Social Forestry Reconsidered

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This paper reviews the expectations for forestry's contribution to rural development – and for its special contributions to the most disadvantaged, to women and the landless users of the forest commons. A growing literature challenges some of these expectations; in particular, certain expectations about cultural differences and physical stocks as explanatory factors for patterns of household behavior. This literature could also be used to support a call for sharper definitions of deforestation, improved indicators of the effects of forest resources on the rural poor, and improved design of forest policy interventions. Our paper reviews the literature, suggests some unifying themes, and identifies the critical issues that remain unanswered.

The primary contention arising from this literature is that households follow systematic patterns of economic behavior in their consumption and production of forest resources, and that policy interventions in social forestry should be analyzed with regard to markets, policies, and institutions. Markets for forest resources generally exist in some form – although they may be thin. Successful forestry projects and policies require careful identification of the target populations and careful estimation of market and market-related effects on the household behavior of these populations. Institutional structures that assure secure rights for scarce forest resources are uniquely important in a forest enviornment often characterized by open access resources and weak government administration. Social and community forestry, improved stoves, improved strains of multi-purpose trees, and even private commercial forest operations can all improve local welfare, but only where scarcity is correctly identified and the appropriate institutions are in place. An increasing number of observations of afforestation from developing countries around the world is evidence that forestry activities do satisfy these conditions in selective important cases. The critical point for policy is to identify the characteristics of these successful cases that are predictive of other cases where new forestry activities can be welfare enhancing.

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1 Introduction

Social forestry generally refers to the range of activities associated with forest products, the rural environment, and subsistence agricultural communities. It often features external development assistance intended to benefit these communities and their environments. Over the past ten years, the prevailing wisdom on social forestry as a welfare enhancing technology has run the full course from optimism, even enthusiasm, to a current attitude of caution, and even scepticism. Meanwhile, a developing body of analytical literature is beginning to provide evidence. This literature consistently supports the optimistic view – but only under carefully selective conditions.

This is a good time to examine the evidence, to identify reasonable hypotheses about the successful uses and limits of social forestry, and to identify the important questions that are yet to be addressed. This is our objective.

Our fundamental contention is that successful social forestry activities must be assessed in terms of their contributions to human welfare. This contrasts with a view that forest cover, therefore forest protection and afforestation, is a useful end in itself. The latter view bolsters policy decisions to halt deforestation or policy objectives to maintain a fixed share of land in forest cover, "one third of the land" in the case of India (Rao and Srivastava 1992) or all land with greater than an eighteen percent slope in the Philippines.

Physical standards are poor measures of human welfare. Welfare, including the welfare gains due to social forestry activities, is revealed by household preferences in the context of local markets, institutions, and policies – not measures of physical stocks. Furthermore, we anticipate that those rural households that are affected by social forestry follow fairly systematic patterns of behavior with respect to these markets and the policies that affect them. This perspective is consistent with Dewees' (1989) earlier observations for social forestry, with Schultz' (1964) observations for the broader experiences of farm households, and with the general literature of rural development.

Nevertheless, some important differences do distinguish household participation in agriculture from participation in social forestry. The source of these differences is the open access characteristic of the natural forest. This characteristic accompanies important gender and wealth distinctions in the classes of resource users and seasonal differences in forest use itself. It supports insights to resource use (by whom, when, and for what purposes) that are different from the agricultural experience where households tend to have more secure rights to their lands and capital. Questions about deforestation, sustainable use, and reforestation each require insights to the use of the open access forest and to the conditions that cause local farm households to shift from reliance on this resource to the secondary forests that are beginning to appear on the farmers' own agricultural lands.

Our paper begins by revisiting the social forestry concept itself and the general expectations many hold for its beneficial impacts on rural communities and their environment. These expectations lead us to the new questions, as well as the doubts that some practitioners eventually began to raise. Both the original expectations and the new questions induce us to review the empirical evidence. We will review the evidence on i) consumption, ii) production and supply, and iii) investment in new technologies, before submitting iv) a summary characterization of the general forest environment, and then v) closing with our view of the lessons for policy analysis.

We will find that market incentives identify the most likely households to invest in any new technology only when the return is good, the rights to the technology and its products are secure, the risks are acceptable, and the policy environment is stable and predictable. We think that some, but not all, of the critical market information is well understood, and that there is some comprehension of the impacts of forest policies and other institutions. Nevertheless, we think the factors that explain which regions and households actually do invest are poorly understood, that the opportunities for improved performance by local institutions are largely unexamined, and that the crucial impact of the overall national or regional policy environment has been almost entirely ignored.

2 Background: Prevailing Wisdom

As the concept of social forestry has become more widely accepted, its definition has become more elusive. It includes local community and local private activities, often by subsistence households. For our purposes, it refers to the production and use of fuelwood, forage and fodder, fruits and nuts, latex, gum, and various other non-timber forest products. It includes domestic uses and local market exchange of construction timbers – but it does not include industrial wood production or domestic woodlot production for shipment beyond local markets.

The applications of social forestry have grown beyond its original conception as seedling distribution, planting and technical assistance to incorporate watershed management and the broader class of forest contributions to the natural environment. Its practitioners recognize the soil sustaining properties of trees and good forest management. They also recognize the indirect gains from substitution; in particular the gains from substituting woodfuels for agricultural residues and the gains from introducing improved stoves. When woodfuel replaces dung and straw the latter remain in the fields where they add structure and nutrients that help sustain depleted soils. Improved stoves decrease the consumption of combustible material and, thereby, save both forests and soils.

Social forestry is seen all the more favorably because those who benefit from it are often the most disadvantaged: women, and the rural poor, and especially landless users of the forested commons. In many developing economies it is a woman's task to collect the materials provided by the forest, and the forested commons is a resource of last resort for the poorest households. Especially in times of greatest economic stress, it can become a source of both food and marketable products.

In sum, social forestry has always had a local household or community orientation and the effects of activities that increase the occurrence of trees and forests on the local landscape seem to be uniformly positive. The additional contributions of social forestry to global concerns for reforestation and environmental sustainability are clearly positive as well.

The rural character of forestry means that many market transactions and a substantial amount of consumption from the forest never appear in any country's national accounts. Nevertheless, various estimates have been calculated. Some suggest, for example, that hunting generates 20–50 percent of cash income for forest villages in developing countries, and that wood constitutes fourteen percent of overall energy consumption in developing countries in general and nearly fifty percent of energy consumption in Africa (cited in Persson 1998). In a summary measure from the most complete attempt to date to incorporate non-market environmental and resource values in the national accounts, Peskin and delos Angeles' (IRG with Edgevale Assoc. 1994) estimate that subsistence household use of the forest is the single largest undervaluation in the Philippine accounts, larger than water or air pollution or soil depletion, and larger than subsistence consumption of agricultural or fisheries products. It is a reasonable hypothesis that subsistence households in other developing countries obtain comparable large relative values from their forests as well.[1]

The institutional budget for forest development projects is good evidence of a policy commitment that is consistent with these observations. The World Bank's recent annual commitment has been in the neighborhood of US$250 million. The Bank, through the Global Environmental Facility, administers another US$20–25 million annually to protect biodiversity that largely occurs in forest environments. Bilateral aid agencies, regional development banks, and local government agencies contribute additional sums. In India, for example, social forestry projects were 25 percent of the national budget for rural development in the late 1980s (Sharma, McGregor and Blyth 1991). India paid a staggering 35 billion rupees for afforest 13 million hectares (Kajoor 1992). Almost all of these forest development activities have important links to the local human populations that live in and around the forest.

Finally, the spontaneous and independent tree planting undertaken by many local farm households around the world is the best evidence of the on-the-ground success of social forestry. Our own experiences include examples in Pakistan, India, Nepal, Indonesia, the Philippines, China, Vietnam, Ethiopia, Kenya and Malawi. Often the local magnitude of the tree planting activity is small but it can accumulate to real importance across broad regions. In Bangladesh, for example, local farm production accounted for 3/4 of all timber and fuelwood consumption in the 1980s (Douglas 1982). It probably accounts for an even larger share now.

Nevertheless, despite the evidence of success, there have been many failures as well, and these failures have generated a healthy scepticism among practitioners. More constructively, evidence of both sterling successes and stunning failures encourage questions of "why some social forestry activities succeed while others fail" or "what distinguishing characteristics of the successes would predict success in future introductions of new social forestry technologies"?

We might anticipate that failures occur where non-forest consumption and non-forest uses of household labor are more important than forest consumption and production. Surely it is reasonable that some poor households and some communities have more immediate concerns with food than with forestry. This observation is related to an income or household budgetary effect and we can anticipate greater likelihood of success where forestry occupies a larger share of the household budgets of income or effort. In addition, many have pointed to the importance of local institutions, and especially to well-established property rights for trees and forest land, as prerequisites for successful long-term forest investments.[2]

Finally, Byron (1997) points out that the changes that occur in the course of normal development can be a deterrent to social forestry. For example, the demands for some forest products decline as income rise. As the values of forest products rise, the pace of substitution away from them also increases. Furthermore, the expanding commercialization that accompanies development modifies gender roles, inter-household relationships, and the competition for property rights and, thereby, modifies production and consumption and the attraction of specialized social forestry activities.

Can we build on these insights on income effects, property rights, and changes in overall economic conditions to create a broad basis for anticipating the locus of successful social forestry investments? That is our task in this paper.

3 Responses to Scarcity

Both global concerns for deforestation and local concerns for improved household welfare can be expressed in terms of scarcity and prices. Greater deforestation means increasingly scarce forests; therefore, increasingly scarce forest products. Increased scarcity means higher prices and greater opportunity for welfare enhancement by any of the myriad of social forestry activities that decrease forest consumption or expand forest production.

Godoy (1992) supports this argument with 21 regional examples of farmers in Africa, Asia, and Latin America who responded to high forest product prices by planting trees. Godoy also points out, however, that high prices are not a sufficient condition for tree culture. Our own observation is that rising prices flag a potentially emerging opportunity for social forestry but an opportunity that is realized only when prices rise to a level sufficient to induce substitution, either substitution of alternative sources of forest products or substitution of altogether different non-forest products for the forest products.

The first part of this argument, and Godoy's evidence, encourage us to examine the literature on household price responses in the consumption and production of forest products. The latter part of the argument – that high prices alone are insufficient – encourages us to examine other factors as well as the own-price of forest products, factors like household income and demographic characteristics and factors like the prices of substitutes.

