Settler Welfare on Tropical Forest Frontiers in Latin America: A Review and Synthesis of Select Recent Research

Catherine M. Marquette
Centro Centroamericano de Población (CCP)
Universidad de Costa Rica,
San José 2060, Costa Rica
email: cmarquette@ccp.ucr.ac.cr

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Table of Contents

List of Tables

A. Introduction

'Saving the rainforest' from the adverse impacts of human settlement and economic activity is now a global rallying cry for conservationists and a goal of environmental policy across Latin America and the world. But, while the tropical forests of Latin America encapsulate many of the worst fears of conservationists, they also embrace the best hopes of the small farmers and producers who come to the frontier looking for land and a better life. "Deforestación en Costa Rica: La Pesadilla y la Esperanza" (*Deforestation in Costa Rica: the Nightmare and the Hope*), the title of an article by Nuñez (1993), tersely captures this paradox.

Because of urgent concerns to protect tropical forests in Latin America, social science research has been generally 'forest-centered.' It asks questions from the perspective of forest welfare, like: 'Why are forests disappearing?' or 'What are the impacts and costs of this loss?' and "How can it be prevented?" This forest-centered approach considers the people who inhabit the frontier as agents of land use change and forest conversion and focuses on how their actions affect forest cover. Welfare indicators for frontier populations (for example, on income, education, health, or access to basic services) are addressed, but only incidentally, in terms of how they influence land use.

'People' as opposed to forest-centered research has been less common. People-centeresearch asks questions from the perspective of human welfare on the forest frontier, questions like: 'Are frontier settlers better off than they were before?' or 'What kind of socio-economic impacts does frontier life have on the people who live there?" and "How can their lives be improved?" People-centered research sees frontier populations as agents of change in their own lives as well as in the forest. It considers their socio-economic welfare, not only as a driver of land and forest use patterns, but also as an end in itself.

We have learned much about the impacts, especially adverse impacts, which settler activity on the frontier has on forest cover. Because of limited people-centered research, we know much less about the impacts this activity has on settlers, themselves. This is an important gap. Governments, actively and passively, see frontier settlement as a means of poverty alleviation. Yet, there is little welfare information for evaluating the validity of this approach. On a more human level, families who come to the frontier are aggressively trying to improve their standard of living and make their lives better. They make the unusual choice of migrating to the frontier rather than the more common one of going to another rural area, the city, or out of the country entirely. After decades of large-scale forest settlement across Latin America, we know something about the pay-off this extraordinary choice has for the forests. We know far less about the pay-off it has for frontier settlers, themselves.

In response to this gap in information, this literature review adopts a `people-centered` approach. It focuses on recent studies that shed light on the welfare of settlers in tropical forest frontiers in Latin America. The studies considered come from social science

research rooted in numerous disciplines including: geography; anthropology; economics; demography; geographic information systems (GIS) analyses, and development studies. We survey the literature in English and, too lesser extent, Spanish. Most of the studies discussed are from the period 1995-2004. Articles outside that period are included if they offer important and relevant insights.

In this survey, we consider small agricultural producers or what some studies call, "forest peasant households" (Takasaki, Barham, and Coomes 2001). Small farmers on the frontier are a compelling focus with regard to welfare since they are the largest as well as poorest landholding group on the frontier (Vosti et al 1998, p.200). Most small farmer households in tropical forest frontiers are migrant colonists, or descendants of recent colonists, who arrived on the frontier over the last several decades. These *settler small farmers* are the specific group of interest in this review.

The main issue of interest is *settler welfare* and the factors that determine settler welfare. Welfare is defined primarily in economic terms. Household income, wealth, and agricultural productivity are interpreted a proxies for welfare in most cases. We also consider welfare in terms of access to basic services (health and education) and living conditions. We particularly consider how settler welfare indicators may change over time on the frontier. *Tropical forests*, defined as tropical, moist, broadleaf forests, are the main ecological setting of interest. These forest areas are generally the largest unoccupied areas in many Latin American countries and are thus, also the main 'agricultural frontier' or area of new settlement for small farmers. We survey empirical research (primary and secondary) on settlers in these forest/agricultural frontiers. The unit or level of analysis in the majority of the studies considered is the settler community or, perhaps most frequently, the settler households. Most of the studies considered may, therefore, be classified as micro level research. A limited number of national level studies, however, are considered primarily in Central America.

