

# **Research Proposal**

## **Tenure Security and Resource Use in the Amazon**

**Charles H. Wood, PI**

### Project Summary

The goal of this study is to carry out a survey of titled and untitled small farmers in the Brazilian Amazon in order to test hypotheses derived from the property rights paradigm. According to the property rights perspective, the lack of secure land tenure means that farmers cannot be sure that they will reap the benefits of their own restraint and investment. Accordingly, 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. To test these hypotheses, the study focuses on the southern region of the state of Pará, a place where the federal government began, but did not complete, a process of distributing land titles to small farmers. As a result, numerous communities in the region contain virtually identical populations of titled and untitled producers who cultivate plots in the same geophysical and socioeconomic environment. A comparison of the two groups in the proposed site therefore circumvents the selectivity problem that has hampered research to date.

A team of ten interviewers will be hired and trained to administer a detailed questionnaire to a random sample of 200 titled and 200 untitled small farmers during the summer, 1996. Data will be collected on numerous dependent variables including indicators of land improvement, the use of land and timber reserves, the choice of crops and related production decisions, as well as associated measures of resource stewardship and access to credit. The geographic coordinates of each farm site will be established using a geopositioning recorder (GPS device) and entered into a geographic information system (GIS). The GIS will include additional georeferenced data on roads, towns and waterways. Land tenure security will be objectively measured by possession of a legal title to land (or equivalent), as well as subjectively measured by the respondents' perception of secure claim. Multivariate statistical techniques will be used to control for such variables as plot size, soil quality, household composition, and length of residence. Spatial econometric techniques will be used, when appropriate, to correct for any identified sources of spatial autocorrelation. To understand the institutional reasons that land titles matter (or not), additional in-depth interviews will be carried out among key informants in extension agencies, banks and credit institutions, and individuals involved in the transportation, storage, and marketing of agricultural commodities.

Because privatization is widely endorsed as the solution to environmental degradation, it is essential to know precisely if, how, and to what extent legal ownership and the perception of tenure security affect small farmer behavior. Understanding the factors that motivate the notoriously destructive land use patterns witnessed in much of the Brazilian Amazon is especially significant in light of the relationship between farmers' behavior and deforestation, sustainable development, biodiversity, and climate change. Research that rigorously tests the independent effect of tenure security on resource use thus has scholarly and policy applications that extend well beyond the Amazon.

# Tenure Security and Resource Use in the Amazon

## Project Description

### A. Statement of the Problem

The property rights paradigm has commanded growing attention among resource economists and policy makers concerned about the deforestation and environmental degradation in the Amazon. According to the property rights perspective, the lack of secure tenure means that farmers cannot be sure that they will reap the benefits of their own restraint and investment. Untitled farmers therefore prefer current consumption over long-term investments, and tend to mine their land and timber resources rather than engage in sustainable production strategies.

The presumed behavioral outcomes of tenure security, and the relative ease with which titles can be provided has prompted policy makers to endorse land titling as a priority means to achieve environmental goals. Yet despite its intellectual currency and its policy appeal, few studies have empirically tested the tenure security thesis because of an intractable methodological limitation. In most real-world situations it has been impossible to separate the independent tenure effect because farmers with and without title nearly always differ in terms of other variables such as income, education, and the quality of the land they hold. Fortunately the selectivity bias is largely circumvented in the Brazilian state of Pará. Because the government began, but did not complete, a process of distributing land titles to small farmers in the state, there are places where titled and untitled small farmers have virtually the same background characteristics, and cultivate lands in the same geophysical and socioeconomic environment. The history of land settlement in southern Pará thus presents the unique opportunity to construct a quasi-experimental design to test the hypotheses derived from the property rights paradigm. To do so, a detailed questionnaire will be administered to a random sample of 200 titled and 200 untitled small farmers in a carefully selected site. To understand the institutional reasons that land titles matter (or not), in-depth interviews will be also carried out among key informants in extension agencies, banks and credit institutions, and individuals involved in the transportation, storage, and marketing of agricultural commodities.

The focus on property rights in this study is justified by the revival of interest in land titling for the purpose of achieving environmental goals (World Commission 1987: 129; Durning 1989; World Bank 1989:20). While the perspective can be applied to many environmental issues -- for example, the establishment of property rights through air pollution quotas -- the property rights approach is an obvious choice for analyzing 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 because it is an instrument that relies on existing laws and agencies, and does not require the introduction of "exotic" concepts, as in the case of pollution quotas.