Markets may be thin but they do exist – even for most minor forest products. Moreover, even subsistence households generally participate in some markets.[3] And when they do not trade in the market for a particular product, they could – because local markets do exist. Households would participate if market prices fell sufficiently to induce them to purchase rather than to expend

Table 1. Consumption responses: price.

Study	Location	Forest product	Measure	Elasticity
Cooke (1998a)	Nepal's hills	fuelwood	demand shadow price	–0.25*
		forage	demand shadow price	–0.10*
		fodder	demand shadow price	–0.11*
Mekonnen (1998)	Ethiopia	fuelwood	demand shadow price	–0.40*
		dung	demand shadow price	–0.72*
Amacher, Hyde & Kanel (1998)	Nepal's hills	fuelwood	market demand price	–1.47*
	Nepal's tarai	fuelwood	market demand price	–0.21
Amacher, Hyde & Joshee (1993)	Nepal's hills			
	low income	fuelwood	collection time	–0.28*
	high income	fuelwood	collection time	–0.84
Heltberg, Arndt & Sekhar (1998)	Rajasthan, India	fuelwood	collection time	–0.11*

Notes: a) Cooke and AHK found that household consumption was more responsive to (implicit) wages than to prices. Mekonnen found that consumption was at least as wage responsive as price responsive. b) Dung is found in the fields, but also in the same open access lands that are sources for fuelwood, forage, and fodder. c) Collection time is a proxy for labor opportunity cost in AHJ and HAS. * indicates statistical significance at least at the 0.10 level.

their own scarce labor collecting the product for their domestic use. When households collect for their own use, they are revealing that the value of the labor they expend in collection is less than the market price of the product but greater than the wage their labor would earn in alternative employment.

This reasoning means that market information on forest products is valid even in subsistence communities – but it is insufficient because the household's consumption and production decisions are inseparable. That is, household production decisions affect consumption, and *vice versa*. An economic modelling approach known as the "new household economics" accounts for this non-separability. It has been applied widely in agriculture, and more recently in several forestry cases. We will rely on this literature and evidence from surveys of rural households to sort out the factors explaining household responses to scarcity.

3.1 Rural household consumption of forest products

Table 1 summarizes the empirical evidence on rural household responses to market prices for forest products. It features the primary forest products in each region of inquiry, but the preponderance of evidence is on fuelwood because fuelwood is the most widely used forest product for rural households. For example, market fuelwood purchases account for as much as 20 percent of household cash outlays in central Malawi (Hyde and Seve 1993), and market fuelwood production is the largest share of the 38 percent of all household income that comes from the forest in one district of Sri Lanka (Bogahawatte 1997). The FAO estimate for the annual world value of fuelwood is US$42 billion, perhaps 10–15 percent of which is sold in the market (cited in Persson 1998.)

Most observers have found that the household consumption of forest products is price inelastic regardless of the forest product – although consumption is less inelastic in the arid uplands of Ethiopia for example (Mekonnen 1998), than in the cool moist hills of Nepal (Cooke 1998a). Cooke noted that household demands are more price inelastic when corrected for seasonal differences in consumption patterns – which are influenced by seasonal differences in weather, seasonal labor availability, and household storage opportunities. Cooke's households are also more wage responsive than price responsive, a condition that raises two possibilities: a) as prices rise, the implicit wage for collecting forest products for the household's domestic use becomes a relatively more important determinant of household consumption, or b) higher wages are indicative of higher incomes and household income or wealth is more important than market prices as a determinant of consumption.[4]

Amacher, Hyde and Kanel (AHK 1998) drew similar conclusions for fuelwood in Nepal's lower elevation and drier tarai region – although not for the breadth of Nepal's hills – and they agreed with Cooke that wages are a more important factor than prices in the household consumption decision.

Amacher, Hyde and Joshee (AHJ 1993) and Heltberg, Arndt and Sekhar (HAS 1998) might take the argument about the relative importance of wages a step further. They found either little price variation (AHJ) or little evidence of market purchase (HAS). Rather than price, they chose to focus on collection time, a measure of the labor opportunity cost and a proxy for the importance of the household wage. Both AHJ and HAS observed inelastic household responses to this measure. Inelastic collection time means that, while households do respond to deforestation and increasing scarcity by decreasing consumption, the consumption effect is small and it is dominated by offsetting increases in collection time. This is not a satisfying finding for those who anticipate that rational household behavior will solve the problems of fuelwood scarcity and deforestation. If the major response to scarcity is an increase in collection time, then increasing scarcity does not induce increased forest protection.

This finding also raises questions about the source of any increase in collection time. Is labor a slack variable, such that households forego little by extending greater effort in fuelwood collection? Or does an increase in collection time mean that less time is available for household chores like agricultural activities, food preparation and childcare? Many have presumed the latter. We will turn to the empirical literature on the question in our discussion of household production.

3.1.1 Income Effects

The observation on the relative importance of wage effects was consistent across all of these analyses. This observation, together with Byron's suggestion that forest products may even be inferior goods (consumption declines as incomes rise), encourages us to examine income effects. Negative income elasticities would indicate inferior goods. Small positive income effects would indicate necessary goods which households consume at relatively constant levels regardless of their wealth. Inferior goods and necessary goods typically (not always) consume a small share of household budgets and are of small consequence to many important household decisions.

Indeed, the seven analyses reported in Table 2 suggest that the effect of household income on the consumption of forest products is generally small, and that some forest products are inferior goods in some economies. Furthermore, two of these analyses suggest that the household's income source does not alter this finding.[5] The source of household income suggests something about the household's lifestyle, or at least how dependent the household is on its own agricultural land. Mekonnen and AHJ both found that it does not matter whether the household relies on income from its agricultural production, from the hire of its labor, or from remittances. In each case the household's income level has only a small effect on its consumption of the most important forest products.

The negligible income effect is one reason why many households and communities around the world have not been especially receptive to external forestry assistance despite local deforestation and rising prices for forest products. We note that this argument corresponds well with Godoy's point that high prices are important, but that they are an insufficient incentive for many social forestry activities.

3.1.2 Substitution

To find those households with sufficient incentives, we need evidence of substitution away from the forest product or into substitutes from

Table 2. Consumption responses: income or wealth.

Study	Location	Forest product	Measure of income/wealth	Elasticity (or coefficient)
Cooke (1998a)	Nepal's hills	fuelwood	upland land area	(+)
		forage	upland land area	(–)*
		fodder	upland land area	(+)
Mekonnen (1998)	Ethiopia	fuelwood	labor income	0.063*
		fuelwood	non-labor income	0.03
		dung	labor income	–0.02
		dung	non-labor income	–0.02
Amacher, Hyde & Joshee (1993)	Nepal's hills			
	low income	fuelwood	agricultural income	–0.31*
		fuelwood	exogenous income	–0.20*
	high income	fuelwood	agricultural income	0.0005
		fuelwood	exogenous income	0.002
	low income	agricultural residues	agricultural income	0.36*
		agricultural residues	exogenous income	0.05
	high income	agricultural residues	agricultural income	–0.0004
		agricultural residues	exogenous income	–0.001*
Amacher, Hyde & Kanel (1998)	Nepal's hills	fuelwood	farm size	0.0005
	Nepal's tarai	fuelwood	farm size	0.07
Heltberg, Arndt & Sekhar (1998)	Rajasthan, India	fuelwood	farm size	–0.25*
Shyamsunder & Kramer (1996)	Madagascar	fuelwood	rice production	–0.01*
		palm leaves	rice production	–0.01*
		wood crab	rice production	0.00
Bogahawatte (1997)	Sri Lanka			
	low income	fuelwood	total income	< 1
		medicinal plants	total income	< 1
		mushrooms	total income	< 1
	high income	fuelwood	total income	< 0
		medicinal plants	total income	< 0
		fuelwood	total income	< 0

Notes: a) The household's private land area is a proxy for income or wealth for Cooke, AHK, and HAS. Household rice production is a proxy for income for SK. b) Agricultural residues include dung, and also crop residues like straw. Dung is found everywhere that cattle roam, including in the forest. Straw, of course, is not a forest product. c) Cooke did not calculate an elasticity but we can infer elasticities of less than or greater than one from her estimated coefficients and sample size. * indicates statistical significance at least at the 0.10 level.

secondary forest "plantations". Table 3 reviews the evidence for substitution in consumption. One study (Cooke) examined forage and fodder substitution. The others feature fuelwood and its substitutes. Commercial fuels like kerosene or LPG seldom penetrate rural markets. Therefore, the common substitutes for fuelwood in these markets are combustible agricultural residues (like straw and dung) and improved stoves, a technological substitute.

Neither Cooke nor Mekonnen found evidence of substitution. Indeed, both observed complementarity, between forage and fodder as animal food in Nepal (Cooke) or between fuelwood and dung for cooking and heating in Ethiopia (Mekonnen). The latter is an especially interesting finding because the general view holds that dried dung is a primary substitute for fuelwood and that the combustion of dung only decreases its contribution to soil sustainability, long-run agricultural productivity, and nutrition in subsistence agricultural communities. Alternatively, increasing the availability of fuelwood decreases the negative effects of burning dung. Mekon-

Table 3. Consumption response: substitution.

Study	Location	Forest product	Measure of substitution	Elasticity (or coefficient)
Cooke (1998a)	Nepal's hills	forage	fodder shadow price	(–)
		fodder	fodder shadow price	(–)
Mekonnen (1998)	Ethiopia	fuelwood	dung shadow price	–0.3*
		dung	fuelwood shadow price	–0.7*
Amacher, Hyde & Joshee (1993)	Nepal's hills			
	low income	fuelwood	improved stove owner	(–)*
	high income	fuelwood	improved stove owner	(+)
	low income	ag. residues	fuelwood coll'n time	(+)
	high income	ag. residues	fuelwood coll'n time	(+)
Amacher, Hyde & Kanel (1998)	Nepal's hills			
	market participants	fuelwood	improved stove owner	(+)
	collectors	fuelwood	improved stove owner	–0.33*
	Nepal's tarai			
	market participants	fuelwood	improved stove owner	(+)
	collectors	fuelwood	improved stove owner	–0.26
Heltberg, Arndt & Sekhar (1998)	Rajasthan, India	fuelwood	improved stove owner	(–)

Where elasticities were not calculated, we can infer substitution or complementarity from the signs on the estimated coefficients and the sample sizes. This evidence on substitution must be read carefully because some coefficients refer to prices or price proxies (collection time) while some refer to quantities (wood, stoves). * indicates statistical significance at least at the 0.10 level.

nen's evidence urges caution on global generalizations of this view.