The geographic foci are both the *Amazon* and *Central America*. Table 1 indicates the distribution of studies considered in this review by region and country within Latin America. Table 2 gives information by country and region for Latin America on forest size, the importance of forests in terms of national territory, change in forest size, forest per capita, and per capita income. Tropical forests are much larger in the Amazon than in Central America and occupy a larger proportion of total area. Amazon countries also have more forest per capita. But, Central America reflects more rapid rates of forest loss. Because of these baseline differences, we also make an effort to track regional differences in settler welfare throughout the review.

This literature review was conducted using the library and electronic research facilities of the World Bank Intersectoral Library where searches were carried out on published and unpublished journals, books, proceedings, and academic documents in English and Spanish. Generalised Internet searches were also used to identify information published electronically. We begin with an overview of settler production strategies, which lay the basis for their welfare outcomes. We then consider how changes over time among settlers, particularly at the household level, may affect their welfare outcomes. Education

and health among settlers and women settlers are singled out for special attention. `Sustainable development' in frontier areas and the possibilities for balancing settler and forest welfare are then discussed. We conclude by considering the limitations of the review and the major insights gained.

B. Settler Production Strategies: The Foundations of Settler Welfare

To understand the welfare of settler farm households on tropical forest frontiers in Latin America, one must first grasp the nature of their economic and land use strategies. Table 3 presents a generalized view of the main activities within settler production strategies, how many settlers engage in this activity, the characteristics of each activity, and regional differences. As noted above, settler land use strategies and their impact on forest cover have been an intense focus of much recent research in tropical forest areas of Latin America. (For general reviews of this research, see Angselsen and Kaimowitz (2001), Geist and Lambin (2001), or Wood (2002)).

Agricultural production is at the center of settler economic strategies. Generally all grow some kind of annual food crop like maize, beans, or rice. Many also grow some kind of perennial tree crop such as coffee, cocoa, fruit trees, and in some cases, illegal crops like coca. Like other modern peasant households, settlers engage in agricultural production for both subsistence and sale, which may be more or less constrained by weak markets inherent to frontier settings, particularly at early stages of frontier development. Plot size among settlers, in regions such as the Amazon, may be from 20 to 100 hectares, strikingly larger than those in long-settled agricultural regions (Murphy et al 1997, p.37). This land abundance is what draws settlers to the frontier in the first place. Settlers can have several plots in different areas and may keep some of their plot(s) in crops, fallow or forest at any given time. They tend to use simple manual technologies, employ little modern agricultural inputs or machinery (with the exception of chainsaws) and receive little technical assistance (ibid). Land and labor are thus, the primary factors of production that settler households have at their disposal. The main forest clearing methods used to create agricultural fields are slash and burn (cut vegetation is burned) or slash and mulch (fallen vegetation is left on ground as opposed to burned).

Many settlers also undertake some animal husbandry or pastoral activities. This may include raising small livestock (pigs, chickens, guinea pigs) and, more significantly, cattle. Cattle raising is attractive because it fulfils multiple needs for settlers serving as an investment, a way of storing wealth, a highly liquid asset, and a food source (of milk and meat). Settler household members may also work off-farm as day labor on other small farms or plantations, in frontier industries (petroleum, mining, timber), or in non-agricultural jobs in frontier urban areas. Adult men in settler households undertake most of the agricultural as well as off-farm labor. Women's involvement in agriculture is limited. But, women and children carry out most of the domestic activities such as childcare, fetching water, cooking, and cleaning, which are necessary for the social reproduction of settler households.

Forest frontiers present settlers with some unique production opportunities in terms of agroforestry; timber and non-timber (NTFP) forest product forest extraction (e.g. rubber tapping, nut collection), and ecotourism (handicrafts sale, as tour guides, hotel workers). The prevalence of these activities varies depending on local markets, practices, and opportunities. In Brazil for example, small-scale rubber and Brazil nut extraction has a long and established tradition in many Amazon settlement areas and markets for these products exist. Also, it has been suggested that some settlers may, like indigenous groups, look at forest products as a form of "natural insurance" when their agricultural activities fail to produce sufficient returns (McSweeney 2004; Dunkhort et al 2003; Godoy et al 1998; Paattanayak and Wills 2001; Shriar 2002; Takasaki et al 2002). More frequent interactions between extractivist indigenous groups and settlers around the protected areas in Central America may make extraction activities more common among settlers there. Ecotourism is an option if there is a nearby protected forest area that may be a tourist destination. Because of the greater prevalence of protected forest areas in Central America, this region may provide greater opportunities for settler participation in ecotourism as well.

