Small-scale managed forestry at the Brazilian agricultural frontier: Adoption, effects and policy issues

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SUMMARY

Forest-based activities compete with on-farm and off-farm activities for smallholders’ time, cash, and land. In most forested frontier areas, forest-based activities fail to compete effectively with non-forest activities, despite evidence in some cases that the expected returns to land and especially to labor associated with these activities dominate those generated by alternative activities. This paper examines the case of small-scale managed forestry in the western Brazilian Amazon. We first compare the performance of this land use system to others in the region; the returns to labor dedicated to small-scale managed forestry are higher than those generated by most alternative land use systems, and are nearly three times higher than the wage rate for daily hired labor. The environmental services provided by small-scale manage forestry dominate those provided by all alternative uses, except leaving the forest untouched. Against this optimistic economic and environmental backdrop provided by land use system analysis, we address the issue of why the adoption of small-scale managed forestry, which can be legally pursued in Brazil, has been so limited. Market and other institutional constraints provide part of the answer. A farm-level bioeconomic model is then used to assess the adoption potential of small-scale managed forestry if all institutional impediments to adoption were removed, and to measure the effects on household income and environmental services if adoption takes place. Results show that removing institutional obstacles to sustainable off-take of timber products on farms would induce adoption, which would, in turn: reduce but not halt smallholder deforestation; leave proportional use of cleared land virtually the same; and improve incomes. Strong financial incentives exist, however, to harvest timber products unsustainably, suggesting that mechanisms for monitoring timber off-take will be required. Costs associated with establishing and monitoring a small-scale managed forestry pilot project in Acre are explored and set alongside the carbon retention benefits of the system; slightly expanding the number of farmers participating in the pilot project would be sufficient to generate benefit/cost ratios greater than unity. Policy issues are discussed.

Keywords: managed forestry, deforestation, income, agriculture, biodiversity, carbon

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INTRODUCTION

Worldwide, the pace of deforestation has been rapid (World Resources Institute, Achard et al.) and loss of tropical forest has been largest in Brazil, where the percent of total forest lost increased from 3.0% in 1978 to 11.2% in 1999 (see Faminow, Chapter 5); forest lost in the western Brazilian state of Acre, the geographic focus of this paper, increased from 1.6% to 9.9% over the same period (Franke et al.). Tropical deforestation has many and complex causes that are influenced by macroeconomic trends, but often these causes are quite local in nature (Lambin, et al.; Angelsen). At household level, reasons to deforest are easier to identify, with smallholders using forests and other assets to improve their welfare in the face of credit, information, and other constraints, including externally imposed limits on forest use (Reardon and Vosti). Where forested land is on private property, and farmers have some and improving links to local markets, as in the case study explored here, relative returns to activities – forest-based vs. alternatives, some pursued on deforested land – would be expected to play a large role in determining amount of forest retained on land. While a broad range of estimates of returns to traditional and other non-timber extractive activities exists (e.g., Godoy et al., 1993, Southgate 1998), site-specific evidence suggests that a large gap divides returns to traditional forest-based activities and those to agricultural activities practiced on cleared land (see Faminow, Chapter 4). Empirical evidence from colonization projects – areas marked out by the Government for smallholder occupation – in the western Brazilian Amazon, an area of relatively abundant natural forest products (Wunder 1999), indicates that the returns to all alternative uses of forested land dominate by a wide margin those associated with traditional extractive activities (by at least 7-to-1 in terms of returns to labor, Vosti, et al., 2001; see Homma for a general discussion of these issues). Under such circumstances, one expects (and finds) the conversion of forested land to agriculture. For those below the poverty line, sufficient resources to access technologies to take advantage of profitable activities will help determine whether deforestation occurs and, in the conversion process, poverty is alleviated. In the absence of sufficient resources, or with greater isolation from markets, poor farmers may have little choice but to deforest in order to survive, but the deforestation will be more limited by the fact that the farmers’ resources to deforest are themselves meager.

Forest conversion, while driven by private costs/benefits, generates social costs as more broadly enjoyed (but not marketed) forest services diminish, providing grounds for governments to intervene (Fearnside, Lele et al., World Resources Institute). While government action to increase financial returns to forest-based activities can reduce incentives to convert forests to other uses, to get an idea of the degree and type of needed government intervention requires more in-depth financial analysis. In many forest margins areas, given the wide profitability gap between forest-based and alternative activities, increasing the financial returns to forest-based activities sufficiently to induce forest-saving behavior will be expensive (Tomich et al., Gockowski et al., Rohter).

Even with an identified level of profitability for forest-based activities expected to slow deforestation in hand, policymakers have few practical and effective policy instruments to enhance the value of traditional forest-based activities. In the Brazilian Amazon, price policies aimed at increasing the returns to Brazil nut and rubber extraction, expensive to sustain, have not surmounted incentives to clear forest
(Carpentier et al. 1999, Homma). Land use zoning and regulation of forest use have emerged as the primary (default) policy instruments for slowing deforestation in the Brazilian Amazon (Government of the State of Acre).

