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A Bioeconomic Rationale for the Expansion of Tree Planting by Upland Philippine Farmers

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ABSTRACT

Upland farmers have long been cast as key actors of deforestation, but in the wake of timber scarcity brought on by deforestation and logging restrictions, many have adopted a new role—tree planters. Responding to market signals, upland farmers in Mindanao have spontaneously been planting fast-growing timber species on parcels going out of annual crop production. What is the prospect for expanding the role of this sector in meeting national tree planting goals? Research was conducted in Bukidnon Province to compare the potential returns from trees and annual crops, and determine whether the typical farm forestry practice of intercropping trees and crops conferred efficiencies that could make it competitive with larger scale plantation projects. A bioeconomic model developed from the research suggests that timber cropping provides higher annualized returns under fertility and labor/capital constraints, and that optimized intercropping designs produce higher annualized returns than monocropping due to growth benefits to the trees and savings in weeding labor. We therefore suggest that farm forestry is economically efficient, environmentally advantageous, and socially empowering, and that policy should be pursued to facilitate its expansion by providing information such as best management practices and by removing disincentives to tree planting such as harvesting restrictions and tenure insecurity. In our view, there is little need for publicly funded planting of fast-growing exotics. Forestry investment should instead be directed at protecting and enhancing the nonmarket benefits of complex forests.

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INTRODUCTION

Once endowed with 92-percent forest cover, the Philippines is now a net importer of timber after a century of accelerated deforestation (Kummer 1992; World Resources Institute 2000). Planting of trees and forest management in the Philippine uplands are both desirable because they take the pressure off the remaining primary forests and are important ecologically and economically for the upland landscape. The Philippines has been committed to reforestation since at least 1988. The Master Plan for Forestry Development of 1990 set a goal of 1.8 million reforested hectares (Philippine Council on Sustainable Development 1997). From this derives the essential policy question: what proportion of the reforestation target is to be met by the private sector (whether companies or individual landowners) and what proportion is to be met by the state, either in the form of direct reforestation work or subsidies and incentives?

To answer this question, information is needed on the viability of private tree planting and reforestation efforts for two reasons: (1) from the public perspective, it is inefficient for the government to pay for something that the private sector will do anyway, and (2) there is evidence that state-sponsored reforestation efforts, in which people are paid to plant trees but own neither the land nor the trees, have been less successful than private initiatives. Pasicolan et al. (1997) detail the failings of several such projects in the Philippines between 1988 and 1992, which cost around US$240 million but with a target success rate of only 10 percent. These figures mirror the disappointing results of the country's deforestation efforts in the first half of the 1990s. The World Resources Institute (2000) estimates that total forest cover in the Philippines declined by as much as 3.54 percent in 1990-1995, the fourth highest loss rate in the world after Lebanon, Jamaica and Afghanistan. Although plantation area increased by 21 percent or 387,000 hectares, such increase represents only 29 percent of the total forest area lost during that period.

Said losses have resulted in increased domestic prices for timber, which has stimulated private tree planting by, among others, smallholder farmers in the uplands (Garrity and Mercado 1994). The model of small-farm forestry runs counter to the prevailing view of upland farmers as encroachers and destroyers of forests, and probably represents a post slash-and-burn stage in upland development tied to the level of agricultural intensification and the ability to continuously cultivate land parcels (Poudel et al. 1998). Widespread farm forestry would, in theory, have important ecological feedback mechanisms, because from the perspective of people living on forest margins who have planted their own trees, forest cutting not only becomes unnecessary but also undesirable. The degree to which natural stocks are protected should have a positive effect on the price of their own wood, and an incentive would exist for community-based forest protection and the associated conservation of biodiversity. Tree stands provide additional public benefits in the form of sequestered carbon both above- and below-ground, permanent or semi-permanent plant canopy cover to reduce soil erosion, improved watershed hydrology, and diversification away from pesticide-dependent annual cropping of maize and vegetables.