Although it is widely accepted that secure land ownership is conducive to access to credit and to the maintenance and conservation of land, little is known about the magnitude of the effects involved. Indeed, there is a striking paucity of rigorous quantitative research on the topic, which seriously hampers the design and evaluation of public policy (Feder et al. 1988: 3). The problem is especially evident in the case of the Amazon where relatively little farm level research has been done, presumably because of budgetary constraints and the

"difficulty of encouraging scientists to work in the field in the Amazon" (World Bank 1992: 55). Finally, a better understanding of the factors that motivate the destructive land use patterns witnessed in the Brazilian Amazon is significant in light of the relevance of land degradation and deforestation to such broader issues as sustainable development, biodiversity, river siltation, greenhouse gas emissions and local climate change. For these reasons there is an urgent need to determine precisely if, how, and to what extent legal ownership and the subjective perception of tenure security affect small farmer performance on lands brought into agricultural production in the Brazilian Amazon.

## **B. Background: Land Settlement in the Brazilian Amazon**

Few topics have captured the world's attention with greater urgency than has the rapid deforestation that has taken place in the Brazilian Amazon in recent years (Map 1). The development policies that stimulated the northward migration of small farmers, ranchers and gold miners have been the topic of numerous studies of the region (Bunker 1985; Fearnside 1986; Foweraker 1981; Moran 1981; Smith 1982). The incentives to populate and exploit Amazonia began in the late 1960s when the federal government, then in the hands of a security-conscious military regime, provided tax and credit incentives to private firms willing to invest in the region. These initiatives were followed in the early 1970s with an ambitious public colonization project and an extensive road building program, including the construction of the Transamazon Highway that extends some 5,000 kilometers across the Amazon basin from the state of Pará in the east, nearly to Brazil's border with Peru and Bolivia in the west. Many of the small farmers and landless poor who migrated to the Amazon were people who came from central and southern Brazil where they had been displaced by the mechanization of agricultural production, and the switch from labor-intensive coffee plantations to labor-saving soy bean cultivation (Wood and Carvalho 1988).

The euphoria associated with the "conquest of Amazonia" in the early 1970s soon gave way to a more sober appreciation of the difficulties entailed in agricultural projects in lowland tropical areas. Colonists settled by the Institute of Colonization and Agrarian Reform (INCRA) in Marabá, Altamira and Itaituba faced numerous problems, especially getting crops to market. The colonization projects nonetheless continued to attract migrants from all parts of Brazil who arrived in Pará in numbers that far exceeded INCRA's capacity in the planned communities. With few alternatives available, small farmers staked out whatever land was accessible, laboring under the mistaken assumption that state lands not being cultivated were theirs for the taking. In the meantime, well-financed investors, mostly from central and southern Brazil, took advantage of profitable tax and credit programs offered through the Superintendency for the Development of the Amazon (SUDAM). They converted huge tracts of land to pasture, or bought land to hold in investment portfolios as a hedge against future inflation. Violence became commonplace when cattle ranchers, land speculators and peasant farmers competed for control of the newly accessible territories (Schmink and Wood 1992).

### Rural Violence and the Crisis Colonization Policy

Because normal bureaucratic procedures failed to resolve the underlying causes of land conflicts, mounting social tensions led to intervention by National Security agencies. Soon after General Figueiredo assumed the presidency in 1979, he asked the National Security Council to study the necessary measures to deal with the escalating violence in the areas lying along the Araguaia and Tocantins rivers in southern Pará. On the Council's recommendation, in February of 1980 Figueiredo established a new agency called the Executive Group for Araguaia-Tocantins Lands (GETAT). GETAT took over INCRA's

personnel and resources, but answered directly to the president and the National Security Council, bypassing the INCRA hierarchy. GETAT's efforts amounted to a kind of "crisis colonization" policy designed to defuse localized tensions and build grass-roots political support for the government (Schmink and Wood 1992).

GETAT commanded far more political and economic power and benefited from a greater degree of bureaucratic autonomy than did any of the land agencies that came before it. Topographic services were provided by the army and by private firms contracted for the task. GETAT relied on these services to demarcate large areas 300,000 to 400,000 hectares in size that were called *glebas*. The *glebas* were surveyed and divided into individual plots to be handed over to small farmers. To distribute land efficiently, the GETAT high command, with its direct connections to the National Security Council, eliminated much of the red tape that had crippled the effectiveness of other agencies. It can hardly be said that GETAT resolved the land problem in southern Pará, yet the act of handing out thousands of legal titles to landless migrants created numerous farming communities (*colonias*). The manner in which these titles were dispensed is particularly relevant to the design of this study.