In some areas, NGOs as well as state-run programs have promoted agroforestry projects that have trained, subsidized, and provided technical assistance to encourage settlers to blend crop production with tree crops in recent years as a sustainable profit-generating alternative to cattle raising (Becer and León 2000; Boege 2001; Browder and Pedlowski 2000; FAO 2000: Velázquez 2003; Vosti et al 1998). The adoption of agroforestry has had mixed success partly because these systems remain less profitable than cattle-raising alternatives (Browder and Pedlowski 2000; FAO 2000; Velásquez et al 2003; Vosti et al 1998). In some regions, settlers have "endogenously" innovated and developed what amounts to 'agroforestry' techniques, for example, intercropping fruit and annual crops (Pichon 1997a and 1997b; Pichon et al 2001 and 2002). Agroforestry as well as extractive activities may also be more frequent among settlers in Central America because remaining primary forest is more limited and reforestation projects are more vigorous.

A common overall characteristic of settlers strategies is that they tend to diversify their production over the activities listed in Table 3 rather than specialise in any single one. This diversification includes both on and off farm activity as well as the extraction of forest products. Diversification of economic activity among frontier settlers may be a way of managing the heightened risk of failure on the frontier (Deininger 2001; Escobal 2003; Lanholz 1999; Paatanayak and Sills 2001; Takasaki, Barham and Coomes 2001). It may also be a way if smoothing the fluctuations of seasonal production (McSweeney 2004). Cattle raising may be a particularly important element of diversification by settlers because returns to labor are higher than in other types of work (e.g. growing annual crops) and because of its flexibility as an asset.

Differences at the country and regional level inevitably exist in settler production patterns. For example, in Costa Rica where small-scale coffee production is prevalent, coffee as cash crop may be a more pivotal element of settler production strategies (Roebeling and Ruerd 2001; Shelhas 1996; White 2001; and Wylels 2003). In Amazon

countries such as Colombia and Bolivia, where the drug economy is significant, high-value illegal tree crops, such as coca, can form a part of settlers cropping strategies. Since the Brazilian Amazon has more expansive and developed urban areas, off-farm work outside of agriculture may be more prevalent in Brazil while in the Ecuadorian Amazon, settlers may work more frequently off–farm in the oil-extraction industries located there. Cattle raising, which is prevalent throughout tropical forest frontiers, may be even more so in Central America where it is associated with cultural ideals of success and wealth (Jones 1990).

There is a consensus in the recent literature that overall standards of living are probably lower in frontier areas than in settled agricultural regions in terms of access to basic services. Settlers may also experience hardships particular to the frontier such as geographic isolation, new health risks, and difficulties in transport. The range of conditions settlers may actually live in is, however, large. Some households do better and live in concrete block houses along a road and have a television and a truck. Others live in open wood structure with dirt floors, no electricity, no toilet, and no motorized transport (See Box 1).

The process of frontier migration is likely one of selective migration and the settlers who come to the frontier may be 'self-selected' to have certain unique qualities that distinguish them from other small farmer producers. Although they may be risk averse when they get to the frontier, their decision to migrate demonstrates an underlying capacity for a certain degree of risk and willingness to tackle the unknown. As Murphy et al 1997 observes, "Frontier settlers are generally determined and hard-working people trying to make better living for themselves and their children under trying conditions" (p.60).

Box 1. Settler Life on the Tropical Forest Frontier:

Settlers in the Northeastern Ecuadorian Amazon

"In the Northeastern Ecuadorian Amazon, the typical farmhouse consists of a one-room, open, wood structure with a zinc roof raised on a platform to avoid the rains. Pigs, chickens, and other small livestock mill around below the house and there is sometimes a 'formal' toilet in the form of pit latrine. Sometimes there is not. More wealthy settlers would have a house on their farm and a substantial cement-block dwelling in town as well as a truck to travel between. ¨

Source: Pichon, Personal Communication, 2004.

Settlers in the Petén in Guatemala

"Few homes have electricity. Kerosene lamps and fires provide lighting at night. Food is prepared with wood from the forest or from farmland fallow. The latter option is more common because recently fallow fields on the frontier are always strewn with a clutter of

unburned branches remaining from initial clearing.

Water is collected in a communal well or is fetched from the closest water sources. Women and children may spend several hours a day lugging buckets of water on their head from the nearest river, stream, or pond. Some households were located as far as seven kilometres from water sources. . .

Besides the immense labor involved in this chore, water sources are often polluted, scarce, and overused. Clothes are washed in the same water that is used for household consumption. In the case of a pond, over time this water becomes increasingly saturated with surfactants. In the case of a river or stream, the pollutants produced by communities upstream (including detergent, herbicides, and human waste) contaminate the drinking water of downstream consumers . . .