While spontaneous tree planting has increased in the uplands in the recent past in response to market signals, the potential for widespread expansion of farm forestry is uncertain. To a large extent, this depends on the relative returns of forestry to agriculture as well as the efficiencies of small-farm timber production that would make it competitive with industrial plantations. Experiences of market-oriented tree planting by small farmers in developing countries are few, but related examples suggest the potential of this model. Small farms produce a majority of Indonesia's total rubber output due to efficiencies not realized at larger scales (Poudel et al. 1998). The great success of New Zealand's farm forestry program results from the improving financial prospects of private forestry to the extent that its returns are three to four times those of traditional agricultural enterprises such as sheep and beef farming (Capill 2000).

This paper reports on farm forestry experiments initiated in Lantapan, Bukidnon, in 1995 to investigate the potential of farm forestry. Of particular interest was whether small farmers are likely to realize significant benefits from the common practice of intercropping food crops with trees at the early stages of the rotation. The efficiency with which polycultures (mixtures of two or more distinct interplanted species) utilize resources is generally greater than that of the same species planted as monocultures (i.e., each species planted in separate lots). Large-scale reforestation projects rarely invest on the management needed to undertake polycultures. If such investment indeed produces enhanced returns, then small farmers would likely have comparative advantages in production that could offset the probable comparative disadvantages in harvesting and transportation. In this report, we focus on small-farm cropping systems and do not attempt to include an analysis of social welfare or nonmonetary benefits of farm forestry.

SITE DESCRIPTION, EXPERIMENTAL DESIGN AND MODEL DEVELOPMENT

The study was conducted on a farm on the footslopes of Mt. Kitanglad in Lantapan. The region is well suited to tree planting because of the warm temperatures and high rainfall in the area, and its location outside the typhoon belt. The fast-growing leguminous tree *Paraserianthes falcataria* was planted at a density of 1,000 trees per hectare in 16 plots. In eight plots, the trees were intercropped throughout the first two years with a sequence of cabbage and maize, and in the other eight plots as a monocrop. Each annual crop was also grown simultaneously as a monocrop. All the trees were given starter fertilizer, and all the crops were well fertilized according to local practices. Trees were pruned according to local practices, and tree-only plots were slashed and weeded once per growing season. Tree height and diameter was measured at least once a year. Annual crop productivity was measured at each harvest, and quantity and price information were recorded for all inputs and outputs, including labor.

Intercropping ceased upon canopy closure after two years. The relationship between tree growth and intercrop yield decline became the central competition function in a bioeconomic model to estimate total system returns for a given tree density, tree rotation length and years of intercropping (Nissen and Midmore 2002). This model was first developed after three years of tree data but has now been updated based on five years of tree growth. For more details on the experiments and development of the model, see Nissen et al. (2001).

RESULTS AND DISCUSSION

Growth of *P. falcataria* was rapid in all plots, but more in intercropped plots (Table 1). The three-centimeter-width advantage developed in the first two years has remained through year 5, while the height advantage has slightly increased. A portion of the difference in mean growth results from significantly more mortality and stunting in sole trees (15%) than intercropped trees (7%). This difference is perhaps due to vigorous weed pressure in sole tree plots, despite the quarter-annual removal of weeds around the tree base and slashing of remaining weeds. This weeding regime doubled the site preparation and maintenance costs of sole trees compared to intercropped trees, and still appeared to be less effective. This labor savings is the first source of efficiency gained by intercropping.

Table 1. Mean diameter at breast height (dbh) and stem length of *P. falcataria* grown with (Agroforestry) and without (Forestry) intercrops for the first two years

System	Diameter (cm)				Height (m)			
	Month				Month			
	12	25	37	59	12	25	37[a]	59[a]
Agroforestry	5.4 (.16)	11.6 (.34)	14.8 (.50)	17.3 (.72)	4.7 (.18)	11.6 (.39)	14.1	17.6
Forestry	4.1 (.18)	8.6 (.40)	11.7 (.66)	14.2 (.82)	4.1 (.27)	9.6 (.57)	11.6	14.8
P > F	*0.0001*	*0.0001*	*0.0004*	*0.0001*	*N/S*	*0.0001*		