The effect of these development policies set in motion a land rush of unprecedented proportions. The extent of the changes provoked by road-building, colonization, and fiscal incentive policies is reflected in a number of statistics. Estimates of the magnitude of the migration flow into the region indicate that the number of net migrants between 1970 and 1980 was around 457,000. The number of net migrants rose to 631,000 between 1980 and 1991 (Wood 1993). The influx of people was associated with the deforestation of large tracts of land, mostly in Rondônia and Pará. Skole and Tucker (1993) used Landsat Thematic Mapper data and a vector-based GIS to map deforestation in the entire Amazon region of Brazil. The results indicated that the size of deforested areas rose from 78,268 km<sup>2</sup> in 1978 to 230,324 km<sup>2</sup> in 1988. These figures implied an annual average rate of deforestation of 15,000 km<sup>2</sup> per year during the period. The largest amount of deforestation in both years occurred in Pará (30,449 km<sup>2</sup> and 95,075, respectively).

Much of the deforestation that took place in the Amazon was carried out by middle and large-scale ranchers who converted the forest cover to pasture, often with the support of fiscal incentives from SUDAM (Fearnside 1987). Yet small farmers were also implicated in the process, as evidenced by the typical cycle of land use. Small farmers commonly clear 2 to 3 hectares of land which they then cultivate for as long as soil fertility remains high. In most areas soil fertility is depleted in 2 to 3 years, requiring the clearing of more land. Since there are approximately 500,000 small farmers in the region, these figures imply a demand for an additional 500,000 hectares of cleared land per year (Homma 1992:9).

Crude as these estimates may be, they nonetheless point to the magnitude of the existing internal demand for new land clearing, even in the unlikely event that the migration of small farmers to Amazonia were to stop altogether. If ranchers have been responsible for the deforestation of vast areas, the cumulative effect of land clearing in small parcels remains a significant problem. The conservation of agricultural land is central, not only to the well-being of the population of small farmers involved but also to the preservation of other natural resources. Valuable or fragile ecosystems that should not be developed because of their biodiversity or vulnerability stand a better chance of being preserved if sustainable systems of production are achieved in areas already brought under cultivation (Southgate 1991).

The role that small farmers play in newly settled areas of the Amazon calls attention to the need to better understand the incentives and disincentives that motivate the patterns of resource use commonly found in the region. While recognizing the extraordinary complexity of the factors that promote deforestation and land degradation in Amazonia as a whole, this study narrows the analytical focus to the effects of land tenure security on the resource use strategies and the productive activities performed by small farmers. A review of the property rights literature identifies specific hypotheses regarding the relationship between land tenure and resource use.

### **C. Tenure Security and Resource Use: Overview**

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, or a portion 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 as they would have in a situation in which all externalities are internalized. Under these conditions 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 land tenure is insecure, and when there is intense competition for land such as occurs in a frontier situation, there is also 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. Many land conservation measures thus need capital input 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.

Secure property rights, on the other hand, will 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 as key to non-depleting use of natural resources (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 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, and irrigation works. Secure legal ownership, moreover, is expected to facilitate the farmer's access to cheaper, 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).

#### **D. Tenure Security and Resource Use: Critique**

The predicted effect of land titling on resource use may be offset by socioeconomic conditions, however. 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). 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.

Critiques of the view that private property represents a superior form of tenure vis-a-vis resource management have also arisen with 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 (forthcoming) extended such reasoning to situations relevant to small farm production in tropical frontiers by addressing the alleged superiority of title lands given 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 is not a theoretical necessity.

For the most part, property rights explanations of land degradation have been highly abstract. They are generally based on conceptual models that neither incorporate nor anticipate the complexity of tenure security in developing countries (Wachter 1992: 3). Empirical studies, for their part, have been hampered by an intractable 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 other critical variables such as income, education and the quality of land they cultivate. Correlated attributes further include different cognitive dispositions, particularly regarding planning horizons, as well as differences in the quality of their respective bureaucratic skills. The latter are pertinent to farm management and to the process of 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 land use. If all titled farmers are educated and cultivate fertile soils while all untitled farmers are uneducated and cultivate hillsides, there is no point in comparing the two groups. Unless such confounding variables are controlled for, the statistical associations found between ownership and land conservation cannot be taken to imply causality.

## **E. Site Selection and Sample Design**

The methodological observations noted above 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 is essential to maximize the comparability of the two groups. In effect, we must identify a research site where we can find two populations of small farmers -- one titled, one not -- who do not significantly differ from one another along other dimensions. Ideally, they must be drawn from the same socioeconomic stratum, and

they must operate in geographical proximity to one another in a similar agroclimatic and marketing environment.

Fortunately, particular areas in the state of Pará provide such an opportunity. As a result of the crisis colonization policy adopted by GETAT during the early 1980s, it is possible to find agricultural areas in the region where titled and untitled small farmers are drawn from the ranks of the same socioeconomic class, who have been present in the region approximately the same length of time, and who cultivate plots in similar geophysical environments. The latter is important because land quality is a primary determinant of the farmer's scale of operation and production potential. Since land of higher quality increases the value of the land and the marginal productivity of inputs, it is necessary to control for this variable. Using maps produced by the Ministerio das Minas e Energia, Departamento Nacional da Produção Mineral, as well as information garnered from local extension workers and other knowledgeable informants, care will be taken to ensure that the two sampled communities do not significantly differ in terms of soil quality.