Regulating deforestation on privately held land has by and large failed in Brazil due to weak enforcement and strong financial incentives to deforest illegally (Lele et al.). In response, as part of its overall strategy to induce farmers to retain more forest on their privately held land, the Brazilian Government is now contemplating allowing farmers to extract timber products using a new technology package that involves methods to limit damage to forests of extraction, and includes technical expertise to guide the selection of species for extraction.

This paper examines the attractiveness to smallholders of this relatively new managed forestry technology/policy package, the constraints to adoption of this system, and if adopted, the potential for managed forestry to conserve biodiversity, reduce CO2 emissions, and increase smallholder income in the context of the western Brazilian Amazon. The next section briefly describes farm households, farms and farming practices in the research area. Section 3 presents the results of land use-system-specific analysis aimed at assessing the environmental and economic performances of several land use systems, including small-scale managed forestry, and the institutional and other impediments to their adoption. Section 4 describes the linear programming model used to simulate farmer behavior (with specific focus on land use system choice) in the face of specified policies, prices and technology options. Section 5 presents the results of a baseline scenario. Section 6 describes the small-scale sustainable managed forestry system and presents the results of the model simulation associated with it, with special attention paid to land uses, deforestation, and household income. The social costs associated with developing, establishing and monitoring a small-scale managed forestry pilot project in Acre, Brazil are estimated and set alongside estimates of the social benefits regarding carbon retention in Section 7. Conclusions and policy implications appear in Section 8.

FARM HOUSEHOLDS, FARMS AND FARMING AT THE STUDY SITE

Smallholder agriculture in the context of the forest margins of the western Brazilian Amazon stretches the international notions of scale of operation; by the Brazilian definition, small-scale farms range in size from sub-hectare plots to 200-hectare farms (IBGE). The government created colonization projects in the area dating from about the 1970s as a means of distributing sizeable plots (roughly 100 hectares) to poor migrants as part of broader efforts to develop the Amazon (Mahar, Ozorio de Almeida and Campari). But scale of operation aside, smallholders in Brazil have much in common with their counterparts in other forest margin areas, especially upon arrival to their forested lots. They tend to be poor and inexperienced in the ways of tropical agriculture. With limited access to food and other markets, they often simultaneously pursue a host of extractive, crop production, livestock and off-farm activities. Their assets are generally heavily skewed toward natural capital, with relatively little labor or financial capital available to earn a living. While forests can play an important role, by providing products that sustain households – particularly the poorest – during times of crisis, in buffering households from agricultural and market risk (Wunder 2001), households often find their hopes for entering markets and earning income rest in clearing forest, due to the profitability gap described above.
This study focuses on a sample of smallholders in the northwestern Brazilian states of Acre and Rondonia, most of who migrated to the Amazon from other parts of Brazil in search of land and in an effort to escape poverty. Households averaged six individuals, and were headed by middle-aged individuals, many practically illiterate. Dependency ratios were high, with many households including a pensioner. Farmers came primarily from outside the region with the intention to clear forest for farming, bringing with them skills not suited to farming the soils at the forest margin. Upon arrival in the Amazon, the average family in our sample had sufficient resources to feed itself for about 4 and one half months, which, depending on when during the agricultural cycle a family arrived, may or may not be enough to guarantee food security. By 1994, households produced farm products averaging almost $3500, or about $575 per capita in the household.

Smallholders’ farms tended to be large (averaging 76 hectares) by international standards, but not by Brazilian ones. Travel time to market, one way, averaged just over two hours during the dry season; this more than doubled during the rainy season. Soils in the region are generally poor, with 70% of households having parts of their farms on land that faced considerable limitations to agricultural activities, e.g., very poor soil fertility, excessive slopes, rockiness, waterlogged areas, or some combination of these. Cattle ranching is the dominant land use in the region, even among smallholders whose herd size averaged 32 head. Most participated in some form of forest extraction, usually Brazil nuts, but these activities contributed only about 10% of value of total output. There was a modest amount of commercialization of agricultural products, e.g., about 33% of farmers reported selling annual crops. Contrary to international perceptions, land tenure among smallholders in colonization projects (such as the one studied here) is reasonably secure (that is, they did not need to deforest further in order to secure their claim to the property); over half of sample farmers had a secure title, and an additional quarter had a document linking them to the land they cultivated.

The two-season climate shapes much of the region’s agricultural activity. A distinct dry season permits agriculture by a slash-and-burn process (contrasting with the slash-and-mulch system in more humid Amazonian areas, see Pichón 1997). A typical agricultural year starts with the beginning of the dry season in June and finishes with the end of the rainy season in May. Forest felling occurs during the dry season from May to July. The cleared area is allowed to dry, then burned in August or September prior to the expected onset of the rains, and planted to annuals, perennials, or pastures.

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Smallholders’ characteristics are derived from field data collected from approximately 200 small-scale agriculturalists in two colonization projects in the western Brazilian Amazonian over the period 1994-1996. (See Vosti et al. 2002 for site descriptions and for details regarding sample selection.)
LAND USE SYSTEM ANALYSIS

For the purposes of land use system analysis, all systems start from forest-clearing and follow a described trajectory over a 20-year time horizon given a particular socioeconomic and geographic setting (Vosti et al. 1998b). They represent both traditional systems and others based on proposed technological advances. The proposed systems, e.g., managed forestry, do not, as yet, appear broadly on the landscape, and one of the ‘traditional’ systems - a long-term annual-fallow cycle of shifting cultivation - has vanished from the study site and from most of the region where standing forest remains an option for expanding area under cultivation.