Source: David Carr (2004a) "Tale of Two Roads: Population, Poverty, and Politics on the Guatemalan Frontier," p. 10

The generalized patterns described in Table 3 are an idealized snapshot of the evolving real strategies that may actually develop over time. As we discuss further below, significant differences in economic welfare may occur in the same household over time as well as between settler households on a frontier. We now turn to consider the evolution of the frontier and of settler households over time and the implications this has for settler welfare.

C. Changes in Settler Welfare Over Time

Forest 'frontiers' in Latin America are not a geographic place but a process of socioeconomic and demographic development that plays out through time and expands through space (Almeida 1992 and Carr 2004a, p.5). Looking at settler welfare means looking at their *changing* welfare and differentials in welfare outcomes between households since physical, social, cultural, technological, and economic conditions are evolving, as are settler households, themselves. The recent literature reflects a strong orientation towards looking at these kinds of chronological dynamics or stochastic changes on the frontier as well as within settler households. We consider the findings these studies offer in relation to settler welfare more closely below.

1. Settlement Phases, Economic Differentiation among Settlers, and the Determinants of Settler Welfare

By the 1980s, the ecological costs of rapid tropical forest settlement, which began in the 1950s and 1960s, were evident in the Brazilian Amazon. During the 1980s, several influential Brazilian studies collected and analyzed empirical information on settlers at the community or `frontier` level in Brazil in order to assess sustainability and future prospects for frontier development (see for example, Little and Horowitz 1987; Moran

1981; Moran 1983; Nelson 1973; Schmink and Wood 1987; Schuman and Partridge 1989). Most of these earlier studies directly or indirectly try to identify common "stages" or phases of adaptation to the frontier that settler households go through over time.

Table 4 summarizes some of these "stages," their determinants, and welfare implications as gleaned from these early Brazilian Amazon studies. During the first five years of settlement, settlers may go through a 'pioneer' or adaptation phase. Risk aversion, adapting to the environment, and gaining a foothold in the region through subsistence production characterize the pioneer phase. The disadvantages of the frontier tend to outweigh the advantages in this phase making overall welfare low. After five to ten years of settlement, settlers may enter an 'experimentation phase.' At this point, settlers begin to take more risk, try new activities in addition to subsistence production, and to diversify. In the experimentation phase, the advantages of the frontier may begin to balance against the disadvantages. After ten years or more, settlers begin a 'consolidation phase' in which they continue to diversify, while also shifting more and more resources toward production activities that are particularly profit earning, such as cattle raising. Positive welfare outcomes at this stage may outweigh negative ones.

An implicit assumption within studies from the 1980s, which conceptualize common settlement "stages", is that settler households start off from essentially the same point and are fairly homogenous in terms of their baseline economic and social characteristics. This assumption is, no doubt, linked to the prevalence of planned settlement programs in the earlier phases of settlement in Brazil, data from which were the focus of many of the studies in the 1980s. Indeed, within planned schemes settler households may be more homogenous since there can be active selection of households for participation based on common characteristics. However the importance of planned settlement programs has become increasingly less important and in some areas has never been a significant factor spawning settlement (e.g. the Ecuadorian Amazon). Most settlers who have arrived and continue to arrive on the frontier in Brazil and elsewhere in Latin America are spontaneous settlers who come on their on accord rather than as part of planned settlement schemes. Settler households are thus, likely to be quite diverse in terms of their starting points, baseline economic and social characteristics, and thus, the eventual paths they take on the frontier. Successive waves or cohorts of settlers also make the frontier a complex "landscape" (Brondizio et al 2002, McCracken et al 2002) or mosaic of households with not only of differing characteristics and paths of development over time but also with varying durations of time or years on the frontier. This makes the elaboration of any common stages impossible to define.

More recent studies, as a result, emphasize more the diversity of settler household starting points, experiences, and economic and welfare outcomes on the frontier rather than any common "stages" of development (see for example, Brondizio et al 2002; McCracken et al 2002; Perz 2001 and Walker et al 2002 on Brazil; Carr 2002 and 2004a, 2004b, 2004c on Guatemala; 2004b Deininger and Minten 1999 and 2002 on Mexico; Escobal and Aldana 2003, Swinton and Quiroz 2003, and Takasaki et al 2001 on Peru; Bilsborrow et al 2004; Marquette 1998, Murphy et al 1997, Murphy 2001, Pann et al 2003, Pichon 1997a and 1997b; Pichon et al 2001 and 2002 on Ecuador; see Walker and

Perz 2002 for an extensive review of these studies). These more recent studies document that since settler households start off on different economic and social footings among other things, they subsequently experience differential success on the frontier. Some do well, some fail, and many struggle to maintain their foothold on the frontier. As a result, settler populations may be highly differentiated in terms of their economic outcomes and welfare with most carving out a precarious existence (See Box 2).