Equally important to the research site is to select a place situated in a context that provides the incentives to conserve resources and to invest in land. Newly settled areas, for example, do not generally meet these conditions because land values are low and distances to market are great. In such circumstances it may be cheaper for small farmers, regardless of their tenure status, to move to new land rather than purchase fertilizers or carry out other investments in the maintenance of soil fertility. A frontier area may also be an unsuitable site because of the confounding effects introduced by the fact that, in such places, untitled farmers often invest in land as a means to establish their claim to land rather than for productive purposes. This phenomenon is evidenced by historical analyses of property rights and land rents that found that, once the economic frontier moved past a particular area, the effect of property rights on investments rapidly improved (Aston, Libecap and Schneider 1994). Hence, we will select a research site where local markets have emerged and land values have increased. We can find evidence of the former in the character of commodity markets, and evidence of the latter in the ratio of local land values to the average land values for the state (published by EMATER).

The selection of the specific site, and the design of the sample selection procedures, is greatly facilitated by the maps produced by the Ministerio da Agricultura, Instituto Brasileiro de Desenvolvimento Florestal, as part of the Programa de Monitoramento da Cobertura Florestal no Brasil. The maps, available through the Superintendency for the Development of the Amazon (SUDAM), give precise locations of property boundaries, and designates the title status of each holding. The title categories include "definitive title" (*titulo definitivo*), "definitive title provided by GETAT (*titulo definitiva GETAT*)" and de facto occupation (*posse*).

Using these maps as a reference, and drawing on the consultation of experts in the mapping of land titles in Pará (discussed under Personnel), we will select a probability sample of 200 small farmers with title and 200 small farmers without title to the land they cultivate. Case selection can be done by randomly sampling fixed property counts (every *n*th farm site), or by fixed geometry (every *n*th kilometer) when the sites are evenly dispersed. We arrive at the proposed sample size through a decision process that accounts for considerations such as: (a) the number of cases likely to be found in approximately the same geophysical and socioeconomic context (the larger the sample size, the greater the likelihood of including dissimilar cases); (b) the number of interviews we can reasonably expect to carry out given the constraints imposed by time, budgets, and logistics (the greater the number, the higher the cost); and (c) the number of cases required for robust tests of the null hypotheses (the smaller the number, the lower the power of the statistical tests).

## F. Survey Questionnaire: Content and Rationale

The questionnaire will be divided into seven sections, each recording information relevant to the research objectives. The questionnaire will be phrased in the proper regional vocabulary, and will include items capable of measuring subtle differences in land and resource use within the range of the choices that are possible in the area. Care will be taken to generate information both on long-term processes, such as capital formation, and short-term activities, such as production and the use of inputs. Items in the questionnaire will distinguish between the land improvements that may have been carried out by former owners and those carried out by current landholders. Many of the questionnaire items have already been field tested by Robert Walker, in his study of farming systems in the region (discussed under Personnel). What follows is a summary of the main issues to be included and a brief explanation of the significance of each variable.

### Dependent Variables

(1) *Land Improvements*. Includes fences, land grading, investment in pasture improvements, the construction of irrigation and drainage works, and the application of fertilizers. The absence of these investments is one indication of nutrient mining, a strategy expected to be more prevalent among small farmers without titles.

(2) *Land Use Decisions*. A central aspect of land use decisions is the choice of crops planted. Perennials (e.g., coffee, cacao, black pepper, fruit trees) take an average of 3 years before they become productive. Some crops, like rubber, may take as long as 7 years. Annual crops such as rice, beans, and corn, on the other hand, can be harvested in a short period of time. Such crops require little investment, and can be consumed in the event that they cannot be sold. The questionnaire will record the number of perennial trees planted and amount of land devoted to annual crops. Other things being equal (especially the relative prices of perennial and annual crops), titled farmers are expected to invest a greater amount of capital and labor in the cultivation of perennials.

The longer time horizons associated with land tenure security may also promote the use of agroforestry techniques. Agroforestry is theoretically sustainable because woody vegetation is more conserving of soil reserves, and due to the positive production externalities for associated annual crops through the maintenance of microclimates conducive to plant growth and through erosion control (Etherington and Mathews 1983).