Each system was evaluated using comparable value-based productivity measures plus quantitative and qualitative assessments of environmental impacts. The first two columns assess biophysical indicators of international interest: carbon storage capacity and above-ground plant biodiversity. Economic returns to land and labor gauge relative productivity while revealing systems more profitable for farmers. Adoptability issues beyond financial attractiveness are measured by total labor requirements (noting seasonal bottlenecks), and institutional constraints to adoption, market- and non-market-related (Vosti et al. 1998b).

The results of land use system analysis appear in Table 1. In a relatively labor-scarce environment, returns to labor would outweigh returns to land in farmers’ decisions to adopt. Table 1 presents both profitability measures for comparison. Systems at or below the average rural daily wage for unskilled labor, approximately R$6.50 (roughly $1 (US) in 1996), would probably not be attractive to farmers.

Several important points emerge from Table 1 as regards managed forestry. First, as compared to traditional Brazil nut extraction, managed forestry dramatically improves the returns to land and labor. Second, the returns to labor dedicated to managed forestry (R$20/person-day) are substantially larger than those generated by any other land use system examined, with the exception of the improved cattle/pasture system, but including the broadly adopted traditional pasture/cattle system. Third, and not evident from the table, the returns to labor in the managed forest system are about three times the going wage rate for daily hired labor at the research site. Fourth, the environmental services provided by managed forest are quite similar to those provided by traditionally managed forests (in this case, forests from which only Brazil nuts are extracted); estimates of above-ground carbon retained are roughly equivalent to those

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4 For details of production systems see Fujisaka et al. 1996, Faminow, Vosti et al. 2001a and Vosti et al 2002; for details of nutrient cycling see Palm et al. 1996.

5 This section of the paper borrows heavily from Vosti et al. 2001b.

6 For carbon indicators, Managed Forest and Annual Crops/Legume-Based Improved Fallow (AC) systems were not measured directly; approximations were based on expert opinion. For biodiversity indicators, measurements were taken in the operational phase, with the exception of fallow systems, where measurement reflects the fallow part of the cycle.

7 The ASB framework uses social prices in profitability calculations; private prices are used in the calculations presented here due to lack of social price data.

8 For details of the managed forestry system included in this analysis, see Section 6.
of untouched forest, and more recent measures of above-ground plant biodiversity based on species counts and on plant functional types suggest that managed forest do not differ greatly from traditionally managed forest in that regard, either (Lewis et al.).

But factor returns are not the only issue in adoption; to achieve those returns requires certain quantities of important factors needed at specific times during production cycles. This can mean land of an appropriate agronomic profile, but more importantly, labor (due to its relative and absolute scarcity) and, for systems requiring purchased inputs, capital. Therefore, a system with high returns to labor may simply be out of reach of many small farmers in the area, given the current labor scarcity and imperfectly functioning labor markets. This seems to be the case for the coffee/rubber system, which demands the most labor by far, nearly 60 person-days per hectare per year (Table 1, data column 5). Managed forestry lies at the other end of the labor-use spectrum and requires only about one person-day per hectare per year to manage; clearly within reach of all small-scale agriculturalists in the study site. The broadly adopted traditional pasture system requires the least labor of any system other than the forest systems, approximately 11 person-days per hectare annually; its intensified version, improved pasture, needs just slightly more than this.

The final pair of columns of Table 1 addresses issues that condition profitability. Substantial institutional obstacles face farmers who might try to establish land use systems and achieve the financial returns reported; their degree and type vary widely from one system to another. Imperfections in labor markets are a factor in adoption in all non-traditional systems. Beyond this, though, practically all non-traditional systems include reliance on other markets plagued by imperfections as well, including the capital market and markets for specific inputs and outputs; the exception is precisely the system most dependent on labor - improved fallows.

Non-market institutions can also impede or facilitate adoption. The regulatory environment, for instance, can be friendly (or not), and the knowledge needed to apply the technology may be a small extension of farmers’ practices or may necessitate broad new understanding. Although all the systems were deemed to face some non-market institutional obstacles, the number and severity of those faced by managed forestry - an attractive system by dint of returns to labor and labor needs - stood out. Sustainable extraction of timber calls on expertise about forest species and felling techniques not readily available in the area. It also demands a level of social cooperation in order to achieve a production scale where management can be sustainable and must navigate regulations limiting or monitoring extraction in forest reserves. The traditional counterpart of managed forestry, low-level forest extraction, a system that has been in place for many years, has the fewest institutional obstacles. Improved pasture and livestock management also calls for knowledge of new techniques and seeds, but, unlike the case of small-scale managed forestry, these can be adopted piecemeal. The ability to overcome many of these institutional obstacles is presumably the most restricted for precisely those farmers who are most at risk of food insecurity and who have fewer resources (financial, know-how, and time) at their disposal.