AHJ did find evidence of substitution in their narrower survey of two districts in Nepal's hills, substitution between fuelwood and agricultural residues, and especially for low income households. They also observed that low income households make the technological substitution of improved stoves for fuelwood.[6]

The real importance of AHJ's observation has to do with target populations. Fuelwood prices were high enough to induce substitution – but only for lower income households. AHK confirmed this point and they sharpened the definition of the target population. In a broader survey of districts across Nepal's hill and tarai regions, AHK observed that as prices rise some households turn from market fuelwood purchases to fuelwood collection to satisfy their own domestic consumption. Households that collect but do not also participate in the market (which are also lower income households, and especially in the hill region) are statistically significant substituters of improved stoves for fuelwood.

3.1.3 Summation

The consumption evidence tells a consistent story. Households do respond to higher forest product prices by decreasing their consumption. However, the household income elasticities for forest products are generally small. This indicates that forest products are generally necessities and also that we should expect only the poorest households to be especially responsive to their scarcity. This is not encouraging for the hypothesis that increasing scarcity will slow rates of deforestation, or for the widespread and general introduction of social forestry activities. Select cases, however, offer more promise. These select cases can be identified by populations that are sufficiently responsive to higher prices to substitute for their consumption of forest products. In AHJ's examples from Nepal, this was not an entire regional population. Rather, it was a poorer subset of the entire population from a region that was relatively more price responsive as a whole. Of course, this is precisely the population that public development projects intend to assist.

Table 4. Production responses: supply prices.

Study	Location	Forest product	Measure	Elasticity
Köhlin (1999)	Orissa, India			
	market suppliers	fuelwood equivs.	market price	
			collection shadow wage	
Amacher, Hyde	Nepal's hills			
& Kanel (1998)	market suppliers	fuelwood	market price	2.99*
			collection shadow wage	6.81*
	domestic collectors	fuelwood	market price	1.57*
			collection shadow wage	1.33*
	Nepal's tarai			
	market suppliers	fuelwood	market price	0.36*
			collection shadow wage	0.55
	domestic collectors	fuelwood	market price	0.71
			collection shadow wage	0.09
Heltberg,Arndt	Rajasthan, India	fuelwood	market price	0.41
& Sekhar (1998)	market suppliers			

Köhlin's fuelwood equivalents are measures of the combustion equivalent to fuelwood that is obtained from all burnable forest products: leaves, twigs, and larger fuelwood. * indicates statistical significance at least at the 0.10 level.

3.2 Household Production

Household production is more complex. The range of household options is broader, including collection from alternate sources of the product, labor reallocation among the household's subsistence activities (including fuelwood collection), and labor reallocation away from forest collection to wage and income producing activities – which then allow the full range of consumption alternatives. The breadth of production alternatives has led to a more diverse empirical literature, and our generalizations from it must be more speculative.

3.2.1 Market Supply

Table 4 summarizes the three insights to household supply known to us. All three observed some degree of price responsiveness, whether households were supplying their own domestic consumption or the local fuelwood market. The latter, market suppliers, are particularly important and they are easy to overlook. Most surveys of non-timber forest products intend to be random and unbiased. Nevertheless, they tend to observe substantial levels of market demand but only occasional market supply. This means that they overlooked some market-supplying households. Unfortunately, these are probably lower income and landless households, the households of our greatest general concern.

Köhlin's (1999) evidence from Orissa in India supports this contention. Köhlin found that women from lower caste and lower income households were the most likely suppliers of market fuelwood. They are also more likely to obtain their market fuelwood from the open access natural forest than from their communities' managed village woodlots – although the village woodlots were always closer than the natural forest in Köhlin's region. This seems to confirm the evidence of several (notably Jodha 2000) that open access resources are resources of final resort for the poorest households.

AHK's evidence largely supports Köhlin, although it is less complete in its description of the market suppliers themselves. It is also consistent with AHK's consumption evidence (Tables 1–3) which shows regional differences in fuelwood scarcity in Nepal and shows that, beyond some level of scarcity, rural households do respond to increasing scarcity by altering their consumption behavior.

Finally, HAS examined consumption, not market supply, but they observed that twelve percent of households in India's Rajasthan sold to the market. Market sales represent 26 percent of all collection for these households and these households are (insignificantly) positively price responsive.

3.2.2 Household Production, Land and Labor Inputs, Gender and the Poor

Table 5 summarizes the more extensive evidence on household production itself. Evidence from a range of cases (Nepal, Madagascar, Ethiopia, India, Malawi) supports the contention that the collection of fuelwood and other forest products declines with decreases in the available forest stock and with decreases in the accessibility of the remaining stock. Furthermore, under conditions of sufficient scarcity, private stocks do become substitutes for forest resources on the common lands. For example, in contrasting districts in Nepal's hills AHJ observed that when fuelwood becomes sufficiently scarce on the community's common lands (smaller and less accessible stocks and higher prices), households eventually begin growing wood on their own private lands. Nevertheless, all observers agree that as the stock declines or becomes less accessible, households generally spend more time collecting forest products.

The evidence that collection declines with decreasing stocks of natural forests is encouraging of the hypothesis that increasing scarcity will slow the rate of deforestation. However, it is also consistent with the consumption evidence that wage effects are more important than price effects. Therefore, we might recommend closer attention to wages and collection time than to prices as evidence of the sort of increasing scarcity that will induce substitution and deter deforestation.

Labor allocation to the collection activity has been a critical question because so many forestry and women-in-development projects presume a unique cultural role for women. Who collects from the forest? Is collection the special responsibility of women, or of women and children? And does an increase in time spent collecting forest products detract from other household responsibilities, in particular the food preparation and agricultural production responsibilities that are crucial to survival in subsistence rural communities?

In fact, Shyamsunder and Kramer (1996), Mekonnen, and AHJ all found that labor allocation varies between genders. Collection is not the domain of women alone whether in Madagascar, Ethiopia, or Nepal, and on some occasions men are the primary collectors.[7]

Cooke (1998, 1998a) and Köhlin (1998) provide the most thorough inquiries into the question of labor allocation. Cooke focused on the seasonality of collection from the forest. Köhlin focused on labor allocation between alternative fuelwood sources. Cooke found that, in Nepal's hills, collection takes advantage of slack labor and opportunities for joint production. Women are the most important collectors of forest products. Nevertheless, men do collect and they increase their collection in off-peak seasons for agricultural labor. Women increase their collection in seasons when they spend more time away from the household itself and in the fields closer to the trees.[8] Youths increase their collection when adults, especially women, are otherwise occupied with peak season agricultural activities. And finally, the collection of forest products does not interfere with agricultural labor. Rather, overall increases in collection time occur during slack seasons or originate from reduced time for leisure activities.

Köhlin found that, in Orissa, men actually collect more fuelwood than women and that the marginal products of men for the collection activity are greater than the marginal products of women. Men, adolescents, and higher caste women do more of their collecting from village woodlots while lower caste women collect more from the less accessible natural forest – whether they are collecting for market supply, as we previously discussed, or for their own household use. Köhlin's households are sensitive to the source of their fuelwood. With increasing plantation stocks they tend to decrease both collection from more distant natural forests and purchases of commercial fuel.

Thus, the story that began with our review of consumption patterns remains intact after our review of production patterns. That is, with suf-

Table 5. Production responses: land and labor inputs.

Study	Location	Forest product	Land and labor inputs
Amacher, Hyde & Joshee (1993)	Nepal's hills	fuelwood	If more plentiful supply: collect from commons; women collect, men do not, children negative collectors.
	Nepal's hills	fuelwood	If more limited supply: rely more on own lands, capital inputs significant, men and women collect but men collect more.
Amacher, Hyde & Kanel (1998)	Nepal's hills	fuelwood	Level of resource stock and resource access significant.
	Nepal's tarai	fuelwood	Levels of stock and access significant, some indication of supply from own land and of increased supply from lands of wealthier households.
Shyamsunder & Kramer (1996)	Madagascar	fuelwood palm leaves wood crab	Collection increases with an accessible primary forest. Men collect more than women.
Mekonnen (1998)	Ethiopia	fuelwood dung	Resource access is important. On common lands: female youth are significant collectors, children contribute negatively. From household lands: men (and women?) are significant collectors.
Cooke (1998a)	Nepal's hills	fuelwood forage fodder	Evidence largely from commons. Collection time (CT): male and youth CT small, women's CT is large, women absorb the increase in CT due to increasing resource scarcity. Seasonal differences in CT: Men increase CT in off-peak agricultural season. Women increase CT (as joint product) when they are in the fields for seasonal agricultural activities. Youths increase their CT when women otherwise busy.
Cooke (1998b)	Nepal's hills	fuelwood forage fodder	Evidence largely from commons. Increases in resource scarcity increase forest CT. Increases in CT do not decrease time for agricultural labor. Rather, collection increases during slack seasons.
Köhlin (1998)	Orissa, India	fuelwood equivalents	Resource stocks from a) village woodlots (VWL, which are managed commons) and b) open access natural forests. Women, adolescents, higher caste collect from VWL. Lower caste collect from natural forest. Men collect more in general and MP(men) > MP(women), but formation of VWLs saves women more time.
Heltberg, Arndt & Sekhar (1998)	Rajasthan, India	fuelwood	Levels of resource stock and resource access significant. Some private tree substitution for open access stocks. Only women collect. Collection isseasonal, occurring when energy demands are high and demands for agricultural labor are low.

ficient scarcity, households do respond. On the consumption side, less-well-off households are more likely to feel the pressure of increasing scarcity. They respond by substituting alternative consumption goods and by increasing their reliance on their own productive abilities rather than on market purchases. On the production side, the literature suggests that household labor allocations are consistent with the economic rewards – rather than with external perceptions of absolute cultural norms like "women collect". Men may even collect more than women when the returns to male collection are greater than the returns to women's collection effort – although this may be unusual because other male wage opportunities are generally greater yet.

Some experience suggests that a) poor households respond to increasing scarcity by relying increasingly on more distant open access natural forests and some suggests that b) those households with land respond by growing the scarce product on their own private agricultural lands. The evidence is not thorough on these points and the identifying characteristics, particularly of the latter agroforestry households, is not clear. Our next section on adoption and investment addresses this issue.

