforestation,  
 Regressed on Title Status and Selected Control Variables,  
 Logistic and OLS Regression Coefficients  
 (Odds Ratios and Standardized B in Parentheses)

Independent Variables	Credit	Fertilizer 1	Fertilizer 2	Deforest 1	Deforest 2
	(Yes=1) Logistic Reg.	(Yes=1) Logistic Reg.	(Yes=1) Logistic Reg.	(Hectares) OLS Reg.	(Hectares) OLS Reg.
Years of school	-.0324 (.9682)	.0071 (1.007)	.1093 (1.020)	.255 (.026)	.365 (.037)
Previous owner of land (Yes=1)(No=ref.)	-.3909 (.9682)	.0097 (1.010)	.0449 (1.046)	1.34 (.029)	1.991* (.043)
Previous urban experience (Yes=1)(No=ref.)	.4616 (.6764)	-.0190 (.9812)	-.1091 (.8967)	6.46* (.108)	5.516* (.092)
Northeast origin (Yes=1)(No=ref.)	-.6035* (1.586)	-.1070 (.8986)	-.0403 (.9605)	1.24 (.028)	2.366 (.053)
No. of adults in household	-.0248 (.9755)	.0177 (1.018)	.0260 (1.026)	.849* (.105)	.900* (.111)
Wealth 0 (ref.)	-	-	-	-	-
Wealth 1	.4512 (1.570)	.6469 (1.910)	.5599 (1.750)	1.77 (.039)	.894 (.020)
Wealth 2	.2525 (1.287)	.4500 (1.568)	.3988 (1.490)	-1.52 (-.033)	-2.114 (-.045)
Wealth 3	-.9407* (.3904)	.3821 (1.465)	.5438 (1.723)	11.04* (.158)	12.61* (.180)
Distance from road	-.0722* (.9303)	-.0424* (.9585)	-.0308* (.9695)	-.379* (-.277)	-.262* (-.191)
Length of residence on lot	.0821* (.9303)	.0354 (.9585)	.0216 (.9695)	.748* (.9303)	.582* (.9303)

		(1.086)	(1.036)	(1.022)	(.232)	(.180)
Title (Yes=1)(No=ref.)	status	1.0985* (3.000)	.9346* (2.546)	.7065* (2.027)	7.33* (.169)	5.026* (.116)
Credit (Yes=1)(No=ref.)		-	-	1.017* (2.765)	-	10.86* (.253)
Constant		.2699	-.9776	-1.082	23.611	18.393
-2 Log likelihood		303.4	283.9	275.3		
R Square					.349	.389

Source: 1996 survey.

\* statistical significance  $\leq .05$ , two-tailed test.

Table 4  
 Plantings of Cacao and Pepper Regressed on  
 Title Status and Selected Control Variables,  
 OLS Regression Coefficients  
 (Standardized B in Parentheses)

Independent Variables	Pepper (Log of No. of Stalks)	Cacao (Log of No. of Trees)
Years of school	.006 (.040)	-.110 (-.061)
Previous owner of land (Yes=1)(No=ref.)	-.004 (-.001)	.196 (.023)
Previous urban experience (Yes=1)(No=ref.)	-.680 (-.067)	.578 (.053)
Northeast origin (Yes=1)(No=ref.)	.606 (.081)	.490 (.061)
No. of adults in household	.156* (.114)	.274* (.186)
Wealth 0 (ref.)	-	-
Wealth 1	1.344* (.175)	-.002 (-.002)
Wealth 2	.325 (.041)	-1.063* (-.126)
Wealth 3	-5.87 (-.050)	-.517 (-.041)
Distance from road	-.001 (.056)	-.004* (-.165)

Length of residence on lot	-.004 (.072)	.129* (.219)
Title status (Yes=1)(No=ref.)	-.265 (-.036)	.527 (.067)
Credit (Yes=1)(No=ref.)	1.924* (.265)	-.450 (-.058)
<hr/>		
Constant	.799*	.892*
R Square	.143	.149
<hr/>		

Source: 1996 survey.

\* statistical significance  $\leq .05$ , two-tailed test.

Table 5  
Cattle Ranching Variables  
Regressed on Title Status and Selected Control Variables,  
Logistic and OLS Regression Coefficients  
(Odds Ratios and Standardized B in Parentheses)

Independent Variables	Pasture (Hectares)	Cattle (Log of Head)	Fencing (Log Meters)	Corral (Yes=1)
	OLS Reg.	OLS Reg.	OLS	Logistic Reg.
Years of school	.314 (.039)	-.005 (-.060)	-.001 (.009)	.0967 (1.102)
Previous owner of land (Yes=1)(No=ref.)	2.039 (.053)	.230 (.064)	.111 (.015)	.2378 (1.268)
Previous urban experience (Yes=1)(No=ref.)	2.148 (.044)	.227 (.049)	.457 (.047)	.4620 (1.587)
Northeast origin (Yes=1)(No=ref.)	.165 (.005)	-.147 (-.043)	-.418 (-.058)	-.0394 (.9613)
No. of adults in household	.362 (.054)	.006* (.093)	.010 (.074)	-.0066 (.9934)
Wealth 0 (ref.)	-	.		-
Wealth 1	2.156 (.058)	.137 (.039)	-.0003 (-.001)	.2285 (1.257)
Wealth 2	2.594 (.068)	.169 (.047)	-.226 (-.030)	.4268 (1.532)
Wealth 3	11.097* (.193)	.511* (.094)	.429 (.038)	.5650 (1.760)
Distance from road	-.117* (-.104)	-.008* (-.172)	-.006* (-.255)	.0049 (1.032)
Length of residence on lot	-.008	-.0003	.004	.0314