But even if all of these market and non-market obstacles to the adoption of small-scale managed forestry could be successfully addressed by farmers and/or policymakers, the results of the narrowly focused land use system analysis might
overstate the adoption potential of this system for several reasons. First, this level of analysis does not address the seasonal or spatial competition at household level for land, labor and cash among alternative land uses. Second this analysis does not address the limited availability or complete use of these inputs at household level. Third, overall farm household objectives are ignored. Finally, off-farm opportunities are not considered, except in the context of a threshold rural wage rate, systems ‘paying’ below which will be of limited interest to farmers.

Table 1. Evaluation of selected smallholder land use systems in Acre and Rondonia, Brazil

<table>
<thead>
<tr>
<th>LAND USE SYSTEMS</th>
<th>CARBON</th>
<th>BIODIVERSITY</th>
<th>PROFITABILITY</th>
<th>LABOR REQUIREMENTS</th>
<th>INSTITUTIONAL REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GLOBAL ENVIRONMENTAL CONCERNS</td>
<td>FARMERS’ CONCERNS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboveground t/ha (time-averaged)</td>
<td>Aboveground (plants) spec/mod</td>
<td>Returns to Land (private prices) R$/ha</td>
<td>Returns to Labor (private prices) R$/person-day</td>
<td>Labor person-day/ha/yr</td>
<td>Market</td>
</tr>
<tr>
<td>Traditional Brazil Nut Extraction – Forest Intact (AC)</td>
<td>148</td>
<td>1.82</td>
<td>-2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Managed Forestry (AC)</td>
<td>~148</td>
<td>nm</td>
<td>416</td>
<td>20</td>
<td>1.22</td>
</tr>
<tr>
<td>Coffee/Bandarra (RO)</td>
<td>56</td>
<td>1.29</td>
<td>1955</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Coffee/Rubber (RO)</td>
<td>56</td>
<td>1.1</td>
<td>872</td>
<td>9</td>
<td>59</td>
</tr>
<tr>
<td>Traditional Pasture (AC)</td>
<td>3</td>
<td>1.45</td>
<td>2</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Improved Pasture (AC)</td>
<td>3</td>
<td>nm</td>
<td>710</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Annual Crops/Traditional Fallow (AC)</td>
<td>7</td>
<td>1.96</td>
<td>-17</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>Annual Crops/Legume-Based Improved Fallow (AC)</td>
<td>~3-6</td>
<td>nm</td>
<td>2056</td>
<td>17</td>
<td>21</td>
</tr>
</tbody>
</table>

Source: Derived from Vosti, et al. 2001a. Original field data were used to generate estimates.

Notes To Table:

Prices are based on 1996 averages, and expressed in December, 1996 R$ (US$=R$1.04).

Technical parameters for land use systems were collected in states where the systems were most prevalent: ‘AC’ refers to Acre; ‘RO’ refers to Rondonia.

“nm” indicates not measured; “na” indicates not applicable.

For Labor Requirements, a bolded figure indicates competition for labor with other agricultural activities (including deforestation).

- For Institutional Requirements, letters indicate institutional constraints to, or impacts of, adoption (upper case indicates a serious problem; lower case indicate a more minor problem): Market: inp = input markets; o = output markets; lb = labor markets; k = capital markets. Non-market: n = information;
THE FARM HOUSEHOLD MODEL

To address these shortcomings of the land use system analysis, a farm-level bioeconomic linear programming (LP) model was developed to simulate the behavior of this group of smallholders as regards deforestation, product mix and technology choice (see Ruben et al. and Kaimowitz and Angelsen for reviews of methodological issues). The model contains a 25-year decision time horizon, explicitly accounts for on-farm competition among alternative agricultural and extractive activities for labor, capital and land, and assesses the impacts of policy and/or technological changes on deforestation, land use, and smallholder incomes. The model was built for the western Brazilian Amazon, calibrated for those agronomic and economic conditions, and subject to extensive sensitivity analyses (Vosti et al. 2002).

More specifically, the model approximates the maximum discounted value of an archetypical family’s consumption stream over a 25-year time by producing combinations of products for home consumption and sale, subject to an array of constraints related to technologies for producing agricultural and extractive products, the impact of agricultural activities on soils, and the financial benefits associated with different activities, including the potential to sell household labor off farm for agricultural purposes. Basically, the model searches over all possible combinations of activities, taking into consideration the costs and benefits of each, and identifies the set that maximizes the discounted stream of consumption over 25 years.