3.3 Investments in New Technologies

Table 6 summarizes the six household econometric investment analyses known to us, plus one data intensive household survey (Scherr 1995) which is also presented from a perspective of multivariate impacts even if its method is not statistical. The specific parameters used in these analyses vary too widely for meaningful comparisons and none of them reported elasticities. Moreover, several of these analyses neglect price and cost factors – despite the almost certain effect of those factors on a household's desire to invest. Nevertheless, they all provide useful insight.

In all cases the empirical findings follow the expectations of economic behavior. Households invest when they anticipate gain in the form of higher prices or lower costs, and the most likely investors are households that can afford to take a chance on new investments of uncertain potential. These are households with "risk capital" in the form of larger incomes or greater wealth or more labor or land than their neighbors, perhaps enough more to allow them to chance a small investment in an unproved new technology. The poorest households do not have the means to take this chance and the risk to them seems greater relative to whatever means they do have.

The investment literature tells us that better-off households invest first. Poorer households follow. The consumption literature told us that some of these poorer households are the more elastic respondents when they do invest.

Furthermore, the adoption of new consumption technologies is a more important question in urban areas where policy often encourages the substitution of commercial fuels as a means of decreasing the drain on forest resources. Since commercial fuels seldom penetrate rural markets, it is not surprising that the only analysis of rural adoption of a consumption technology features improved stoves. Amacher, Hyde and Joshee (AHJ 1992) observed that wealthier households were the first to adopt improved stoves. They also observed that off-farm income is a more important predictor of adoption than income from a household's agricultural production. We might speculate that off-farm income indicates a greater variety of labor experiences and, therefore, broader household experience in general and greater exposure to information about new technologies like improved stoves.

3.3.1 Investments in Trees

Two of the analyses of production-enhancing investments also identified the importance of access to information. In these cases (Amacher, Hyde and Rafiq or AHR 1993; Thatcher, Lee and Schelhas or TLS 1997), information was delivered through training programs or by extension foresters. AHR's Pakistani farmers took additional notice of the personal characteristics of the extension agents who deliver the new information. The extension agent's good character determines the household's openness to information delivered by the agent. To these Pakistani farmers, the agent's character is even more important for successful technology transfer than

Table 6. Characteristics of households and investments in new technologies.

Study	Location	Investment	Explanatory variables: sign of effect on investment										
			Forest prod. price	Price var´n	Income farm	Income off-farm	Substitute	Wealth or land ownership	Land quality	Security of land tenure	H´hold labor total	H´hold labor male	Training and extension
CONSUMPTION													
Amacher, Hyde & Joshee (1992)	Nepal's hills	improved stoves	+		insignif.		+	–	+	NR	NR		
PRODUCTION													
Amacher, Hyde & Rafiq (1993)	Pakistan	tree planting	+		+	+	–	+		+	+	+	
Mekonnen (1998)	Ethiopia	number of trees	NE		⇐ + ⇒		NE	+		+	+	+	
Thatcher, Lee & Schelhas (1997)	Costa Rica	participant: reforest pgm.	NE		–	+	NE	+	–	0	+		+
Patel, Pinkney & Jaeger (1995)	Kenya (Murang'a)	number of trees	NE	–	⇐ + ⇒		NE	+			+		
Scherr (1995)	Kenya (Siega and S.Nyanga)	number of trees	+	–	⇐ + ⇒		NE	+		+	+		
Shively (1998)	Philippines	number of trees	+	–	–		–	+					

Notes: a) NR: not relevant in the consumption form. NE: this critical variable was not estimated. b) AHR also noted the importance of the personal characteristics of extension agents. c) Mekonnen did not separate income sources. He identified a positive effect for increasing numbers of males in the household, both youths and adults, and an additional positive effect for male heads of household. d) TLS also observed a negative effect for improved land quality. Their measures of off-farm income and labor were i) off-farm income as a share of all income and ii) labor/hectare. e) PPJ used expenditure/capita as a proxy for all income, and restricted their measure of labor to labor available for farming. They observed that tree growing is more likely for higher wage households. They anticipate that higher wages mean higher incomes which suggest lower discount rates. The latter is an important factor for long-term investments like trees. f) Scherr did not observe prices directly, but she did observe more planting where returns are greater (prices higher or costs lower). g) Shively's observations were restricted to mango trees.

the agent's knowledge of forestry.

The literature on new production technologies raises additional points about the income, labor, and land variables, and introduces a risk spreading or income diversification argument that favors private investments in trees.

TLS offer a new perspective on income sources and labor availability. They observe that those Costa Rican households that are reliant on off-farm income and employment have less labor available for on-farm agricultural activities. These households may be more receptive to tree planting opportunities on their own lands because, unlike many agricultural crops, trees grow well with minimal labor input and that input can be scheduled for the slack seasons for off-farm employment. TLS addressed these propositions by reformulating the common income and labor variables as i) off-farm income as a share of all income and ii) labor available for farming.

Scherr examined gender differences in the labor input. She observed that while gender does make a difference, the relationship is complex. Investment decisions reflect distinctions in land tenure and off-farm employment and income as well as gender – but it is difficult to separate the effects of these characteristics on the decision to invest in trees. For example, female heads of households in Scherr's regions of Kenya have less secure tenure and males are the greater participants in off-farm employment.

Most farm households have been used to collecting their forest products from the natural forest. For them, forest investments are a totally new experience – different in their use and timing of inputs and in their output markets, different from household experience with the natural forest and different from the improvements many households have grown to expect from new agricultural technologies.

Therefore, it is not surprising that Scherr observed that households invest only incrementally in new agroforestry technologies, beginning at a small scale and expanding gradually as the investment demonstrates its worth. Better-off households are generally the first to invest and Scherr observed that they are willing to invest in longer rotation species and for commercial timber production. When poorer households eventually invest in agroforestry, Scherr observed that they tend to plant short rotation fuelwood species. This is consistent with Patel, Pinkney and Jaeger's (PPJ 1995) observation, for a different region of Kenya, that better-off farmers plant more. PPJ speculate that the better-off have (better access to credit and) lower time preferences.[9] Scherr speculates that a household labor constraint leads the poor to invest in fuelwood plantings as a means to save time spent collecting fuelwood.[10] In contrast, she speculates that land is the more constraining factor for investments in technologically advanced agroforestry practices like alley cropping that are more important for commercial production and more attractive to better-off households.

3.3.2 Risk and Uncertainty

Finally, first Dewees (1995), then Scherr and PPJ, observed the risk reducing characteristics of agroforestry investments in their cases in East Africa. Dewees and Scherr consider that the returns from investments in trees are less volatile than returns from agriculture. Scherr also observed attempts to diversify by planting a variety of tree species. PPJ took particular notice of the importance of tree planting as a factor in controlling environmental risks like erosion.[11]

Dewees' and Scherr's observations on the risk reducing characteristics of many East African investments in trees are related to Shively's (1998) observation that Philippine farmers plant more mango trees when the variation in mango prices is smaller. Scherr also showed that reductions in price variation can be as important to farmers as increases in product prices. All three observations on price variation are comparable to North American evidence that forest investments are a valid tool for diversifying investment portfolios. In North America, investments in trees yield returns that are less variable than average portfolio returns, as well as returns whose cycles run slightly counter to normal business cycles (See Binkley, Raper and Washburn 1996). Is this a general pattern for forest investments in both developed and developing countries?

3.3.3 Overall Summation

The household literature explains a lot about the sequence in which different classes of farm households invest and why they invest, and it reinforces the consumption and production arguments to carefully select target populations for technology transfer and other development activities. Households invest i) because forest products are an important component of the household budgets of money or (especially) time, perhaps ii) for the income protection that product diversification offers, and iii) because relative prices, or imperfections in labor or land markets, are sufficient to make this investment better than some alternative expenditure of household resources. The question that remains is “when are the relative forest product prices great enough or labor costs low enough?”[12] This question is especially important where forestry is an altogether new investment. Farmers who are entirely inexperienced with it will be the greatest benefactors from the advice offered in training sessions and from forest extension agents. When the relative prices and wages are insufficient, however, no amount of additional information can create a good investment. Therefore, knowing when the prices and wages are sufficient to justify investment in a new forest technology will predict when the various forms of technology transfer can be beneficial.

The consumption evidence suggests that prices and wages are sufficient when we begin to observe substitution. We can anticipate that the same signal is appropriate for investments in new production technologies as long as we observe an important caution with respect to property rights for land and trees. Consider poor, and then better-off households, then consider community investment opportunities. Poor households may substitute other goods or alternate sources of the forest resource but they will not invest in new forest production technologies if their landholdings are insufficient even for more critical household products like food. Households with larger landholdings may substitute for scarce forest products but they may not invest in new production technologies when the period of land tenure is uncertain or where roads or government policies limit their access to markets. Communities may be slow to invest if they share rights to common lands with a central government agency and the system of shared rights is uncertain or confining. This final case is common because central governments retain legal ownership of most countries’ forests and degraded rural lands, and because the central governments’ rules for local uses of these lands are often restrictive, yet the central governments do not have the resources to enforce their rules completely and uniformly. We will revisit the question of private or community investment in the next section.

4 Unifying Principles

These observations generally follow a rather basic economic principle – resources (land, labor, and what limited capital these households possess) are allocated to higher valued uses until the marginal gains from their use equal their marginal costs. No one contends that the markets are perfect but increasing scarcity in the local markets does send the anticipated signals, and rural households do reallocate resources in the expected directions. Indeed, the empirical and analytical literature seems to reject the most common claim for a cultural constraint on market behavior, i.e. women collect, in the presence of evidence that both men and women collect, and the question of “who collects” seems to depend on comparative economic advantages within the particular household.