[a] Estimated from sampling of diameter-height relationship

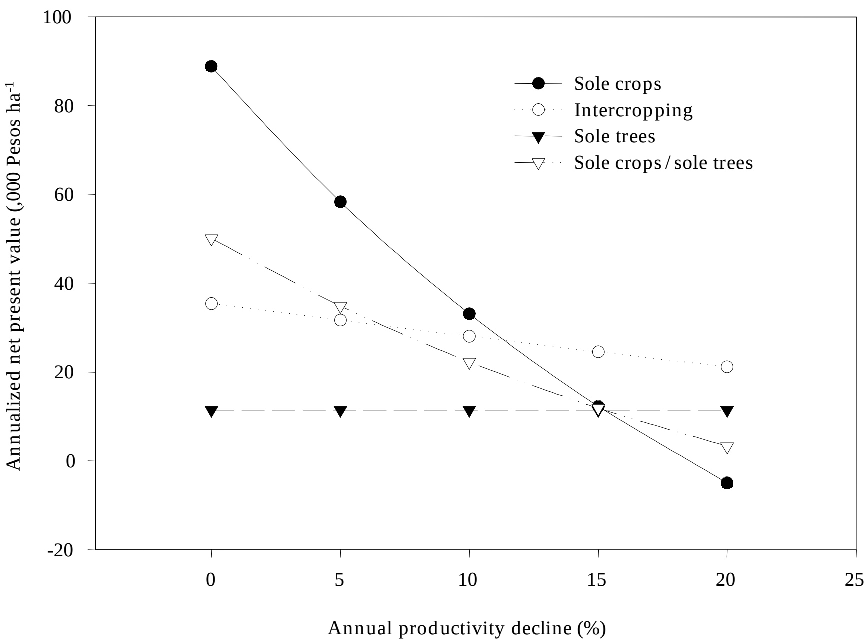
In nutrient- or water-limiting situations, the intercrops themselves can function as weeds and promote competition. An important feature of much of the intercropping in Lantapan is the choice of high-input vegetables and maize as intercrops. Typically high crop fertilization rates in our experiment probably explain the superior growth of intercropped trees even after mortality is factored out. Based on the levels of nitrogen (N) and phosphorus (P) fertilization and estimated levels of crop uptake and export, an estimated excess of 496 kg N per ha and 243 kg P per ha were applied to crops over two years. Future crops can benefit from relatively immobile nutrients such as P, but mobile nutrients such as N may volatilize or leach below the root zone of ensuing crops, and unless captured by deeper-rooted trees, may escape the system. The apparent benefit to tree growth of residual fertilizer supports this safety-net hypothesis and appears to be a second source of biophysical and financial efficiency.

Evaluating system returns was a combination of projecting tree volume growth through the length of a rotation and estimating the tradeoffs between complementary and competitive interactions in intercropping systems. Tree growth projections were based on equations developed in Mindanao for *P. falcataria* by Uriarte and Piñol (1996), and the tradeoffs were evaluated with the bioeconomic model, in which intercropping length and tree density could be adjusted. Crop type and price variations were removed as variables by creating a generic one-year rotation of maize and vegetables, and setting price constant to the two-year mean.

Annual volume growth over the first five years was an estimated 26.4 m^3 for intercropped trees and 21.0 m^3 for monocropped trees, very similar to the growth rates of *P. falcataria* achieved by the Paper Industries Corporation of the Philippines (PICOP) on its plantations and fields run by its cooperating farmers (Hyman 1983; Anino 1997). Although the maximum volume increase occurs in just the second year for this fast-growing species, the economically optimal rotation length was estimated to be seven years due to premiums offered for larger-sized logs and a discount rate equal to the projected rate of increase in timber value. Few tree planting farmers we interviewed anticipated cutting all their trees within seven years, placing a high value on trees as a form of savings and emergency capital. However, since farmers who have until this time been constrained in planting trees will likely have a higher discount rate, a seven-year rotation was selected. Over this period, the value per hectare of increased tree growth due to intercropping was estimated to be P19,700, or P2,814 annually. Reducing initial tree density from 1,000 stems per ha to 500 stems per ha greatly improved intercropping returns by reducing intercrop competition while only slightly reducing total stand volume (Nissen et al. 2001).