Aside from a set of alternative economic activities (and their associated technical production coefficients), their financial returns, and the biophysical factors that constrain activity choices over time, the model contains a set of initial conditions, that is, an explicit set of farm and farm household characteristics and market conditions that indicate both the model's starting point in terms of land already in use (for example, area in pasture), and farm- and household-specific constraints (for example, family size) that can influence the allocation of land, labor and cash to alternative land uses. These initial conditions stem from a subset of field data collected in 1994. Farm households from one policy area (Pedro Peixoto, Acre), colonized relatively more recently and with relatively higher proportions of farms still forested (making sustainable forestry a feasible policy), were clustered on the basis of characteristics deemed to be exogenous to farmers (for example, soil type). Several clusters emerged, each of which can be thought to represent a farm type. The average farm and household characteristics for a relatively well-situated farm type in terms of access to markets were used to generate the model baseline because of trends toward market extension in the area. This group accounted for roughly half the sample. Key among the model’s initial conditions is a set of parameters that limit the flows of certain products/inputs off/onto farms to reflect market imperfections (Vosti et al. 2002). For example, the subset of smallholders being modeled here are fortunate to have access to milk processing plants, but milk sales are constrained by daily quotas (precluding sales altogether affects farmer incomes, but has little influence on deforestation rates). More important for deforestation outcomes, labor market imperfections generate seasonal shortages of adult male labor, and these shortages are captured in the model by limiting the amount of labor that can be acquired (hired),
and sold, in any given month to 15 man-days each. The model uses a constant set of 1993/94 input and product prices for the entire decision time horizon, but values are reported in terms of 1996 Brazilian reais (when approximately 1US$=1R$). Differences between farmgate prices and market prices exist in the study area and are captured by the model by introducing product-specific price wedges.

The model also endows the farm household with food storage capacity, an initial cash balance, some cleared land for immediate use in agriculture and about 3 adult male equivalents of labor. With this initial portfolio of assets, households begin to engage in on- and off-farm activities that must always be sufficient to meet livelihood security needs of household members (monthly minimum expenses) and maintain cash for emergency purposes (seasonal minimum near cash balance). The baseline includes no provision for credit beyond this seasonal period.

The model also includes an explicit policy ‘package’ to reflect realistically the policy setting in the western Brazilian Amazon at the time the study was undertaken, some elements of which influence land use. For example, smallholders are not legally allowed to extract timber products from their forest reserves without formal, written authorization to do so from IBAMA; the vast majority of smallholders have no such authorization. And, during the time period covered by this research project, smallholders in states with approved land use plans were required to retain 50% of their land in forest, but this limit was not enforced in the study area. The baseline simulation (the results of which are presented below) mimics observed smallholder reactions to these policy and policy implementation issues in the study area: lack of enforcement of the 50% rule practically allows for complete deforestation of farms (hence, the baseline permits this as a possible outcome), but the sustainable off-take and sale of timber products is not permitted (hence, the baseline precludes this option).

**MODEL RESULTS – BASELINE, ALTERNATIVE INITIAL ASSET PORTFOLIOS AND ALTERNATIVE MARKET SETTINGS**

*Baseline Scenario Results* – Figure 1 depicts land uses (including forest, and therefore implicitly deforestation) generated by the model for a 25-year time span for a typical small-scale farm. It shows the amount of forest retained clearly declining over time, finally disappearing in about year 25, despite the small but positive revenue provided by the extraction of Brazil nuts from forested areas. In terms of area, cattle production is the dominant activity and pasture to support it eventually occupies about 85% of the farm, while annual crop production occupies about 8% of the farm throughout the 25-year time horizon. Perennial crops (in this case, manioc, with a production cycle spanning more than one year) take up about a hectare of land over time, and secondary fallow weaves into and out of the baseline land use scenario, becoming more significant as forests disappear completely.

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9 Current Brazilian law requires that farms of all sizes in the Amazon retain at least 80% of land in forest.

10 An ‘intermediate’ option also exists, i.e., sell trees or felled logs to sawmills. This did occur at the study site, but the frequency was not high among smallholders in the sample, and the farm-gate prices of such raw materials were quite low.
Figure 1. Smallholder land use patterns over 25 Years – The baseline scenario

Land Uses -- Baseline

Note: Land uses are ‘stacked’ from bottom to top as follows: primary forest, pasture, annual crops, perennial crops and secondary fallow; degraded pasture is an option in the model but did not appear in this simulation.

The dominance of pasture on the archetypical farm merits special attention. Dairy production begins early on in the 25-year scenario and continues to play an important role throughout — once the milking herd is established (by about year 10) roughly 77% of income is derived from dairy operations, which occupy 42% of available household labor, with the exception of May (Faminow; Vosti et al. 2001a). Beef cattle production emerges in year nine, and it’s contribution to income peaks in year 18 at which time it represents 25 percent of household income, but on average occupies just 4 percent of available household labor. Overall herd size, a key asset to smallholders, increases up to about year 18 and remains constant thereafter at about 51 head: 11 steers, 15 calves and 25 cows. Degraded pasture, a land use option in the model involving an 8-year fallow period and subsequent reestablishment costs, did not emerge as a land use choice in most of the scenarios presented in this paper; the lone exception is that of very low agricultural technology, addressed below.

Extraction of Brazil nuts is a continuing, but diminishing source of income to smallholders in the baseline run, with the supply of Brazil nuts directly linked to
Financial flows from on-farm agricultural and Brazil nut extraction activities and off-farm sales of adult male labor are substantial. Savings during the first few years allow for subsequent investments that boost production (and, hence, consumption) in later years. Large investments (negative savings) are required in years 5, 9, and 11 to expand pasture areas. Farm profits plateau at about year 13, at a level of approximately R$9,000 per year. The net present value (NPV) of the 25-year stream of the net value of total output (VTO) is R$50,688 (using a discount rate of 9%, roughly the real rate of interest prevailing on institutional credit at the research site during the research period).