4.1 Von Thunen’s Pattern

A common pattern begins to emerge from the observations summarized in this review, a pattern of rural development, deforestation and increasing scarcity of forest products, and eventual substitution with forestry investments that could potentially limit further deforestation. This pattern is an application of the concepts of economic geography first proposed by von Thunen (e.g., Dickinson 1969, Samuelson 1983). Our Fig. 1 captures the basic elements of this pattern. It also provides the key reference points necessary for further reflections on investment timing, in-

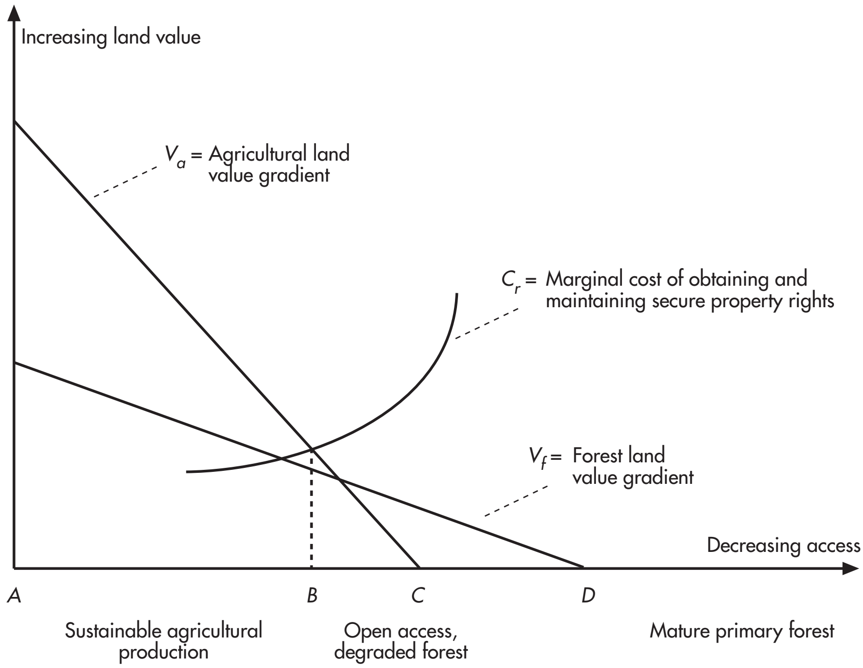

Fig. 1. The forest landscape – a new frontier.

stitutional constraints, and the policies affecting social forestry.

Fig. 1 describes a simple landscape of agriculture and forests. Consider agricultural land first. The value of agricultural land is a function of the net farmgate price of agricultural products – which is greatest when the farmgate is near the local market at point *A*. Land value declines with decreasing access (which is closely related to increasing distance) as described by the function V_a. Our exposition will be clearer if we separate the costs of insuring property rights from other management costs. The function C_r describes the cost of establishing and maintaining secure rights to the land. This function increases as the level of public infrastructure and as effective control declines as the cost of excluding trespassers increases. Both increase with distance. Local communities may protect some lands beyond *B* to a declining degree further from their homes – as by sending children out to manage their grazing livestock – but eventually no number of forest guards can fully exclude open access users of remote forests.

The functions explaining agricultural land value and the cost of secure property rights intersect at point *B*. Farmers manage land between points *A* and *B* for permanent agricultural activities. They use land between points *B* and *C* (where agricultural land value declines to zero) as an open access resource to be exploited for short-term advantage. They harvest native crops that grow naturally in this region, crops like fodder for their animals, native fruits, and fugitive resources like wildlife. They do not invest even in modest improvements in the region between *B* and *C* because the costs of protecting their investments would be greater than the investments are worth. Their use of this open access region is unsustainable except in pulses of natural regrowth.

Initially, the mature natural forest at the frontier of agricultural development at point *B* has a negative value because it gets in the way of agricultural production and its removal is costly. Settlers remove trees whenever the agricultural value of converted forest plus the value of the trees in consumption exceeds their removal costs. Eventually, the most accessible forest resources will have been removed. The function V_f de-

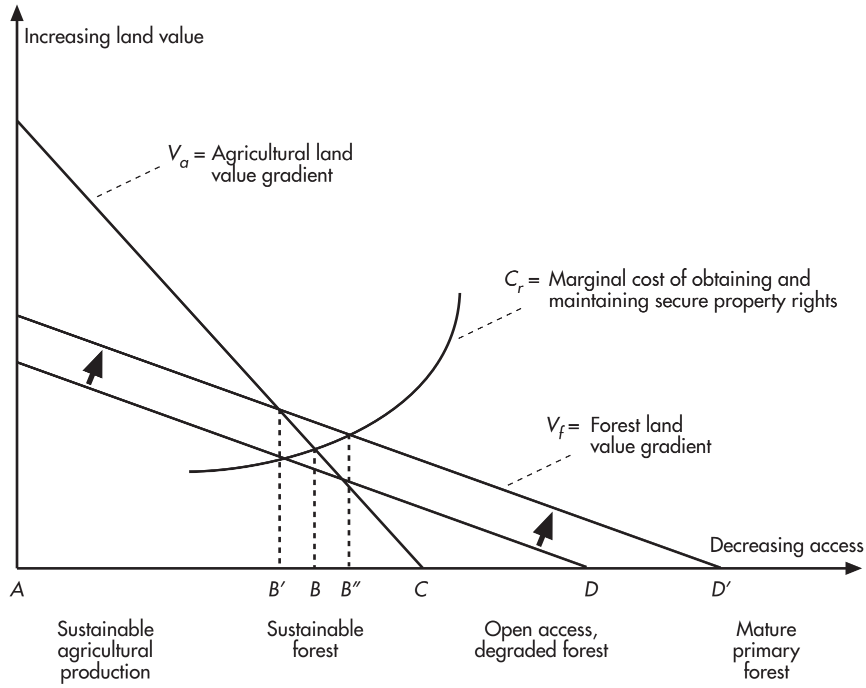

Fig. 2. The forest landscape – a mature frontier.

scribing forest value must now intersect the horizontal axis at some distance beyond *B*. Market demand for forest products may still justify their removal at this time, and it will continue to justify their removal as the forest frontier gradually shifts outward to some point like *D*. The market price of forest products is now just equal to the cost of their removal and delivery to the market. The *in situ* price at point *D* is zero, and the value of forestland at *D* is also zero. The region of unsustainable open access activities now extends from *B* out to either *C* or *D*, whichever is farther. The costs of obtaining and protecting the property rights insure that this region will remain an open access resource. Some governments protect some lands past point *B* but they must absorb the increasing protection costs – and even then trespass occurs. Some amount of illegal logging occurs almost everywhere in the world and no number of well-trained and well-motivated forest guards can prevent it.

The construct of Fig. 1 conforms to the common description of any initial settlement. In some cases, trees actually impede agricultural development, the forest rent gradient is very low, and point *D* can even be to the left of point *C* if net forest resource values are sufficiently low. Apparently, this describes the forest frontier in Cote d'Ivoire (Lopez 1998) and Bolivia's Amazon region today (Bowles et al. 1997). In other cases, the region between *B* and *D* can be large (e.g., in Nepal's hills or India's Rajastan) but the forest in this region is generally degraded. In the latter case, the positive net value of the original resource, together with the open access character of the region, has assured removal of the best resources. Some degraded vegetation remains in the region and it will re-grow naturally. The lowest wage households will continue to exploit these resources when the scattered vegetation grows to a minimum exploitable size or when its fruits begin to ripen (AHJ 1993, Foster et al. 1998).

As the natural forest is depleted over time, the forest margin at *D* will gradually extend farther and farther from the market. Deforestation will continue, and the delivered costs of forest products will continue rising. The incentives are insufficient to induce tree planting and any attempt at forest management will be unsustainable. As Godoy (1992) points out, the prices of forest products may be rising, but they are not yet sufficient to induce forest management.

Eventually the margin at *D* extends far enough – and delivered costs and local prices become great enough – to induce substitution. Substitution may take the form of new consumption alternatives to forest products (for example, kerosene or improved stoves as substitutes for fuelwood), or it may be production related (as in planting and sustainable forest management on some land closer to the market). In Latin America alone there are 165 million hectares of this secondary forest, an area three-fourths the size of Mexico (Smith et al. 1998).

The forest rent gradient rises with the increase in delivered costs (following the arrows in Fig. 2) until it intersects the agriculture rent gradient to the left of agriculture's intersection with the property right cost function. We might call this a "mature" frontier of primary forest. At this time forest product prices will be sufficient to justify the substitution of planted and managed forests for the resources of the open access natural forest. The new managed forests will occur in the region *B'B"* of Fig. 2. They may take the form of industrial timber plantations or they may take the forms of agroforestry or even of just a few trees planted around individual households. The latter are excluded from most measures of the forest stock but their economic importance can be large. In Bangladesh, for example, they account for 3/4 of all timber and fuelwood consumption (Douglas 1982). They are major sources of fuelwood consumption in Malawi (Hyde and Seve 1993), timber production in Kenya (Scherr 1995), and of positive environmental externalities in northern China (Yin and Hyde 1998) or the Murang's region of Kenya (Patel, Pinkney and Jaeger 1995).

In all cases, removals from the mature natural stock are concentrated around a point like *D* in Fig. 1 – or *D'* in regions characterized by the higher forest rent gradient in Fig. 2. Mature natural stocks in the region before *D* (or *D'*) were removed in earlier times. In most cases a mature natural forest of no economic value exists beyond *D* (or *D'*). Sometimes this region is small (e.g., in Ireland or Cape Verde). Sometimes this latter region continues well beyond *D* (Siberia, Alaska, northern Canada, much of the Amazon) until it can become much the largest share of reported physical stocks. Many countries possess regions of both cases because many forest products are either bulky or perishable and do not transport well. That is, standing natural reserves remain in some regions while the forests in other regions are depleted and some households in the latter may have begun planting on their own lands.

4.2 Evidence and Qualifications

A number of empirical studies have demonstrated this development pattern for commercial timber.[13] More recently, several have demonstrated its relevance for fuelwood and for agricultural expansion. In particular, Hofstad (1997) confirmed a pattern of expanding extraction for charcoal in the vicinity of Dar es Salaam and Chomitz and Griffiths (CG 1997) confirmed a similar pattern for charcoal from multiple population centers in Chad. CG also observed the substitution opportunities that constrain expanding supply regions and rising charcoal prices once a backstop energy source or technology price is attained. Their observation that substitution eventually constrains deforestation is consistent with observations from the household literature that substitution constrains the consumption of high cost fuelwood.

Most everyone is careful to recognize that market access on the horizontal axis of Fig. 1 is more complex than distance alone. It probably includes road quality and density and measures of both terrain and moisture: steep and swampy areas are less accessible than flat dry areas. Site quality can also be important for some land uses and Chomitz and Gray (1996), for example, were careful to incorporate an element of land quality in their assessment of agricultural expansion into the forested regions of Belize.