The proportion of land that has been converted to pasture is another key indicator of land use decisions. With the price of forested land typically 30 to 60 percent that of pasture, the small farmer, using his own labor, can make a reasonable return on his land sale, which can then be reinvested into new forest -- a land use strategy commonly associated with untitled landholders. Small farmers with title to their land may also find it profitable to convert forest to pasture when they can rent grazing rights or raise their own animals. In addition, some forms of rural credit in which cattle rather than land are put up as collateral may promote the creation of pastures. Hence, the same outcome (i.e., the conversion to pasture) may result from different causes. The questionnaire will therefore include several items that record not only the amount of land in pasture but also the reasons producers made their particular choices. Additional indicators will be formulated to measure the intensity with which pastures are used, ranging from "light" use (less than 0.5 animal units/ha.) to "heavy" (1.5 or more animal units/ha.) (Uhl, Buschbacher and Serrão 1988).

The value of the main production components (annual crops, perennials, and cattle) will be determined using a producer price series for the state of Pará, provided by the Empresa de Assistência Técnica e Extensão Rural (EMATER), in conjunction with the appropriate deflators (Homma et al. 1994). These values will then be used to determine for each property a scale measure of total value, and the proportion of the total value that is accounted for by its various components (perennials and cattle).

(3) *Use of Timber.* The sale of mahogany and other high grade woods is an important source of income to small farmers. The rate at which the timber is harvested, and the manner in which this is done, are critical variables. Untitled landholders are expected to exploit timber resources as rapidly as possible on the basis of unfavorable contractual arrangements with loggers. Titled farmers, with a longer time horizon in mind, are expected to harvest timber more selectively, reserving a proportion of the high grade stock for future use.

(4) *Use of Credit.* In order to obtain institutional credit a small farmer must have clear title to his or her land. However, the anticipated positive association between the possession of a land title and the use of institutional credit may not obtain if it is unavailable in the area, or the cost is prohibitive, or the individual has defaulted on previous loans. A set of questions will be formulated regarding attitudes about and the use of informal and institutional sources of agricultural credit.

#### Main Predictor Variables

(5) *Land Title and the Perception of Tenure Security.* The most obvious indicator of land tenure security is the possession of a legal title to the land. Legal titles come in several varieties. Some are issued by the Federal government (e.g., via GETAT); others by the state land agency (ITERPA). In some cases individuals pay taxes on land that they do not own in the hopes that the tax receipt itself will legitimize their claim. Yet the possession of a tax receipt, or even the possession of a legal title, may not necessarily be associated with increased security. Hence, items will be included in the questionnaire that objectively measure the possession of title (or equivalent, such as the Licença de Ocupação), as well as items that measure the subjective perception of land tenure security.

The presumed relationship between title holding and the perception of tenure security is ultimately an empirical question. Just as titled farmers may have little tenure security, there may be other circumstances in which untitled farmers perceive a high degree of tenure security. Much depends on such factors as the level of competition for land, the degree to which property rights are enforced in the area, and the existence of informal mechanisms that govern tenure security.

#### Control Variables

(6) *Sociodemographic Characteristics of Household Members.* Includes the age, sex, educational achievement (literacy; number of years of school completed), work experience (number of years the individual was primary decision maker on a farm) of household members, and length of residence in the research site. The number of adult members (14-65 years of age) represents a fixed endowment in the short run that reduces the need for cash to hire labor. The number of adults, plus children and the elderly, is also a determinant of household consumption requirements. Education and work experience are both indicators of human capital, which is assumed to be positively correlated with the marginal productivity of variable inputs and, hence, the demand for inputs and the derived demand for cash.

Domestic life-cycle effects may be significant inasmuch as advanced stages of the cycle may be associated with the switch to investment crops.

(C) *Characteristics of the Landholding.* Includes the size and the location of the plot, and the distance to secondary and all-weather roads that lead to the nearest market. The geographic position of the farm site will be recorded using a GPS receiver capable of locating the farm site within 40 to 100 meters. Other features of the landholding that may affect the outcome variables include the incline of the land, the presence of water, and other variables that limit or expand land use options.

## **G. In-depth Interviews with Key Informants**

The quantitative results of the social survey will be complemented by additional data collected from in-depth interviews with key informants. A key informant is an individual strategically placed with respect to information about the system of production, land use, or related marketing and financial institutions. Key informants include farmers, ranchers, extension agents, merchants, bank officers, indeed anyone who can speak knowledgeably about the event or process of interest. Multiple interviews with key informants in similar strategic positions will be carried out to cross-check and validate the information gathered. The purpose of the qualitative analysis is to generate information necessary to a proper interpretation of the empirical findings. For example, the survey results may show that titled and untitled farmers do not significantly differ in terms of, say, access to credit. In order to identify the institutional barriers that may be at work, it will be necessary to go beyond the farmer to collect information from representatives of banking institutions and extension agencies. The method has been used to good effect by Wood over the course of his fifteen years of research in the region.