Even at optimal rotation lengths, one should note that the annual returns to fast-growing trees are much less than those of consistently high-yielding annual crops over the same time period. In our model system, monocropped trees were worth about P11,400 per year, only 13 percent the value of annual crops of nondeclining yield (Figure 1). Such is the value of vegetable crops under high-yielding conditions that the small declines in yield resulting from intercrop competition make intercropping one hectare less profitable than planting crops and trees independently on half hectare each. This disparity is probably higher in our data than among farmers. Yields of our annual crops were in the top of the range for the region and about double the local average (Tautho and Kumori 1991; Poudel et al. 1999a). We were cultivating previously fallowed land, and have extrapolated two-year returns out to the length of the rotation. Maintaining consistently high yields is difficult in Lantapan, where the mean natural slope for the main vegetable parcel is greater than 15 percent (Poudel et al. 1998). On a cropping-system site at 40 percent slope in the same area, cabbage yields on the lower half of the plots were 78 percent higher than the upper half after two and one-half years (Poudel et al. 1999b), and the combined cabbage yields in the last year were 50 percent less than the previous year (Poudel 1998). Pest pressure also tends to increase in continuously cropped plots. Incorporating a productivity constraint into the projections significantly changes the attractiveness of vegetables compared to trees. Assuming constant

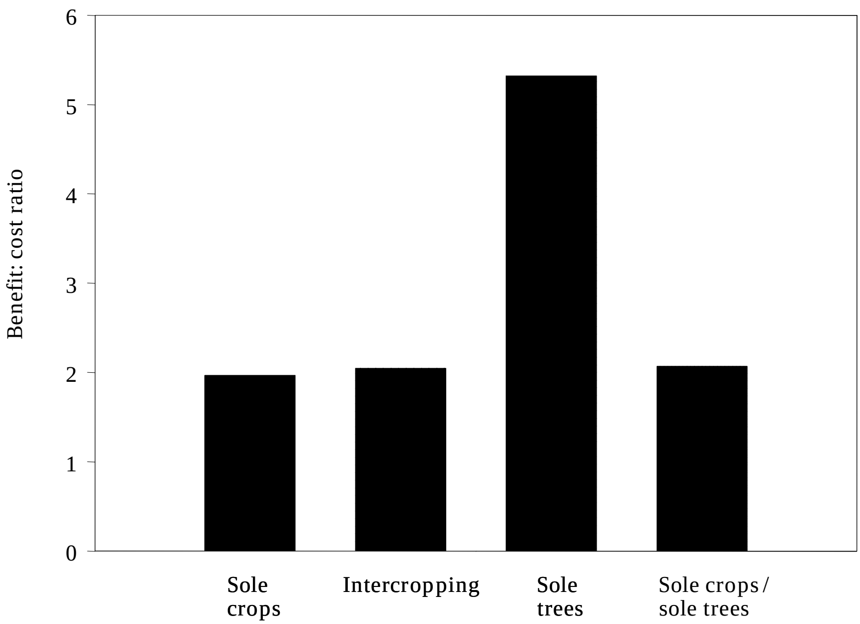
Figure 1. Sensitivity of annual net present value of cropping systems to declines in annual crop productivity. Sole crops/sole trees is the mean of the two components and serves as an index with which to evaluate tradeoffs of intercropping. Trees are planted at 500 stems per hectare in both sole trees and intercropping.



inputs, an annual productivity decline of 7 percent reduces returns from sole cropping below intercropping, and a decline of 16 percent reduces the value of crops below the value of trees (Figure 1).

However, the attraction of trees is not fully captured in the calculation of per hectare returns. Results from a survey we conducted showed that 22 percent of all vegetable farmers had land that had been fallowed for longer than a year, with no plans for bringing it back into production (Poudel et al. 1999a). The intense labor demands of vegetables, which is three to five times as much as maize in our experiments, as well as the increases in off-farm employment, create a premium for planting options with low labor requirements. The labor requirement for monocropped trees was less than 10 percent that of vegetable crops over the first two years, and reduces significantly after canopy closure. A benefit-cost analysis in which all labor is priced at local wages shows the superior returns of trees to labor and inputs, even under no productivity constraint (Figure 2). Because such a large portion of the costs in the sole crop / sole tree system comes from the crops, the ratio in this system is about equal to that of intercropping, which realizes significant savings in site preparation and weeding costs. With any decline in crop productivity, the benefit-cost ratio of intercropping exceeds both sole crops and sole crops+sole trees. Financial returns to both land and costs are perhaps the main factor that generates tree planting in the uplands, especially on degraded soils.