Most everyone would also recognize that there are many forest value gradients. Rather than the single sharply defined gradient V_f in our figures, each forest product has its own gradient. And most recognize that the cost function C_r varies with the individual and institutional particulars in the local market. It almost always includes an element of hazy uncertainty that is not fully acknowledged in our sharply drawn figures. (We will return to this latter point about property rights later.) Regardless of these adjustments, von Thunen's pattern prevails in general.

There is a data problem, however, that imposes exceeding difficulty for accurate measures of the economic forest stock, for economic measures of resource scarcity, and for meaningful estimates of rates of deforestation. The common estimates of resource supply in forest policy analyses are actually measures of the standing physical stock. Adjustments for the difference between physical stock and economic supply are seldom incorporated in analysis and the potential for error is great. Alston, Libecap and Mueller (1998) demonstrated the importance of infrastructure to accurate measures of secure economic supply. In particular, they demonstrated the negative relationship between access to population and government administrative centers and the costs of enforcing claims on land use in frontier regions of Brazil. (This is precisely the function C_r in our figures.) Hyde, Krutilla, Barnes and Xu (1998) observed that the standard measures of physical resource stocks include a large component of forest beyond point *D* (or *D'*). They corrected for the difference between physical stock and economic supply with adjustments for terrain, road density, and moisture. Their corrections explained forty percent of the variation in estimated physical stocks across 31 regions in eight tropical countries. General policy differences explained no more than twenty percent of the variation. The obvious point should be that elements of infrastructure and terrain are critical. They can dominate elements of policy, yet assessments of forest policy and forestland use only rarely account for them.

4.3 Further Development: the Rural Poor

So, the empirical evidence confirms the pattern of our von Thunen figures, but how do the figures and this evidence relate to the human populations and the production and consumption of those products of greatest concern for social forestry, the topic of our review? They argue that local users of the forest will continue to travel farther and farther to collect and deplete the natural forest until the local market prices or the implicit wage for their own collection time attains a level sufficient to induce substitution of a backstop technology. For households without land or without secure rights to their land, the backstop technology can be consumption substitutes like kerosene or improved stoves. For those with secure rights to their own land, it can be a production substitute like private or local community tree plantings. This is exactly what the household literature observed with respect to prices and wages or collection time, substitution, and adoption.

But what about the rural poor? They are the greatest concern of rural development, and several of the production and consumption assessments discussed earlier in this paper noted greater participation of the poorest households in the array of activities sometimes identified as "social forestry".

Foster, Rosenzweig and Behrman (FRB 1997) addressed this question with a general equilibrium model of three sectors: agriculture, rural manufacturing, and open access forests. In their model, land is an input to agriculture and forests, but not to manufacturing, and forests are open access resources. FRB's model could be interpreted as similar to our figures with all manufacturing taking place at the origin. FRB's open access forest is, of course, the region to the right of *B* in Fig. 1 (or *B"* in Fig. 2). In FRB's model, the marginal product of agricultural labor is its wage. The average product for forest labor falls until it equals its marginal product – in what is the standard observation for open access resources – and the wage for forest labor is below the wage for agricultural labor.

FRB confirmed their analysis with satellite data on land use and an extensive household survey from 250 villages in eleven states of India. One of their conclusions is that the lower wage for forest labor causes the removal of forest resources to extend past the optimum for forest properties with secure property rights – as our figures also show. Perhaps more interesting for us is the implication of their analysis that it is lower wage households and individuals that participate in extraction from the forest.

We would hypothesize that since individuals from lower wage households are satisfied with a lower return for their marginal effort they can afford to venture further into less accessible regions to obtain the products of the forest. And in the more accessible regions of depleted open access forests, individuals from lower wage households can afford to remove lower quality material that would not provide sufficient compensation for the effort of the better-off. The poor will renew their exploitation of the degraded open access regions as the depleted resources in these regions recover to minimal levels. These depleted resources will never attain a level sufficient to compensate the effort of the better-off. Of course, FRB's analysis and this hypothesis explain many observations around the world of the greater dependence of the poor and otherwise disadvantaged on the forest. Once more, they are consistent with observations from the household literature, observations that poorer households are the first to respond to increasing prices and they first respond by shifting from market purchase to household collection from the open access forest.

Finally, FRB showed that technical change has a varied effect on forest use. Technical change in the manufacturing sector raises wages and attracts labor from the other sectors. By drawing labor from the forest, it decreases dependence on the forest. Bluffstone (1995), with evidence from Nepal, anticipated that off-farm labor opportunities in general would have this effect. On the other hand, FRB showed that technical change in agriculture has a different effect. While technical change in agriculture also raises wages and attracts labor, it can deplete the forest by inducing land conversion to agriculture. We would anticipate that the new agricultural land would come from the region of point *B* for new frontier communities described by Fig. 1. It would come from the plantation forest region *B'B"* for the mature communities described by Fig. 2. Sunderlin and Wunder (1998) confirm these contrasting effects of manufacturing and agricultural sector growth on the forest with macroeconomic evidence from a broad sample of 67 countries.

5 Shortcomings in Data and Research

We have reviewed an extensive body of empirical analysis. Much of it is recent, and most of it is internally consistent. This literature does have its shortcomings, however, and it would be useful to identify them before drawing any conclusions for policy. The shortcomings fall into the general categories of data, the agriculture/forestry interface, and macroeconomic policy impacts. Each imposes cautions on the policy conclusions we draw in the final section of this paper and each reminds us of research questions that are yet unanswered.[14]

The first set of shortcomings has to do with data. Many of the household analyses conducted to date feature South Asian examples. A few rely on examples from Asia outside of the Indian sub-continent and a few rely on African data. The particular dearth of Latin American examples may not be a serious shortcoming because the majority of Latin America is not a forest scarce region, and perhaps it is not a serious shortcoming if one accepts the general premise that human behavior is similar everywhere. In this case the important range of examples for social forestry would be the full spectrum of relative scarcities for the important local forest products regardless of their geographic identity. Nevertheless, it would add confidence to any generalizations we might draw if Latin American experiences were a greater part of the literature.

A second and potentially more important data shortcoming is that most household surveys shortchange the local landless population. This was not their intention but we did note in our discussion of household production that most surveys have more evidence of household market purchases of forest products than of household market sales. Since the sellers of forest products in subsistence economies tend to be lower income and landless households, this means many data sets must under-represent the poor and landless households. This is a particularly unfortunate shortcoming because the poorest households are the most important target of economic development.

A third data shortcoming has to do with reliance on physical rather than economic measures of forest stocks and, especially, physical measures that capture stocks of dense forest whether or not these stocks are economic while entirely disregarding the economic contribution of sparser groups of trees in fields, along hedgerows, in farmyards, and in degraded areas. Both corrections can be critical. We are reminded that HK-BX's sample from 31 regions in eight tropical countries found that correcting for the error or uneconomic stocks accounted for twice the variation in established forest stocks due to policy differences. Meanwhile, we are also reminded that Douglas observed that 3/4 of economic supply in Bangladesh originates from unmeasured, mostly private, stocks. Of course, the real problem is that the data- and analysis-intensive effort necessary to overcome these shortcomings would overwhelm most forest policy analyses.[15]

The second major analytical shortcoming largely has to do with the agriculture-forestry interface. As the natural stock of forest resources becomes scarcer, the economic reasoning and the empirical evidence pretty much establish that households eventually substitute land and labor away from activities like agricultural production and toward forest activities. Should we be concerned that these poor households may be foregoing some component of their agricultural subsistence? They may also switch labor away from household activities like nutrition and health care to forest activities. Or, stating it as a question "How much do human health and productivity suffer from a decline in forest cover?" In contrast, as development proceeds, improving wage labor opportunities may correlate with increased forest cover. How much do health and productivity gain from an increase in forest cover?

Most, not all, data sets and household analyses to date have restricted themselves to open access forest resources and to forest-related household activities. We cannot expect to understand social forestry and its welfare impacts without improving our understanding of the opportunities for alternate allocations of the household's most important productive inputs, its labor and its agricultural land.[16]

Finally, our questions have all been framed in the perspective of what scarcity means for substitution. We might also inquire what improvements in agricultural productivity have meant for the availability of land and labor for forest production. Does increasing agricultural productivity effectively, if indirectly, eliminate scarcity in forest products?

The third major shortcoming has to do with policy, specifically policy that induces either immigration or emigration to the rural and forested interior and alters the composition of the population of rural poor. Because neither immigrants nor emigrants are likely to be perfectly representative of the rest of the population, the population subsequent to imposition of the policy may have different consumption and production patterns. Our ability to predict the performance of the new population with respect to social forestry activities or anything else will suffer until we learn more about the policies that induce rural migration and the behavior of the populations that most commonly migrate. This is an important shortcoming because so many government policies and so much successful development is accompanied by migration either to or from the forested rural interior.

6 Final Policy Observations

Despite these research shortcomings, we have learned a tremendous amount about rural household responses to the increasing scarcity of forest resources and about opportunities to introduce the technologies generally identified with social forestry. Despite forestry's unusual characteristic as a standing mature open access resource that is almost always available as a substitute for managed production, we have evidence that rural households follow systematic patterns of economic behavior in their production and consumption of forest resources. We also have evidence that managed and sustainable social forestry activities are successful in select economic situations within select regions and for select populations. Furthermore, their success often occurs among those poorest households who are the intended targets of most development activity. We can identify these select situations. The remaining questions have to do with policy. Where should we look for policy opportunity? And what cautions does the evidence recommend for policy makers?

Our figures can help reflect on these two questions. All three functions in the figures can be affected by policy, and shifts in any of the three affect the management of either sustainably managed forests, or open access natural forests, or both. We will consider each in turn.

But first, let's consider government investments in infrastructure, in roads in particular. These investments affect the overall form of the von Thunen model, improving access for all land uses and shifting the intersection points for the agriculture and forest land use gradients (*C* and *D* or *D'*, respectively) to the right. The net effect on sustainable forest crops (region *B'B"* in Fig. 2) is uncertain, but road improvements also clearly extend the region of consumption from the open access natural forest. Therefore, road design is clearly important to local forest use and governments would be well-advised to design their road improvement programs to minimize access to those forested areas that are critical for their non-market values.

6.1 Spillovers from Agricultural Policy

Agricultural incentives shift the agricultural rent gradient upward and outward. Where forestry is a sustainable activity and managed forests represented by the region *B'B"* in Fig. 2 do occur, then agricultural incentives make agriculture relatively more attractive than managed tree cover. They induce land conversion away from sustainable forestry and toward agriculture.