Box 2. Differentiation Among Settlers in the Northeast Ecuadorian Amazon
"By 1990, we observe a continuum in which some households subsist from more remote, new, small, low-income farms; depend on wage work; and are less robust in the face of external shock. Large prosperous landowners have most of the pasture, cattle, cars, consumer goods, and better homes. In between, these extremes the majority of settlers make a modest living from diversified farms, combining perennials, rice, bananas, chickens, pigs, and some cows. Thus, spontaneous settlement---while it does provide a better (if hard and uncertain) living for the thousands of families who migrate in search of land—has not equally distributed frontier lands and the opportunities to cultivate it. An eventual and inevitable outcome is to recreate the inequities and social relationships of the highlands in the coastal lowlands." Murphy 2001, p. 76

Table 5 brings together some of main factors that may shape this economic differentiation based on the recent studies cited above. These factors fall roughly into four categories: (1) structural socioeconomic, political, and organizational conditions on the frontier; (2) farm characteristics; (3) 'history' or significant period events; and (4) household socioeconomic and demographic characteristics. Overlap and interrelationships between these categories of factors clearly exist. For example, the farm characteristic of road access is connected to structural conditions shaping the development or road infrastructure. However, most of the above recent studies that provide insight on the determinants of settler welfare are multivariate ones that try to estimate the comparative discrete importance of these four groups of factors rather than interactions between them. In these analyses, structural factors (1) and farm characteristics (2) emerge consistently as the two most important determinants of settler land use, productivity, and, ultimately, economic differentiation and welfare. We review all four categories of factors, however, in more detail below.

Structural factors (1) encompass the key elements of civil, political, infrastructure, and land tenure organization on the frontier in which the settler household is immersed. The structural factor of most importance may be that of the legal system that shapes land tenure security. If land tenure is not secure, a household may, in extreme cases, lose its land and foothold on the frontier. Also, a household that does not have secure tenure has little incentive to invest in the land. Given lack of land tenure security, a farm household may fail to succeed no matter what. Farm characteristics (2) include plot size, quality, and road access. If a plot is very small or has unproductive soils, it will have lower baseline productivity regardless of other factors. Also, if it has poor access to roads the marketability of its products will be highly restricted. In this way, structural factors and farm characteristics together act as a basic "straightjacket" (Pichon 1997a and 1997b) on settler production and welfare.

'History' or period events (3) may also have profound significance for settler welfare. These kinds of events can include commodity booms or busts that affect the price and demand for crops, economic or political policies that may also affect prices, and armed conflicts or violent events that threaten the lives and livelihoods of settlers (e.g. the 'drug war' in Colombia). It may also include the wave of settlement that a settler came in and whether they participated in a planned settlement project. Early settlers generally have better choice in terms of getting better quality and better-located plots near roads. Also, settlers who participate in planned settlement schemes organized by the state or private enterprises may be more likely to procure better plots with more secure land tenure. Analysis of early, planned, settlement schemes in Brazil suggested that settlers who participated in these programs did not seem to benefit especially from more organized settlement strategies (see for example, Nelson 1973). More recent research from Brazil suggests that planned settlers can have certain advantages in terms of initial capital, access to basic services, better land quality, and more secure land tenure (Almeida and Campari 1995). In any case, the majority of settlers that come to tropical forest regions do not come as part of planned settlement projects but, are 'spontaneous' settlers who come to the frontier on their own.

The socioeconomic and demographic characteristics of the farm households (4) include their initial wealth upon settlement, duration of residence, household structure and labor availability, and educational and previous farming experience of the household head. The impact these household level factors, in particular household lifecycle effects, may have on settler economic success, differentiation, and welfare have received an increasing amount of attention in recent research. We, therefore, look more closely below at the insights this recent micro level research on settler households offers toward understanding their welfare outcomes.

2. Changes in Welfare over the Lifecycle of Settlers Households

A revisionist approach has emerged that reevaluates the potential that individual households have to 'tighten' or 'loosen' the "straightjacket" of structural and farm level factors shaping settler production and welfare (see Perz 2001 for a detailed review of this

literature). In this context, several studies have considered variation in settler economic outcomes over the course of the household 'lifecycle.' The household lifecycle refers to the series of demographic and economic changes that households pass through over time with the birth of children and loss and gain of household members through death or migration. In a frontier context, where the use of hired labor on household farms is limited, family labor is generally the same as farm labor. Thus, household demographic changes over time have direct implications for the basic level of need in the household (consumption), its capacity to meet those needs (the size of the household labor force), and the relationships between household needs and capabilities (the dependency ratio or burden) (See also Box 3).