## **H. Hypotheses, Models and Methods**

The tenure security thesis predicts that (1) the perception of tenure security will be positively associated with the possession of legal title. The thesis further anticipates that, compared to untitled farmers (and/or those with low levels of perceived tenure security), titled farmers (and/or those with high levels of perceived tenure security) will (2) invest in land improvements; (3) will show a greater preference for perennial crops; (4) will carry out pasture conversion for productive rather than speculation motives; (5) will engage in more selective logging strategies; and (6) will make more frequent use of credit to finance production and land improvements.

To test these hypotheses, we will apply ordinary least squares and logistic regression techniques to interval and dichotomous dependent variables. We will use dummy variable coding to introduce the indicators of tenure security (possession of title; subjective perception of security) after statistically controlling for the sociodemographic characteristics of household members, the physical characteristics of the landholding, and the geographic location of the farm site (discussed below). The controls for household and land characteristics are necessary to remove the effects of individual variability that may remain even after selecting a research site that minimizes the differences between the population of titled and untitled farmers.

The information on the farm location will be recorded using a ge positioning device, and the data will be entered into a geographic information system (GIS). The GIS will also yield data on the location (coordinates) of nearby settlements and towns, and the location

and length of road networks. These variables form the basis for calculating a range of accessibility measures. The specific GIS system used to accomplish this will be Arc/Info. The GIS will also yield the base information on the spatial arrangement of the farm sites needed for the computation of spatial statistics (i.e., for the construction of the spatial weights matrix). Spatial statistics are required whenever spatial effects are potentially important (Anselin 1988). In this study, for example, levels of the outcome variable may be intrinsically spatial to the extent that land investment decisions follow a diffusion pattern, incorporate adjacency effects, or are systematically correlated with, say, the distance to roads (substantive autocorrelation). Similarly, spatial effects may be present due to unmeasured variables, such as the clustering of soil types, topographic features, and microclimatic variations (nuisance autocorrelation). Whenever appropriate (e.g., in the case of interval-level dependent variables), we will test for the presence of spatial dependency in both the dependent variables and error terms (from OLS) in order to determine the presence of substantive and nuisance spatial autocorrelation. Such tests require the use of a "weights" matrix, based on the pairwise distances of all farm properties. Should spatial autocorrelation be detected, we will implement the appropriate models and re-estimate the regressions by moving the data from Arc/Info in SpaceStat, a data analysis software specifically designed to handle such estimation problems (Anselin 1992).

## I. Personnel

### Charles Wood, Principal Investigator.

Charles Wood specializes in the sociology of development and in population studies. His work on the Brazilian Amazon began in 1976, when he participated in a study of the sociodemographic impact of migration and colonization in the southern region of the state of Pará. That initial experience (Wood and Schmink 1978) led to a fifteen-year longitudinal study of the process of frontier expansion in the region (Schmink and Wood 1992). He returned to Amazonia in 1978 to complete a baseline analysis of the research site, and carried out two follow-up studies in 1981 and 1984, with additional field work in 1987 and 1989. On the basis of qualitative and quantitative information collected at each point in time, he was able to reconstruct the events that occurred during the period, including a sustained effort to track the evolution of Amazonian development policies within the planning bureaucracies of the state and federal governments. The results of the project were recently published in a book called *Contested Frontiers in Amazonia* (Schmink and Wood 1992). The volume showed how deforestation, settlement patterns, and the intensity of rural violence were outcomes of the competition for resources among peasants, ranchers, Indians, and longtime residents of the region. The analysis further documented how national and international forces often shaped events at the local level.

In preparation for this project, Wood received a travel grant from the Institute for Latin American Studies at the University of Texas to visit southern Pará in May and June, 1993. The objective of the trip was to renew institutional contacts, and to verify that described research design is feasible. Wood's extensive research background in the Brazilian Amazon is central to the proposed study. His intimate knowledge of the places and the people involved in the process of migration, settlement and land cover change provide the kind of in-depth understanding of the region necessary to the specification and interpretation of the statistical models. Moreover, his data collection experience, his firsthand knowledge of local conditions, and his longstanding contacts with scholars, bureaucrats, and policy makers in the region contribute significantly to the design and execution of the planned field study.

### Robert Walker, Collaborator

Robert Walker has extensive experience in field research. He specializes in the development and implementation of surveys to elicit quantitative data appropriate to econometric analysis (Walker and Greenstreet 1991). His most recent work applies this methodology to small producers in the Brazilian Amazon. In the Fall of 1992, Walker and his Brazilian colleague from EMBRAPA/CPATU, Alfredo Homma, led a field activity on the Santarem-Cuiabá highway, between Santarem and Rurópolis, in the state of Pará, Brazil. Over a period of one month, they interviewed small producers using a twenty-page questionnaire to elicit information on demographic characteristics, personal attributes of the household head, farming systems, land allocations, farming technology, and durable goods possession. In the summer of 1993, Walker and Homma led three research teams to the Transamazon Highway and successfully completed interviews using the same questionnaire with modifications.