Agricultural incentives have a very different effect in regions that are still reliant on the open access natural forest. These regions are better described by Fig. 1. Increasing the agricultural rent gradient in this case induces land conversion as well, but from either the mature forest at new frontiers where forest removal is still a deterrent to agricultural expansion (the neighborhood of point *C*), or the degraded forest in longer established communities (between *C* and *D*). Agricultural incentives in cases characterized by Fig. 1 also raise the price threshold or backstop that must be overcome before forestry can become sustainable.

Therefore, we anticipate that agricultural incentives will always work against sustainable forestry activities, either currently or by delaying their application in the future. Revising ill-conceived agricultural incentives can only promote sustainable forestry, either now or once local forest product prices have risen sufficiently to justify sustainable activity.

6.2 Direct Forest Policies

Direct forest policies include incentives like cost sharing, free seedlings, technical assistance, investments in public lands, and public silvicultural research, as well as disincentives like taxes or restrictions on harvesting and shipment. Incentives raise the forest rent gradient and disincentives lower the gradient. The latter, especially disincentives on shipment, are common in developing countries. They include export bans and domestic processing requirements, any number of licensing requirements, and restrictions on the mills or regions within a country to which raw material shipment can be made. Their objectives are generally to assist the local industry or the environment – although their effect is not always favorable for either one.

The impacts of either incentives or disincentives depend, once more, on whether the affected region is a region of sustainable forestry (described by Fig. 2) or a region that still relies on an open access natural forest (described by Fig. 1), and some forest policy instruments affect one region but not the other. For example, simply subsidizing the prices of forest products (or reducing taxes on them) raises the forest rent gradient and increases the area under sustainable forest management in Fig. 2. It also extends the area of open access forest depletion. Restrictions on shipments do the opposite. They decrease the number of potential competitive purchasers and, therefore, decrease the prices of forest products and shift the rent gradient downward, decreasing the area of sustainable management but also decreasing the area of open access forest depletion.

Seedling distribution and technical assistance, on the other hand, decrease forest management costs and raise the net value forest gradient in regions characterized by sustainable forestry.

They have no effect on regions characterized by open access extraction because prices in these regions are insufficient to justify planting and households in these regions obtain no economic advantage from the free seedlings or the management advice offered by technical assistance.

These forest policy observations imply that siting can be an important aspect of social forestry. Köhlin's (1998) work with households in 23 villages in Orissa illustrates this point. (We discussed this work in our sections on consumption and production.) Köhlin observed that some villages gain from the introduction of new village woodlots while others do not. Location is an essential variable for the villages that do gain. The greater the distance between new woodlots and the natural forest, the greater the gain.

Location is especially important in subsistence economies because the regional infrastructure tends to be poorly developed. Shipment of bulky and perishable products is restricted and markets are geographically limited. Since forest products are generally one or the other, bulky or perishable, a weak regional infrastructure can be particularly restrictive. Where the markets are all local, social forestry projects and target populations must also have a very local orientation. Geographically broader forestry projects risk incorporating both regions characterized by sustainable forestry and other regions characterized by newer frontiers and open access forest consumption – which may ensure project failure in one region or the other.

Fortunately, many social forestry development projects are local. Also fortunately, government extension programs provide an instrument that is capable of addressing local differences. Extension's role in technology transfer may be particularly appropriate where forestry is a new "crop" with which local households have little prior management. If extension services can identify those communities where forest product prices are about to attain the threshold that justifies substitution, and if they can identify the appropriate technology for the conditions of land and labor availability that characterize the community, then their role as transfer agents can be vital for improving both the forest condition and local welfare.

No empirical literature known to us fully describes how to predict when prices will reach the substitution threshold, or when some households and regions will be ready for the technology transfer. This is an unsolved problem worthy of real consideration. Once this problem is solved, the literature on adoption suggests that the poorest households are not the best initial targets for new technologies. Households with more resources, households that can afford to take some risk, are more likely initial adopters. The poor rapidly follow the leadership of successful adopters, however, and they may receive the greatest eventual benefit from many social forestry activities. Obtaining these benefits, is generally contingent on possessing secure land use rights for the properties on which households might plant and manage trees. This brings us to the final category of policy opportunities.

6.3 Secure Rights to Forest Properties

The third function in our figures reflects the costs of establishing and maintaining secure property rights. Decreasing these costs shifts the function downward and converts some of the degraded open access area to the right of *B* or *B"* in the figures into sustainable use – either for agriculture or for forestry. In regions where forestry is not yet sustainable, decreasing these costs reduces the price threshold that sustainable forestry must eventually overcome. Some promising policy options for social forestry; e.g., joint forest management and community forestry; can be described in terms of shifts in this third function.

The function captures two categories of activities, direct costs and uncertain rights. Direct costs are costs like title or contract registration and fencing. Uncertain rights refer to either the uncertainty the user has for use of the land or its forest resources, or the uncertainty the user has about the overall policy environment. An uncertain policy environment affects long-term expectations for returns on investments in the land and, therefore, willingness to make long-term investments like forestry.

6.3.1 Direct Costs

The important prospects for reducing direct costs lie in improvements in the regional infrastructure that could make title registrations easier in formal economies. Simply opening local offices for registration or reducing the bureaucratic formality for registration are two examples. The counterpart to these in less formal economies is improved access to the village headman or other enforcer of local rules.[17] Of course, the right to easy transfer must accompany possession of secure rights. Otherwise, higher use values will eventually replace some historical values and create land use conflict and uncertainty even for those with formal rights to the land.

Formal rights can be uncertain even in the present. The classic case in forestry features a government ministry which holds the formal rights and which may attempt to enforce them, but which does not have the means to enforce full compliance with all of the ministry's rules for forest use. The many examples of this case have led to joint (ministry and local community) forest management (JFM) in India and to arguments for both privatization of natural forests and land transfers to community-based forestry in the Philippines, Indonesia, VietNam, Colombia, Zimbabwe, and numerous other countries.

6.3.2 JFM, Community Forestry, and Privatization

JFM provides some rights for local users but reserves other rights (usually for mature timber) for the government. Kant (1996) showed that two conditions are necessary for successful JFM: heavy local demands on the forest and a population that is homogeneous in these demands. With a lower level of dependence, the local community has little incentive to invest its own resources in forest management and remaining open access stocks may be sufficient. Heterogenous demands suggest competing interests and difficulties in arriving at and respecting community decisions. Even where his two conditions are met, Kant observed that local demands on the forest vary across communities. Therefore, he argued that JFM contracts must be community specific. Furthermore, most of the household production literature shows that local demands are not homogenous. Women and men, landed and landless households, farmers and those with off-farm employment opportunities, the poor and the better-off all have different demands on the local forests. Therefore, communities characterized by both of Kant's conditions may be uncommon and successful applications of JFM may be special cases.

Finally, Johnson (1998) reminds us that suboptimal rewards are obtained when the residual claimant is not the party with greater ability to affect forest use. In Johnson's example from Honduras as well as India's JFM, the government claims the residual timber but local users have greater impact on the forest. In Honduras, local resin tapping delays timber growth to maturity and delays the financial returns expected by the government.[18] This is an additional reason to anticipate that successful joint public agency and local community management operations may occur only infrequently.

Some recommendations for community forestry, and even for private forest management, overcome these problems. They recommend either permanent transfers or long-term agreements with private contractors or local citizen groups – who have full rights rather than partial rights shared with the government agency, as in JFM. The argument for the transfer of rights to communities is that governments, as absentee landlords, have difficulty enforcing their rules or in taking advantage of locally specific land use opportunities. Local managers are better at both. Furthermore, if local groups managing the forest as a commons have a cost advantage over private individuals it is in protecting the forest for preferred common uses. (Their cost advantage is the equivalent of a reduction in the property rights cost function in our figures. The cost reduction extends the area of sustainable agriculture or plantation forest management and decreases the region of open access depleted natural forest.)

There are also important cautions for expectations of successful community forestry. First, the community management solution may not be permanent. As development proceeds, local relative values may be modified and some other lower cost management arrangement may replace the original community management. This is not a problem as long as the forest ministry expects and permits modifications in the contractual arrangements over time.

Second, some forest ministries impose serious restrictions on community forest activities. Each restriction only offsets the cost savings that transfers to local use were designed to create. Philippine plans for Community Based Forest Management (CBFM), for example, once required local hire of a professional forest manager, a forest inventory and plan, several steps of public and government agency oversight, restrictions on shipments of forest products beyond provincial boundaries, and payment of 44 percent of gross forest revenues to the ministry (Hyde et al. 1997). The Philippines' more recent success with CBFM has only begun after many of these restrictions were simplified or eliminated. Current discussions of transfers from the ministry to community management in Colombia, Nepal, and Zambia all include similar restrictions. We must recall that one reason for the transfers to community management is the ministry's prior inability to enforce rules like these. The ministries must minimize their restrictions on community management and focus their own efforts on enforcing simple rules for the remaining ministry objectives.

6.3.3 The Long-term Policy Environment

We initially identified a second category of uncertainty, an uncertain policy environment. Conflict in the contract between the formal owner (generally the ministry) and the community group with use rights is not the only source of uncertainty. Uncertainty can also arise from any number of external sources that raise doubts about continued land use. Consider a couple examples.

Deacon (1994), with data from 120 countries, observed that rates of deforestation increase in unsettled political environments; for example, in regions characterized by substantial political turmoil, military governments, or guerrilla activity. One explanation for Deacon's observations would be that, in unsettled political environments, those with rights to commercial forests perceive a risk of loosing their claims on these forest resources. Therefore, they claim the market reward to their rights while the rights are still in their possession. Those without rights may also feel that unsettled times provide them with greater opportunity for trespass and theft with impunity.

Yin and Newman (1997, updated and reconfirmed by Zhang, Uusivuori and Kuuluvainen 1999) provided confirming evidence of short-term maximizing behavior for forest management under political uncertainty. They examined timber harvests and reforestation in two regions of China after individual farmers in communes were given long-term land use contracts. In one region the new contractual rights were administered consistently and the lands were fully redistributed within six years. In this case, farmers harvested timber and invested in reforestation. Authorities in the second region first distributed, then recalled, contracts for some forestlands. Despite a 15-year upward trend in land under long-term private contracts and despite rising timber prices, farmers who held contracts in this second region perceived the uncertainty in the local authorities' decision making, and they harvested without reforesting.