Figure 2. Benefit-cost ratio for modeled cropping systems over a seven-year rotation. Trees are planted at 500 stems per hectare and no productivity decline is included.



Anticipating the general rate of productivity decline is an important feature of designing optimal systems (Figure 3). Perhaps roughly correlated with slope, farmers are likely to have a sense of this number based on personal history of plot and crop rotations.

Figure 3. Effect of intercropping length (in years) and annual decline in crop productivity on tree-crop systems in which trees are planted at 500 stems per hectare

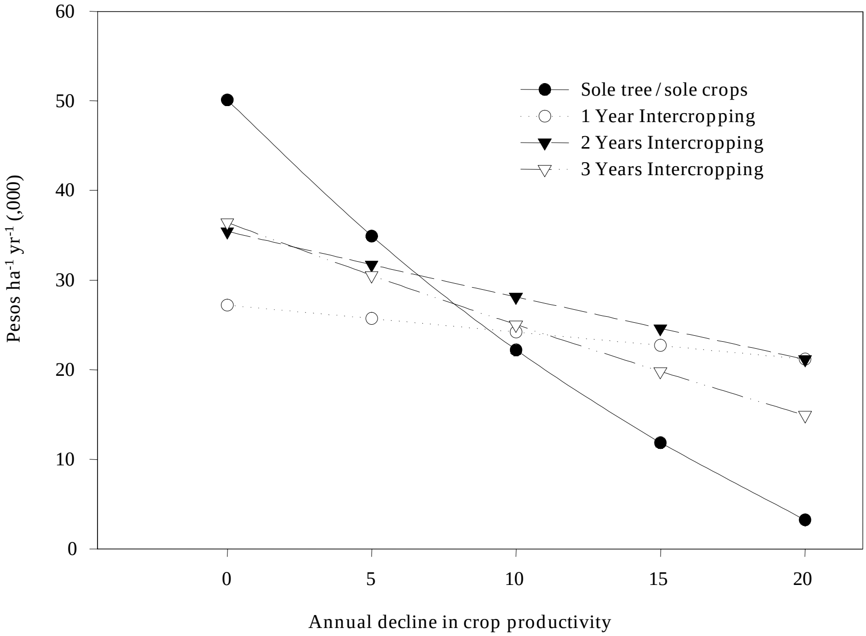


Figure 3 summarizes in graphical form the general trend observed among upland farmers, who stated that they were planting trees on their least desirable parcels of land while leaving their best land for vegetable production. Planting trees on the contour may lessen productivity declines due to erosion, in that they provide a perennial no-till strip that promotes the formation of natural terraces (Alegre and Rao 1996; Poudel et al. 1999b). Other possible long-term benefits of tree-fallow systems, even where most of the biomass is exported off the plot, need to be investigated.

IMPLICATIONS FOR POLICY

The increase observed in farmer-planted timber in Lantapan is a spontaneous response to market forces, in which tree prices have increased to a level high enough to provide acceptable returns to land and superior returns to costs for labor-limited farmers. Farmers who must abandon plots after short periods of cropping because of fertility losses or pest pressure may increase their total returns by incorporating tree seedlings into the system one to two years before the expected fallowing date. By establishing trees among intensively managed, highly fertilized intercrops, farmers minimize the level of nutrient export associated with tree rotations without specifically fertilizing the trees. Site preparation and weeding costs are also greatly reduced, making initial investment costs quite small. In the study, establishment and maintenance of trees over the first three years totaled US$246 in 1997, one-fourth the amount cited by Pasicolan et al. (1997) for government-sponsored reforestation projects in the Philippines between 1988 and 1992. A comparison of growth and economic data between the Lantapan sites and plantation forestry projects from around the world show that the advantage of reduced establishment costs (due to reduced labor requirements) increases as the discount rate increases (Table 2). Lack of development of the farm forestry enterprise in Lantapan leads to relatively high harvesting and local transportation costs, but even at current levels, Philippine farmers apparently enjoy returns comparable to international large-scale plantations. Wood products have relatively high international transportation costs because of their low value-to-weight ratios, and therefore, an extra level of protection is afforded to the domestic industry (Sedjo 1983). Unlike other commodities grown in the uplands such as vegetables (Coxhead 1997), timber appears to be a product that can thrive without the need for import restrictions.