Information generated by these field activities addresses a number of issues pertinent to land use dynamics in tropical forest areas, including the use of fire by small producers (Homma et al. 1993), the conditions leading to agricultural intensification (Homma et al. 1994), and the relationship between farming system type and wealth accumulation (Walker et al. 1993). His work on deforestation has focused on the conditions and incentives that compel small farmers to liquidate valuable natural resources in tropical country settings. Walker has shown how the structure of logging contracts can lead to deforestation (Walker 1987), and how a high risk institutional environment, including political instability, can motivate loggers to disregard their contractual commitments to forest maintenance. Walker has further documented the linkages between deforestation and economic development (Walker forthcoming). His current theoretical work addresses small producers in tropical frontiers, drawing on household production theory to develop behavioral models that depict the decision processes regarding the use of land and natural resources.

#### Consultants

The process of selecting the research site and of designing the questionnaire will be done in consultation with Brazilian experts in various fields of research. Three individuals will collaborate on the project: Dr. Alfredo Homma is an agronomist at the EMBRAPA, the major agricultural research institution in Brazil. Prof. Jean Hebette, formerly professor of sociology at NAEA (Nucleus of Amazonian Studies) in Belém, is currently director of the Centro Agroambiental Tocantins (CAT), a research and extension NGO that works closely with small farmers in the Marabá area. Homma and Hebette will offer important contributions to the content and the design of the survey questionnaire. The third consultation will be Pedro Mourão de Oliveira. Mourão works in the Superintendency for the Development of the Amazon (SUDAM) where he is responsible for mapping the locations of landholdings in the state, both titled and untitled. His expertise will be of particular value in the selection of the research site, and in the construction of a sample design.

#### **J. Research Agenda**

During the Spring semester, 1996, Wood and Walker and two half-time research assistants will carry out a complete review of the literature on property rights and resource use. They will prepare a draft of the questionnaire that will be applied in the field. The final questionnaire will be constructed with the additional input of three expert consultants in Brazil, during a five-day trip to Brazil by the Principal Investigator and his assistant. The meeting, to take place in Belém, will also be used to collect the necessary information for the sample design.

Wood, Walker, and Stephen Perz (Research Assistant, UT) will travel to Belém, Brazil in the Summer, 1996. During the period June 20-30, they will hire and train ten interviewers. On July 1 the research team will travel to the research site to begin data collection. Data collection will consist of applying 400 questionnaires to small farmers in the selected research site, as well as in-depth interviews with key informants in banks, extension agencies, and related institutions. The group will return to Belém at the end of July. August 1-7 will be devoted to data entry, with the assistance of two coders retained from the interviewer team. Wood, Walker and Perz will return to the US on August 8, 1996.

In the Fall, 1996, Wood and Walker will clean the data and carry out statistical analyses of the survey information. During the Spring and Fall, 1997, they will disseminate an executive summary of the main research findings, and will prepare journal articles and a book manuscript for publication.

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## Tenure Security and Resource Use in the Amazon

### Policy Relevance

#### The Relevance of Tenure Security as a Policy Instrument

The focus on property rights in this study is justified by the revival of interest in land titling for the purpose of achieving environmental goals (World Commission 1987: 129; Durning 1989; World Bank 1989:20). While the property rights perspective can be applied to many environmental issues, the approach is an obvious choice for analyzing land degradation in developing countries, where land tenure is frequently unclear, unspecified, disputed, or nonexistent (Wachter 1992:8). Moreover, the option of providing land titles is eminently attractive from a public policy standpoint because it is an instrument that relies on existing laws, agencies and bureaucratic procedures.

Although it is widely accepted that secure land ownership is conducive to access to credit and to the maintenance and conservation of land and other resources, little is known about the magnitude of the effects involved. Indeed, there is a striking paucity of rigorous quantitative research on the topic, which seriously hampers the design and evaluation of public policy (Feder et al. 1988: 3). The problem is especially evident in the case of the Amazon where relatively little farm level research has been done, presumably because of budgetary constraints and the "difficulty of encouraging scientists to work in the field in the Amazon" (World Bank 1992: 55).