Recent studies indicate that although farm level factors and structural constraints may be most important, household lifecycle dynamics are evident and can have a significant effect on settler production and welfare (see Walker et al 2002 for a review of this literature and individual studies by Bilsborrow et al 2004; Brondizio et al 2002; Carr 2004b; Hall 1997; Marquette 1998; McCracken et al 2002; Pan et al 2003; Perz 2001 and 2003; Perz and Walker 2002; Pichon et al 2001 and 2002; Walker et al 1996, 2000, and 2002). Table 6 gleans information from these studies on the lifecycle stages settler household pass through and the agricultural strategy, labor, consumption, and welfare characteristics associated with these different stages. Table 6 implies that household lifecycle shapes land use, economic outcomes, and welfare among settlers by affecting three areas: (1) household subsistence needs or consumption; (2) available household labor; and (3) cropping patterns and overall agricultural and economic strategy.

Box 3. Views on the Household Lifecycle Among Frontier Settlers in Brazil
"Recent settler families in a frontier are predominantly composed of young, nuclear, households, with a head couple in their mid-20s to early 30s and a few young children. Their initial agricultural activities involve clearing a small area of forest (three to five hectares) to cultivate annual crops such as rice, beans, and manioc for consumption and fore sale in local markets. Each year additional forest area is cleared and previous plots are either left in fallow, formed into pasture, or planted in perennial crops. The shift to cattle and perennial crops is typically a slow process that involves high initial capital and labor costs, and the gains from these activities will only be reaped in later years. Typically, perennial crops will not provide any returns to the family for three to five year, while acquiring cattle may be an important capital-saving strategy. Cattle can be quickly purchased or sold depending on household needs." (McCracken et al 2002) "Generally the scenario starts with the migration of a young family to a plot of land beyond the extensive margin of agriculture. With time, the household head ages and, through experience and experimentation, is able to improve his or her farming practices. Concurrently, the number of dependent children rises, imposing a consumption burden on the household's active workforce. The children ultimately add their productive power to the sum total of household workers, which allows for the farm expansion and the extension of existing activities into new endeavors. As the life cycle, winds down with aging of the household head, activities may contract or continue in a robust fashion should adult children remain in place and build on the family's patrimony… As colonist smallholder begin their families and start farming, they meet subsistence needs with limited economic resources since youthful children are strictly consumers. Dependency, risk aversion, and high discount rates create strong incentives to achieve food security through annual crops. As the children age and expand, the family labor force and as the household head acquires experience, production constraints are relaxed, discount rates are lowered and risk aversion is mitigated. The stages is set for investment in commercial crops and cattle raising" (Walker et al 2002, p 172).

'Young' households may be particularly vulnerable to failure on the frontier due to their small size, limited labor, and high dependency burdens. Young frontier households with small children have less adult labor and proportionally more consumers than laborers. Adult men in these young households may have to work harder, on either their own farm or another, to make ends meet. Off-farm work by men in young households has implications for women and children since they may need to add agricultural tasks to their domestic activities when men are away.

'Maturing' or 'mature' households may be better off than young households. They benefit from the 'natural' mechanism in which the birth and aging of children into laborers relaxes labor and consumption burdens as it increases the number of household laborers. Demographic development thus, turns from an economic constraint to an engine

of economic development in older households. Increased labor options and more balanced labor/consumption ratios stimulate not only higher production in agriculture but also allow expansion into more lucrative activities such as the production of cash crops, cattle raising, and off-farm employment. On the other hand, there may be other maturing or mature households in which their demography continues to works against them due to events such as deaths and out-migration, which may suppress any increase in household labor over time. These kinds of adverse demographic events may keep even older households in the same precarious terrain as younger households indefinitely.

Household lifecycle dynamics provide some insight into why settler households are able to diversify their economic activity over time. Relaxed labor constraints due to later household lifecycle may facilitate diversification by allowing some households to position more labor in off-farm work or even higher paying non-agricultural work as they mature. Both cattle raising and perennial crop growing maybe more labor intensive than food crops, such that households can undertake them only at maturing and mature lifecycle stages when there is more labor available (McCracken et al 2001. p.188). This may partly explain why cattle raising is associated with households only at later durations of settlement (ibid; Murphy 2001; Marquette 1998). The household lifecycle also brings to the front the dynamic nature of settler welfare. When we look at welfare changes over the household lifecycle, we see it is not a static question of whether or not basic or other needs are met. Rather, it is a negotiated balance or 'welfare function,' which changes over time depending on what households need at a particular moment in time and how well they can meet those needs.