Given this set of conditions in Lantapan, and probably other upland areas of the Philippines, in which direction should policy proceed to stimulate and expand private tree growing, including nontimber species such as fruit and coffee? We suggest that the spontaneous planting now going on in Lantapan is a response to market forces, and the efficient functioning of these markets is the single most important factor influencing farm forestry. Early reforestation projects in developing countries were often designed as though upland farmers were isolated from market influences, emphasizing low-value subsistence needs such as firewood and even prevent-

Table 2. Comparison of costs and returns of Lantapan farm forestry with plantation forestry projects from different regions of the world. Net present value (NPV) is calculated both at 5-percent and 10-percent discount rates at 1997 constant prices. Data adapted from Sedjo (1983)[a]

Country	Species	Rotation (yrs)	Mean annual increment (m^3/ha/yr)	Initial costs	Subsequent costs	NPV (5%)	NPV (10%)
				(US$/ha)			
Lantapan-Sole trees[b]	*P. falcataria*	7	21	504	1163	1992	1060
Lantapan-Intercropped[b]	*P. falcataria*	7	26	246	1277	3396	2255
USA	*Pinus taeda*	30	12	588	307	3864	420
Brazil	*Eucalyptus spp.*	7[c]	25	1156	1433	5593	2527
New Zealand	*Pinus radiata*	18	25	1008	984	6417	760
Gambia-Senegal	*Gmelina spp.*	10	15	774	553	4041	1507
Borneo	*Pinus caribaea*	15	14	612	917	4092	668

[a] 1979 Sedjo data adjusted for inflation.
[b] Philippine pesos converted at 1997 rate of P25 per US$.
[c] First of three harvests per root stock.

ing selling, with poor rates of spontaneous and sustained adoption result (Arnold 1992). Social forestry programs in India in the 1980s paid too much attention to planting targets and not enough attention to market functions, precipitating a glut of farmer-grown timber and a price collapse. In addition, farmers had to compete with fuel wood supplied to urban markets from state forests at subsidized prices (Arnold 1992). In our opinion, government-funded planting programs of fast-growing exotic species are not only inefficient in their own right but also a direct disincentive to private tree planting.

To be sure, policy instruments to encourage tree planting can work (Zhang and Flick 2001), and we cannot argue that market forces will produce the socially optimal level of tree planting in itself. Yet, given the risks involved in manipulating the market, we suggest other governmental priorities. The first is to facilitate the efficient functioning of markets, which has driven private tree planting to this point. Before adding interventions to make timber planting more attractive, it may be worthwhile to first eliminate the agricultural interventions (in the form of import restrictions) that lead to misallocation of land to annuals (Coxhead 1997). Tenurial insecurity is a well-known obstacle to long-term investment, and current bureaucratic restrictions on the harvesting and transport of planted wood products scramble market signals and add unneeded elements of risk (Venn et al. 2001). Improvements in infrastructure and information will also serve the interests of private planters. Garrity and Mercado (1994) suggest that the public sector could best serve the interests of private reforestation through dissemination of information on prices, best management practices, and uses for improved and diversified tree germplasm while "staying out of the business itself."

The business the public sector should be in, however, is the protection of nonmarket forestry benefits (Wibe 1992), especially those that do not overlap with farm forestry. While a watershed patchwork of farm forests containing primarily fast-growing exotics confers, to some extent, public benefits such as flood and erosion control, carbon sequestration, and reduced chemical inputs, it does not promote other forestry benefits such as plant biodiversity, wildlife habitat, and recreation and tourist appeal. To these ends, public investment in forestry should be directed toward the protection of indigenous forests and, if trees are to be planted, regeneration of complex forests with native species. Public funds would also be well invested in research on management practices and improved germplasm so that farmers may remain competitive with large-scale private plantations with in-house research.

Such is the appeal of entrepreneurial small farmers voluntarily converting land back into perennials, with its potential for rural economic and social empowerment and environmental enhancement, that many will be anxious to spur this development with aggressive tree planting incentives. We recommend restraint, for as long as spontaneous reforestation proceeds in socially desirable directions without subsidies, the global transition from reliance on old growth forest to reliance on planted stocks appears to offer the best incentives available.

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