The results of the proposed research are of direct relevance to the formulation of public policy related to environmental concerns in this region. By comparing titled and untitled farmers along a wide range of behaviors, the findings will document precisely the kinds of activities that land titles promote and the activities that they discourage. Some of the outcomes may have the anticipated positive consequences. Others may be deemed to have negative environmental implications, as in the use of title-based credit to expand cattle ranching. An empirically based inventory of the behavioral outcomes of land titling will go a long way to introducing needed specificity into the overly general policy assumptions of the property rights paradigm. Such an inventory also provides concrete guidelines for the formulation of corrective legal and fiscal incentives pertinent to the specific case of the Brazilian Amazon.

The results of our analysis of the survey data may also show that the possession of a title has no measurable effect. In this case, the findings of the qualitative component of the study, based on in-depth interviews with key informants, will identify the contextual and institutional factors that swamp the presumed tenure effect. With respect to both the inventory of behavioral outcomes, as well as the qualitative findings from the in-depth interviews, the results of the proposed study will offer a firm empirical basis for specific policy recommendations that target a range of potential users, including: environmental policy agencies at the federal and state level in Brazil, regional development institutions (e.g., SUDAM) and NGOs operating in the Amazon (e.g., PESACRE, and CAT), agricultural research and extension agencies (EMBRAPA, EMATER), as well as US-based environmental policy dissemination organizations (e.g., NASA-supported CIESIN/SEDAC), and international entities, such as the World Bank.

#### The Relevance of this Study to the Global Research and Policy Agenda

Numerous programs and institutions have identified the need for site-specific case studies that specify the social, economic, and institutional factors that contribute to environmentally destructive outcomes in different national contexts. The International Geosphere-Biosphere Programme (IGBP) and the Human Dimensions of Global Environmental Change (HDP), via the Land-Use/Cover Change (LUCC) project, have called for comparative case study analyses to identify the role of key driving forces of land-use maintenance and change. According to the IGBP, the subject of global change requires a large number of case studies that provide a firm empirical basis for characterizing the major determinants of land-use/cover dynamics (Turner, Meyer and Skole 1994). Case-based empirical modeling will advance understanding of LUCC if subnational models incorporate the policy interventions at the local level that account for varying patterns of land use and cover change. The goals set forth in the IGBP-HDP agenda are echoed in parallel documents produced by the Committee of the Human Dimensions of Global Change of the International Social Science Council (ISSC), prepared in co-operation with UNESCO (Jacobsen and Price 1991), and by the National Research Council (NRC 1992). Similar recommendations have been put forth by the Social Science Research Council Committee for Research on Global Environmental Change, and the 1991 Global Change Institute on Global Land Use Change, sponsored by the Office of Interdisciplinary Earth Studies.

#### The Relevance of Land Use Decisions to Environmental Concerns

The behavioral and institutional factors that promote particular land use strategies among small farmers in tropical lowlands has assumed priority concern in scientific research, in environmental policy, and in international relations. Deforestation in particular has been singled out as a key element in studies of the global carbon cycle and climate change, biomass burning and atmospheric chemistry, and land surface water and energy balance (Houghton and Skole 1990, Salati and Vose 1984). A major concern with tropical deforestation arises because of its impact on climate change by altering sensible and latent heat flux and planetary albedo (Shukla et al. 1990). Local effects include increases in the fraction of precipitation as surface run-off, soil erosion, and an eventual local decline in precipitation. The increase in the proportion of precipitation running off the land in the form of ground water can alter the flooding pattern of the Amazon river and its tributaries, and potentially change the hydrology of the entire Amazon watershed (Sioli 1985). Perhaps the most immediate change associated with the expansion of the agricultural frontier, and the destructive forms of timber extraction observed in the Amazon is the loss of biodiversity from habitat destruction and fragmentation (Ehrlich and Wilson 1991). For these reasons an understanding the factors that motivate the deforestation and the land use patterns witnessed in the Brazilian Amazon is relevant to broader issues such as sustainable development, biodiversity, and climate change. The results of this study are therefore relevant to individuals and institutions with a commitment to environmental policies pertaining to a wide range of issues.

#### Dissemination Strategies

In addition to the traditional venues, such as scholarly journals and book publications, we will employ the internet and other electronic means of making the findings available to the environmental policy community. The Population Research Center (PRC) at UT has a home page on the World Wide Web, as well as a gopher site. The PRC's Bulletin Board Service, which is linked to the WWW home page, routinely makes available working papers, executive summaries of major research projects, and the complete text of selected

manuscripts. The Data Services core at the PRC will also post a description of the project to the various Listservers that focus on environmental policy issues. Finally, Charles Wood is a member of the Users Working Group of the Socioeconomic Data Application Center (SEDAC), of the NASA-funded Consortium for the International Earth Science Information Network (CIESIN), an organization devoted to the dissemination of policy relevant data archives and research findings. Research results of the proposed project will be entered into the CIESIN/SEDAC catalog system that serves the global change research and policy community.