The lifecycle effects that shape settler welfare can be more complex than Table 6 implies. Household lifecycle and duration of frontier settlement may frequently parallel each other, that is, many settlers come to the frontier as young households and mature on the frontier (McCraken et al 2002, p. 173 on Brazil; Meertens 1993, p. 264 on Colombia; Marquette 1998 on Ecuador). But, households may also come to the frontier at different stages in their lifecycle not only at the initial stages. Some 'households' may not even come to the frontier as a household but rather migrate gradually. Men may come first to establish a farm and the family may "reconstitute" itself progressively as it accrues the assets necessary to support a larger group (see Sydenstricker Neto and Vosti, 1993 on Brazil and Meertens 1993, p. 262 on Colombia).

In addition to intra-household lifecycle effects, there are also inter-household 'cohort' effects that shape settler welfare over time. Frontiers are a "landscape" (Brondizio et al 2002) that blends together older and newer settlement areas made up of "cohorts" or groups of households that settle at different times (McCracken et al 2002). These different settlement cohorts may experience very different sets of temporal conditions and thus, can reflect very different farm, land use, and production strategies, and ultimately, very different welfare outcomes. For example, one cohort effect is that settlers that come to the frontier in the early years of frontier development will as a group generally procure better quality land near roads. Cohort effects also intersect with the 'history or period events' discussed in Table 5. For example, certain cohorts of settlers will experience the same set of temporal conditions if they participate together in a

planned settlement scheme, or are subject to a given set of economic or policy changes, commodity booms or busts, or violent events linked to the flare up of armed conflicts.

The studies discussed above that have considered settler household lifecycle, focus almost exclusively on the Amazon, particularly in Brazil and Ecuador. Because of a lack of comparative research for Central America, it is difficult to know if these Amazon also prevail in Central America.

D. Education, Health, and Welfare among Settlers

So far, our consideration of settler welfare has focused mainly on economic welfare linked to their agricultural production strategies, economic activity, and household-level characteristics. But, as also discussed above, structural conditions on the frontier, including access to basic services in health and education (see Table 5), are one of the most important overall determinants of settler welfare on the frontier. A recurring sub theme in many of the studies considered in this review is, not surprisingly, that a lack of basic services in health and education creates fundamental underlying challenges to settler production and their daily quality of life and welfare outcomes. We therefore, single out education and health conditions among settlers for attention below.

1. Education

Despite their importance, there appears to be little systematic or comparative recent information on education or health on tropical forest frontiers in Latin America. Information on formal education on the frontier, for example, on the availability of schools or levels of education, is basically anecdotal. Some household surveys looking at land use among settlers have asked about attendance at school for children (see for example Pichon 1997a in Ecuador). In Ecuador, attendance by children appears to be low and seasonal. Apparently, if children are old enough to go to school, they are old enough to work on the farm, which takes precedence. Studies of settlers, which do consider education, look generally at education of the household head in relation to land clearing (see Escobal and Aldana 2003 on Peru; Godoy et al 1998 for Honduras; Carr 2004b on Guatemala; Murphy 2001 on Ecuador). These studies find, not surprisingly, that more educated heads have economically better-off households. But, education of the household head, among first generation settlers at least, tells more about their area of origin than the frontier. 'Continuing' education, such as training in agricultural methods or marketing is occurring through numerous projects (see for example, Wyels 2003 on Costa Rica) and technological assistance programs. There appears to be little recent systematic analysis of these types of opportunities as well.

2. Health

Health conditions have particularly important implications for welfare because they affect not only daily quality of life but also household labor availability and productivity. Limited information on settler health exists, is mainly on health outcomes as opposed to

services, and covers, mainly, Brazil or Ecuador. Evidence from the Brazilian Amazon, suggests that settlers in tropical forest frontiers may be subject to disease vectors particular to moist forest habits including: malaria, river blindness, filiarisis, and schistosomiasis (Moran 1981, p.183). Also rates of injuries, skin infections and the prevalence of childhood illnesses such as gastrointenstinal infections, parasites, and respiratory infections may be high (ibid). The diets of settlers may also be deficient with malnutrition common among children (ibid). Poor health directly contributes to settlers leaving the frontier since households with more days lost due to disease and fewer children attending school may abandon their plots more frequently than others (Moran 1989).