		(.033)	(-.011)	(.070)	(1.610)
Title (Yes=1)(No=ref.)	status	4.213* (.118)	.350* (.104)	.492 (.070)	.4763 (1.610)
Credit (Yes=1)(No=ref.)		10.607* (.300)	1.458* (.438)	2.475* (.355)	1.436* (4.205)
<hr/>					
Constant		10.393*	1.020*	3.953*	-1.038*
R Square		.246	.398	.370	
-2 Log Likelihood					344.18
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Source: 1996 survey.

\* statistical significance  $\leq .05$ , two-tailed test.

Table 6  
 Logging and Reforestation Regressed on  
 Title Status and Selected Control Variables  
 Logistic Regression Coefficients  
 (Odds Ratios in Parentheses)

Independent Variables	Valuable Trees Left Standing (Yes=1)	Engage in Reforestation (Yes=1)
Years of school	.0225 1.027	.0713 (1.074)
Previous owner of land (Yes=1)(No=ref.)	.3042 (1.356)	-.5224 (.5931)
Previous urban experience (Yes=1)(No=ref.)	-.8686* (.4196)	-.0205 (.9797)
Northeast origin (Yes=1)(No=ref.)	-.1089 (.8968)	-.2897 (.7485)
No. of adults in household	.0344 (1.035)	-.0198 (.9804)
Wealth 0 (ref.)	-	-
Wealth 1	-.0792 (.9239)	1.843* (6.321)
Wealth 2	.3921 (1.480)	1.2920 (3.639)
Wealth 3	.1275 (1.136)	2.369* (10.688)
Distance from road	-.0253* (.9750)	.0456* (1.0466)

Length of residence on lot	-0.0449 (.9561)	.1230* (1.1309)
Title status (Yes=1)(No=ref.)	.6875* (1.989)	2.704* (14.945)
Credit (Yes=1)(No=ref.)	.1812 (1.199)	-.0416 (.9592)
<hr/>		
Constant	2.746*	-4.7168*
-2 Log Likelihood	248.54	108.52
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Source: 1996 survey.

\* statistical significance  $\leq .05$ , two-tailed test.

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<sup>2</sup>Yearly estimates of deforestation in the Brazilian Amazon can be found on the Website maintained by Brazil's Instituto Nacional de Pesquisas Espaciais (INPE): [www.inpe.br/amz-01.htm](http://www.inpe.br/amz-01.htm).

<sup>3</sup>A notable exception is Feder et al. (1988).

<sup>4</sup>The data set represents an important contribution to environmental research in the Amazon, where relatively little farm-level research has been done, presumably due to budgetary constraints and the "difficulty of encouraging scientists to work in the field" (World Bank 1992: 55).

<sup>5</sup>The threat to private rural properties has increased in recent years in Brazil with the rise of the Landless Movement (*Movimento Sem Terra*) and the nationwide mobilization of rural workers who engage in organized invasions as a means to forcibly acquire land, and to protest the high degree of land concentration in the country.

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<sup>6</sup>A common practice in the Brazilian Amazon is for individuals to pay taxes on land that they do not own in the hopes that the tax receipt alone will legitimize their claim. We did not include the possession of a tax receipt in our definition.

<sup>7</sup>These conclusions were confirmed by a multivariate approach (not shown). When the indicators of human capital and initial wealth were regressed on title status (treated as a dichotomous dependent variable) using logistic regression, none of the variables reached statistical significance.

<sup>8</sup>In 1996 both cacao and pepper fields in Uruará were suffering from blights that caused a great deal of hardship for farmers in the area. This contingency does not affect our findings because we recorded the cumulative investments that farmers had made in the two crops in previous years.

<sup>9</sup>On the other hand, with the price of forested land typically 30 to 60 percent that of pasture, landholders, using only household labor, can make a reasonable return by simply clearing the forest and then selling the “improved” land. This practice is quite common, especially among poor landholders who have no resources to invest in the purchase of cattle, and in areas where turnover rates are very high. Similarly, landholders in the Amazon often clear forest not to engage in cattle ranching but, instead, as a means of establishing a claim to land. Compared to such places, the turnover rate in Uruará is relatively low, and most landholders who establish pastures also engaged in cattle ranching (the correlation between the number of hectares in pasture and the number of cattle is .64). Moreover, the need to establish a claim by clearing land is not relevant in a managed colonization site, such as Uruará, where land parcels are distributed in 100 hectare lots.