In our own experience, land managers in the southern Philippine island of Mindanao have been slow to invest in forestry: i) despite rapid growth in long-term capital investment in other sectors of the local and national economies (indicating good macroeconomic conditions for forestry investment), and ii) despite evidence of forest plantations in neighboring Indonesia (indicating good biological and external market conditions for forest investment). We would hypothesize that the difference (until recently) has been a stable policy environment in both Indonesia and in other sectors of the Philippine economy but a Philippine policy of ever-changing environmental rules for the forest industry.

In each of these cases uncertainty made a risky prospect of land use and the rights to the standing forest resource or to new investments in forestry. The manager's uncertainty could be due to uncertainty in the broader economy, an unpredictable local political environment, or uncertainty specific to the prevailing rules for forestry.[19] In all cases, the source of the uncertainty is external to the behavior of the land manager, and in all cases it induces short-term unsustainable decisions characterized by resource depletion and deforestation without reinvestment. This behavior is identical to our expectations for behavior on open access forestland without any legitimate and enforceable claims. Removing the basis for the uncertainty effectively secures tenure for more land and forest resources and permits the land manager to obtain the rewards from investments in lands and forests. Therefore, removing the uncertainty lowers the cost curve for property rights and increases the likelihood of sustainable activities.

7 Conclusions

In conclusion, forestry, forest depletion, and the scarcity of fuelwood and other forest products consumed by rural households are not the problems many anticipated when Eckholm (1976) called attention to these issues 25 years ago. We now have good empirical evidence that people adjust to changes in forest cover. Rural households all over the world display a large amount of flexibility in their consumption and production decisions for forest products and services.

Rural households eventually take advantage of opportunities to substitute for their consumption of forest products; for example, substituting agricultural residues and improved stoves for some fuelwood. In the event of real scarcity, however, their initial adjustments tend to occur on the production side, and household labor – or the time households devote to collecting forest products – is as important as the physical scarcity of the forest resource. In particular, the opportunities households have to collect while jointly pursuing other household activities or to collect during seasons of slack labor use provide flexibility for many forest production activities.

As scarcity increases yet further, farm households do respond by planting trees. They treat trees as another crop and many of the experiences of subsistence agriculture become relevant for forestry. There are constraints on agroforestry activities, however. Land tenure and government policy can be critical deterrents. The poorest households often have no land to plant trees. And those households with land are reluctant to plant unless their tenure is certain for a period at least as long as the productive life of a tree crop. Where land and its tenure pose no problem, then government policy often acts as a deterrent to tree planting and management, sometimes creating an uncertain overall environment for investment of any sort, sometimes encouraging agriculture or some other land use in preference to forestry, and sometimes directly discouraging forestry itself by restricting the price or movement of forest products. Uncertain tenure and detrimental public policies reduce household expectations for forest product values, decrease the value of land in forest cover, and decrease the area of sustainable forestry.

We must recognize that even when the conditions of land tenure and government policy are entirely favorable, sustainable forestry will never be a universal phenomenon. The very best policy cannot make it so because the costs of establishing and maintaining secure property rights will always exceed the value of the standing forest resource on some frontier lands. Efficient household behavior will always treat lands described by this condition as open access resources and exploit the forests on these lands unsustainably. And for lands without pervasive positive externalities, efficient government policy will not alter this land allocation.

Nevertheless, the depletion of forest cover and the increasing relative prices of forest products that we observe in numerous regions around the world create an expanding opportunity for social foresty. Households and communities in a broad range of geographic and demographic situations have responded by planting and managing their own trees. The forest management responses of many farmers add up and the total impact on a country's forest cover can be great, despite the local limitations of many markets for forest products. Markets are often local because forest products are generally bulky and perishable and also because roads and other regional infrastructure are not well-developed.

If we accept this description of rural households and the rural environment, then foresters have a critical role. They can learn i) where the local relative prices are great enough to induce the introduction of social forestry technologies and ii) where the local experience with these technologies is limited. Foresters have a role as agents of technology transfer in these locations. The regions, target populations within a region, and even the sites and institutional arrangements for forestry assistance require careful selection for the foresters to be effective. Forest ministries and international donors can support this technology transfer role. They have two additional roles: i) identifying detrimental tenurial arrangements and unfavorable government policies and advocating for their change, and ii) identifying and protecting areas of significant external social value within the regions of open access and unsustainable forest depletion. Altogether, the tree planting and management activities of rural households, technology transfer activities of foresters, and policy and protection activities of ministries and donors can improve the social welfare of rural households and increase the regions of sustainable land use. They must be selective and well-designed, however, because scarcity of forests and forest products is distinctly not a universal phenomenon.

Notes

1 Environmental accounting incorporates the value of non-market environmental and natural resource services in a country's system of national accounts. See Hyde and Amacher (1996) for a review of forest values in environmental accounts.

2 Dan Bromley and many others with connections to the University of Wisconsin were early leaders in the discussion of this issue. Jeff Romm and more recently Jeff Campbell of the Ford Foundation have encouraged the idea of formal local participation in what traditionally have been public or state forest properties. Many good scholars have developed the original themes of the Wisconsin and Ford insights.

3 Indeed, the initial conceptualizers of the dual economy were clear on this point. See Boeke (1948, 1953) and Furnival (1939, 1948), or see Ginsberg (1973) for a review. Boeke and Furnival featured households and populations that are predominantly subsistence oriented, but which always include at least occasional market participation. Neither Boeke's and Furnival's households nor their communities relied totally on subsistence production without any market exchange.

4 Wages appear in the demand functions of households whose production and consumption decisions are non-separable (Singh, Squire and Strauss 1986). Some of the household forestry analyses calculate a shadow wage from the marginal product of labor in fuelwood collection. Wage responses that are more elastic than price responses would indicate greater flexibility in household labor decisions than in household consumption decisions. This is a reasonable finding in regions with remaining open access forest resources, seasonally slack labor, and for forest products that can be stored. The relative effects of wages and prices are a theme that reappears throughout our paper.

5 The income effect is small in all six studies that estimate its magnitude. Whether it becomes larger or smaller with an increase in income remains uncertain. Bogahawatte and AHJ observe a switch from a small negative to a small positive income effect for various forest products as incomes rise – although their statistical reliability is not great. A declining income effect, indicating an inferior good, would suggest that forestry activities will become less important as regions develop.

6 AHJ's evidence contrasts with prior observations of many development practitioners that improved stoves and increased fuelwood consumption are correlates. In fact, stoves and consumption are correlates even with AHJ's data, but multi-variate techniques that separate the effects of price, income, and improved stove on fuelwood consumption reveal that stoves are technological substitutes for fuelwood.

7 In contrast, HAS report that only women and children collect. It is not clear whether their survey inclluded a male collection response. Collection did increase with the number of men in HAS's households in Rajasthan.

8 Mekonnen and AHJ reinforce Cooke's observation on joint production with another example. They both observed that children spend time collecting forest products but their contribution to total collection is negative. This suggests that when women take children to the forest, they expect to produce something more than forest products. Perhaps instruction and child rearing are joint products with collection from the natural forest. HAS added a third joint production possibility: collection while tending grazing livestock.

9 Sajise (1998), with evidence from the Philippines, is examining whether the income distributive incentives for new investments are more complex than yet recognized. The issues of income source and level will remain important in our review. We will revisit them yet again in our discussions of deforestation, property rights, and policy.

10 This observation is consistent with previous observations that fuelwood consumption and production are more wage than price responsive; in particular with AHK's observation that poor households in Nepal are the most wage responsive in fuelwood production.

11 Dewees and PPJ disagree in one important respect. Dewees believes farmers invest in trees because imperfect markets limit their other opportunities. Relying on evidence from the same region of Kenya, PPJ argue that once the erosion control contributions of trees are accounted for, then the local markets appear efficient.

12 Sajise is also examining the rate and timing of adoption, critical questions both for endangered environments and for estimates of the economic potential of long-term technology transfers. He points out that while the literature we have reviewed focuses on the decision of whether to invest, the investment timing decision can be even more important. That is, even if prices are high enough to justify investment, three characteristics of investments

can explain landowner decisions to delay: i) their uncertain nature, ii) the sunk cost and, therefore, irreversible nature of investments in forestry, and iii) the fact that investments can always be postponed. The many examples of government policies that restrict private harvests or require licensing or other permits before transportation of privately produced forest products only enhance the second characteristic and reinforce the option to delay.

13 See Berck (1979) or Johnson and Libecap (1980) for examples from US history. Stone's (1998) assessment for Brazil's Paragominas is an especially clear example for a developing country and a modern context.

14 A reviewer pointed out that more evidence on the efficiency of local markets is always welcome. The reviewer is correct, of course. Most of the literature we have reviewed, however, seems to suggest that the existing markets are more instructive than often anticipated. Therefore, we prefer to highlight these other three shortcomings in the literature.

15 Chomitz' work is all the more important because its intensive use of GIS data does help overcome the problem (Chomitz and Gray 1996, Chomitz and Griffiths 1997).

16 Indeed, in some cases these relationships become very complex. For example, increasing the forest cover near stationary water can improve the habitat for mosquitos and increase the prevalence of malaria. On the other hand, one species, Azadirachta indic, or the neem tree, produces seeds and a chemical discharge that may be mosquito deterrents. Rural households in parts of East Africa and India plant this species near the household for that purpose.

17 For agriculture, Feder et al. (1988), with an example from Thailand, measured the productivity gains from title registration and showed that these are sufficient to cover the costs of the government titling activity. For sub-Saharan economies with a briefer formal history, Migot-Adholla et al. (1991) concluded that the informal system works well and there are few gains from establishing formal title.

18 This is reminiscent of taungya, an agroforestry system that originated in Burma's hills a century ago. Taungya combines government agency objectives for a high-valued timber plantation crop with subsistence agricultural objectives. In exchange for protection of newly established forest plantations, the agency allows the local community the rights to produce agricultural crops on the plantation until the young tree growth shades out the agricultural crops (Nair 1991). Of course, taungya often fails because the community quickly perceives its own incentives to maintain the agricultural rights by deterring the forest growth.

19 An unstable macroeconomy has the same effect because macroeconomic instability makes long-term rewards uncertain and, therefore, deters long-term investments. We can observe relevant examples in the Russian forestry sector since the early 1990s and in Indonesia since the beginning of the East Asian financial crisis in July 1997.

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