While all forest is eventually converted to agriculture, smallholder income is clearly rising (the plateau level is about three times the average field-level VTO cited above). The model suggests an ongoing capitalization process by which farm households use forests – by felling them – to pull themselves toward greater financial security through self-financing investments.

Given that forest-to-pasture conversion is being driven primarily by the low value of forest products relative to agricultural alternatives, a policy option (small-scale managed forestry) was considered that increased the value of standing forest to smallholders making use of already existing markets while potentially within smallholders means to adopt given their objectives and limitations as captured by the model.

A POLICY EXPERIMENT – SUSTAINABLE, SMALL-SCALE MANAGED FORESTRY

This policy/technology package allows smallholders to sustainably extract timber products from private forests (an activity not allowed in the baseline scenario). Moreover, farmers can select the amount of forest they retain for this purpose (and for Brazil nut extraction), but not the per-hectare rate at which, or the species-specific way in which, timber is extracted, both of which are dictated by the imposed

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11 Previous modeling experiments that dramatically increased the value of Brazil nuts only slightly slowed deforestation (Carpentier, et al.).

12 Sensitivity analysis was performed varying the discount rate; due to the numerous biophysical and labor market constraints influencing model choices, even large changes in the discount rate did not greatly affect deforestation rates, household income or use of cleared land (Vosti et al., 2002).

13 Smallholders with different initial asset bases or facing different market conditions, however, might behave differently, perhaps averting the apparent poverty alleviation/environmental trade-off seen here. Under different policy conditions or with different technologies available, moreover, smallholders might be induced to save forest without sacrificing income. Model simulations examining these issues are presented in Vosti et al.(2002).

14 Here, the term ‘sustainable’ refers only to the block of forest being managed, which itself may be decreasing in size, and not to the farm as a whole.
technology designed to maintain the ecological integrity of the forest (Oliveira 2000).  

*Description of Technology* – Farmers are allowed to extract up to 10 cubic meters of timber from selected trees species per hectare, per year, a rate and method judged by local foresters to be sustainable over a 10-year forest production cycle. Low-impact harvesting methods judged to be superior to mechanical methods are deployed, e.g., sawn logs are hauled using oxen to the roadside for processing into planks (for a comparison of the effects of different timber extraction methods on forest dynamics see Oliveira 2000). Labor requirements for every phase of the production process (felling, on-farm transport, sawing of planks, etc.) are explicitly accounted for (Sá et al. 1998, Oliveira 2000).

*Details of the Policy Experiment* – 1996 market prices are used to determine the values of timber products, purchased inputs (including labor) and transportation costs involved in this activity. Investments (saws, log hauling materials, etc.) required to begin harvesting operations are made and paid for by farmers, who experience negative cash flows from timber operations during the first two years. Establishment costs also include a forest inventory (R$ 20 per hectare), silvicultural treatments (R$ 10 per hectare) and the preparation of an Annual Operation Plan (R$ 10 per hectare) (IBAMA provided such technical expertise to smallholders at one project site in 1996/97 for a fee of approximately R$ 26 per private forest lot – Marcus d’Oliveira, personal communication.) Markets are assumed to exist for and be able to absorb all timber products produced over the entire 25-year decision time horizon, at constant 1996 prices. The volume of sales required to reduce transportation costs, combined with the relatively small legal reserves held by most smallholders, likely requires that groups of farmers combine forested areas and capital to engage in the sustainable harvesting of timber products. Expertise regarding how to select species, fell trees, and produce and market timber products is assumed to exist, perhaps via technical assistance during the initial phases. Finally, farmers are constrained to follow specific rules regarding species selection and felling, and do so at zero supervision cost to farmers when the activity is undertaken.

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15 Technically, formal IBAMA authorization to sustainably manage a forest plot precludes converting any portion of it to agriculture. To examine the financial incentives for doing so, this constraint on forest conversion is not included in this policy experiment, but the issue of the social benefits of adhering to IBAMA rules is revisited in Section 7.

16 Constant 1993/94 prices are used for all other activities; a short-term spike in coffee prices and a short-term, policy-driven dip in the prices of coffee inputs made the overall 1996 price series less representative of longer-term relative prices of agricultural inputs and products than the 1993/94 series.

17 Estimates are based on costs of R$ 2/cubic meter and R$ 1/cubic meter for forest inventory and silvicultural treatments, respectively (Sá et al. and d’Oliveira, personal communication). These establishment costs have not yet been included in the model, but when introduced are expected to slightly decrease the first-year profitability of the system, but not sufficiently to affect adoption or overall system performance.

18 No effort has been made here to assess the financial wisdom of adhering to these constraints. However, logic suggests that in an unconstrained world farmers would select and harvest all of the most valuable species first (controlling for on-farm transport costs) and then move on to harvest the
Results of Managed Forestry Policy/Technology Simulation – Farmers begin to adopt managed forestry in year 1. Initial, but incomplete, investments in chainsaws and oxen are made in year 1 and by year 2 off-take begins (4 cubic meters). Investments are completed in year 2 and off-take increases annually and reaches a maximum in year 5 (36 cubic meters), after which it declines as the stock of forest is slowly depleted by deforestation. The pace of adoption (and increase in off-take) could be slightly faster if all available household labor and cash were devoted to this activity, but some of the labor that could be used for managed forestry is dedicated instead to pasture establishment activities in the month of May during the first 5 years of the simulation period.

Land uses resulting from the simulation of this policy experiment appear in Figure 2; differences emerge vis-à-vis the baseline, without-managed-forestry scenario. Land held in forest in year 25 is approximately ten hectares, as compared to zero area in forest in year 25 of the baseline scenario, with area in secondary forest fallow disappearing, and a slight reduction in the amount of pasture (though this continues to be the predominant land use). Land in annual and perennial crop production is quite similar to that of the baseline scenario. So, over this time horizon and vis-à-vis the baseline simulation, deforestation is slowed, secondary fallow is eliminated, and pasture remains the predominant (though slightly reduced) land use.

The managed forest scenario also generates differences vis-a-vis the baseline scenario in other parameters of interest. Both seasonal labor hiring patterns and the absolute numbers of man-days hired change; much more labor is hired generally (but still subject to the 15 man-day per month limit), and forest extraction activities concentrated in July and August boost labor demand in those months. As expected, seasonal labor use patterns adjust to reflect large increases in manpower dedicated to timber extraction activities over the May-September period (dry season), thereby increasing the on-farm competition for labor during the deforestation season, and providing another source (aside from the profitability of sustainable managed forestry) of downward pressure on deforestation.

less valuable species. Ecological integrity of the forest would be quickly undermined by this harvesting method.
Engaging in small-scale managed forestry increases farm income, especially during years 5 through 9, prior to which substantial start-up costs reduce cash flow. The NPV of the value of total output under this policy experiment, R$55,000, was approximately 8.5% higher than the baseline figure of R$ 50,688. Therefore, while smallholders can earn a living by converting forest to agriculture, their incomes increase if they do so in concert with sustainably managed timber extraction.

Land use proportions, however, are still changing in year 25 in this policy experiment. When land use proportions stabilize (after about 35 years), only .12 has. of forest is left, and of the cleared land 49 has. are in pasture, 2.8 has. are dedicated to annual crop production and fallow land returns to the landscape after year 25, stabilizing at 7.5 hectares in year 35. Allowing small-scale managed forestry, then, slows deforestation, and delays the virtual elimination of the forest by approximately ten years. The predominant land use remains cattle.\(^\text{19}\)

\(^{19}\) Higher timber prices would induce larger amounts of forest retained and higher income levels; see Vosti et al. (forthcoming) for details.
The farm-level costs associated with establishing and managing small-scale managed forestry systems were presented and discussed above, and are borne by farmers, perhaps with support of formal and/or informal credit institutions. The cost of developing, establishing and monitoring these managed forestry systems, on the other hand, represents a substantial social investment by Embrapa, IBAMA and others.

For example, Embrapa-Acre has developed and established a 400-hectare managed forestry system comprised of the legal reserves of 10 smallholder farms. Equipment costs were estimated to be approximately $US 10,000 per year for the first two years. Technical assistance provided by researchers, assistants and field staff during the first five years of the project totaled approximately $49,000 per year, with research support for the following 5 years of the project totaling approximately $US 2,000 per year. Including overhead charges, the total establishment costs over the first 10 years of the project are estimated to be $US 280,000 (undiscounted).

In addition to the system development and establishment, timber off-take and sales will have to be monitored. IBAMA will undertake project monitoring over the entire 25-year period; annual costs of monitoring are estimated to be $US 2,000. Total monitoring costs for the project, including overhead, are estimated to be $US 44,000 (undiscounted).

Total establishment and monitoring costs are estimated to be $US 325,000 (undiscounted). At a discount rate of 10%, the net present value of this stream of costs is approximately $US 228,000.

While the profits associated with small-scale managed forestry could, in principle, be tapped to cover the costs of system development and monitoring, in fact this is unlikely to happen and may even be unwise in cases of poor farm households. Therefore, society at large will likely shoulder these costs.

However, even in the absence of private contributions by smallholders towards the costs of developing and monitoring of managed forestry systems, the social benefits of the system may be large enough to cover a large portion of these costs. Although the benefits to biodiversity conservation (vis-à-vis all alternative non-forest uses) have been demonstrated (Lewis et al.), valuing these biodiversity benefits is so far not practical. Valuing the benefits of carbon retained on farms is feasible. Indeed, Carpentier et al. (2000) found a 28% increase in year-25, above-ground carbon stocks (from 4,021 tons to 5,137 tons) when comparing baseline and managed forestry model simulations. At a value of US$ 7 per ton, the undiscounted, social benefit of US$7,812 per 60-hectare archetypical model farm would contribute substantially to covering such social costs. Scaling up these results to account for the ten farms participating in the Embrapa-Acre project that were 33% larger than the archetypical

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20 Cost data for the Embrapa-Acre project were provided by Braz (personal communication).

21 Prices for carbon spiked at about $12.50/ton in October of 2002, are currently at about $7/ton (Reuters) and are expected to remain in the $6-$7/ton range for the next 5 years, though expert opinions of the range of expected prices increases considerably as the time frame is extended (PointCarbon).
farm examined in the simulation exercises, the amount of carbon saved rises to about 15,000 tons over a 25-year period. At US$7 per ton, the NPV (10% discount rate) of these social benefits amounts to US$ 31,000. If one assumed that farmers participating in the project would adhere to the 50% rule regarding deforestation, then the saving in carbon would be on the order of 104,000 tons, with a NPV (10% discount rate) of social benefits of US$ 96,000.

Hence, the benefit/cost ratio for this pilot project is less than one (US$ 96,000/US$ 281,000 for the scenario respecting the 50% rule), as one would expect. If the project is successful, it is easy to imagine how this ratio could be increased. First, the number of farms adopting this system could be increased at low marginal cost; indeed, for neighboring farms holding forests similar to those examined in the project the marginal cost of expanding participation would be low. Simply expanding the number of farms in the Embrapa-Acre project to 25 from 10 would be sufficient to generate a benefit/cost ratio above one. Second, as with most research projects, many of the silvicultural and social science research results would be relevant for farms over a fairly broad area, thereby making project replication much less costly. Third, there are possible scale economies in monitoring, which would help reduce these costs as well. Finally, and perhaps most important for policy design, selecting farms for participation in managed forestry projects that are ‘closer’ to their 50% forest limits would effectively ‘push forward’ the social benefits (e.g., of carbon retention) which only begin to accrue once this on-farm limit is reached.

CONCLUSIONS AND IMPLICATIONS FOR POLICY

Adding value to forests held by small-scale farmers by developing and promoting small-scale managed forestry can slow deforestation and boost incomes. Indeed, land use system analysis undertaken in the context of in the western Brazilian Amazon reports returns to land and labor for this system that are far greater than the returns generated by traditional forest extraction activities and even by traditional pasture/cattle systems. However, this narrowly focused analysis does not consider the bureaucratic, knowledge gap and other obstacles to the legal extraction of timber products, all of which reduce the expected returns to managed forestry and hence limit its adoption to date.

If these obstacles could be eliminated, as they were in the model simulations presented here, smallholders would adopt managed forestry.

However, the adoption of small-scale timber extraction, even if practiced sustainably by smallholders, will not halt deforestation. Indeed, allowing farmers to practice this activity merely delays by a decade the long-term amount of forest retained on the small farm. At the margin, the financial returns to agricultural activities continue to dominate the returns to forest-based activities, despite the introduction of small-scale managed forestry as an option. Therefore, the real **environmental** gain associated with small-scale managed forestry is the slowing of deforestation and the gaining of instance to devise other solutions to the deforestation problem.

The welfare gains enjoyed by smallholders, though, begin almost immediately and generate an overall increase in income of approximately 8.5%; small-scale farming in
the western Brazilian Amazon pays reasonably well and combining managed forestry with farming increases household income.

The likelihood that smallholders will extract timber products sustainably is not high for several reasons, all relevant to policymakers. Profitability of illegal and unsustainable extraction schemes will likely discourage farmers from adhering to the strict guidelines of the proposed policy/technology package. While community-level institutions and mechanisms for ensuring sustainable harvesting are emerging, they are generally untested. Important institutional investments (such as timber extraction monitoring and verification systems) need to be made to ensure that the extraction of timber products is done sustainably.

Efforts to speed up and improve timber certification processes and to increase demand for sustainably produced timber products could be undertaken alongside efforts to promote small-scale managed forestry systems; doing so would increase expected income gains and further slow deforestation. That this could also increase demand for unsustainably produced timber products only underscores the importance of monitoring (perhaps as part of certification).

The use of cleared land was not changed in important ways by the introduction of the managed forestry technology/policy package; cattle ranching remained the dominant activity. Therefore, small-scale managed forestry should not be promoted as an instrument for altering use of cleared land.

Finally, society has so far borne the costs of developing, establishing and monitoring small-scale managed forestry systems. The net present value of establishment and monitoring costs of the Embrapa-Acre pilot project, for example, were estimated to be approximately US$228,000. Smallholders have not been required to pay for these services, but research suggests they could pay some of these costs from income gains associated with the system, and that smallholders would be willing to do so. But the social benefits associated with this system may be sufficient to cover a large portion of these costs. The net present value of carbon benefits (valued at US$ 7/ton) alone of the 10, 80-hectare small-scale farms participating in the Embrapa-Acre project was estimated to be approximately US$ 31,000 if deforestation continued beyond the 50% limit, and US$ 96,000 if the 50% limit on deforestation were respected. Expanding this pilot project would almost surely and quickly lead to a benefit/cost ratio greater than unity, suggesting that groups benefiting from reduced carbon emissions have an important role to play in paying for the development, establishment and monitoring of this system in the study region.
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