A cluster of studies has looked specifically at malaria on the frontier. Sawyer (1992) suggests that the movement of large populations into the Brazilian Amazon has created new conditions and patterns of malaria transmission on the frontier, which may be particularly difficult to control. Because settlers may come to the Amazon at older ages, they do not have natural immunity to malaria and are more susceptible to contracting it. Low immunity, temporary and often unsanitary conditions of frontier settlement, high and intense exposure to bites, high-levels out-door transmission rates, and drug-resistant strains create a particularly unstable pattern of "frontier malaria" (Sawyer 1992, p. 11). He suggests that transmission may peak over time as progressively more areas of forest area cleared. Poorer settlers may be more likely to contract malaria since there is an association between higher economic status, knowledge of preventative measures such as insecticide, and lower incidence of illness (Sawyer 1993).

Sawyer (1992) notes that although malaria control was an important part of public health measures outside the Amazon, it has not been within it. Efforts at eradication and treatment similar to those in settled regions in Brazil, improvements in household dwellings and compounds, and reducing modifications of the environment can decrease disease transmission. Like Moran (1989), Sawyer also concludes that malaria has contributed to instability in settlement and high settler turnover on the frontier and imposes economic and social costs that extend far beyond those of the illness, itself (Sawyer 1993). A more recent study in settlement areas in the Brazilian Amazon linking social and geographic data has shown that ecological changes due to patterns of forest clearing, land use, and community organizational factors may also affect rates of malaria transmission and infection (Singer and de Castro 2001). Carr 2004a confirms that malaria has similar negative impacts on settler welfare in the Petén in Guatemala.

Ecuador has been the focus of several health studies with regard to pollution caused by oil extraction in the region. Settlers are exposed to water and solid pollution from oil activity due to pipeline spills and leaks. This exposure to crude oil and other industry contaminants, either directly or through drinking water, may contribute to higher levels of blood disorders and cancer among settler groups (Center for Economic and Social Rights 1994). In the early 1990s there appears to have been no effective regulation of the petroleum industry or effective way of enforcing their compliance with environmental regulations (ibid).

These conditions likely persist to date. A recent press release by the Pan American Health Organization (PAHO) in April 2004, titled "La explotación del petróleo en la cuenca amazónica del Ecuador produce una emergencia sanitaria" (Petroleum development in the Ecuadorian Amazon has produced a health emergency), presents data from a health analysis in the area (Clark 2004). This report indicates that contamination of water sources used by frontier communities due to petroleum industry activity has created concentrations of hydrocarbons as much as a hundred times the limits specified by the European Union. Health outcomes for women have been particularly adverse with increased incidence of debilitating illnesses and a doubling of spontaneous abortion rates in communities in the vicinity of petroleum activity. Additional study by San Sebastián (2003) confirms these findings. These studies suggest that measures to address the frontier health situation in Ecuador must also include industrial regulation and environmental cleanup in addition to better provision of services.

E. Women's Welfare on the Frontier

Recent analysis of welfare outcomes for subgroups of the settler population, such as women, is as sparse as data on health and education. Women's and health issues intersect with regard to reproductive health on the frontier. Despite excellent reproductive health information for women throughout Latin America, little direct data exist on this among frontier settlers. Surveys in both Brazil and Ecuador, suggest that rates of natural increase are higher in frontier areas because of higher birth rates. This is partly related to poorer access to health and thus, contraception services in frontier areas (Thapa et al 1996). Concurrently, perinatal as well as child mortality may also be higher because of higher numbers of unattended births and poor health service access on the frontier. No information could be located in this review on maternal mortality among settler women but it is also likely higher for the same reasons.

In studies in frontier areas in Bolivia and Mexico, Townsend (1995, p.32) observes that women settlers in Latin America may experience declines in their overall status and well being on the frontier. While they may have owned and managed assets in their areas of origin, for example, they generally have to relinquish these on the frontier. Women may also be less integrated into agricultural extension and training activities on the frontier, which are often open exclusively to men. Based on study in the Colombian frontier, Townsend concludes that women settlers undergo a process of "housewifisation" (ibid, p. 41) in which they give up any involvement in agricultural activity to undertake full-time work in household reproduction activities or childbearing, childcare, food preparation, and household chores such as washing and cleaning (See Box 5). Women may also have little separate economic power or control over income and may not be able to hold land titles (ibid). Studies in Guatemala also indicate that land tenure systems on the frontier may formally exclude women from holding land titles and from participation in training activities (Monterroso 2003).

A study of women settlers in the tropical forest settlement areas in the Mexican lowlands reveals a glimpse into two other factors that may shape the quality of women's lives on

the frontier: domestic violence and high labor burdens (Townsend 1995, p. 57). The life histories of women settlers in these frontier areas suggested alcoholism among spouses and domestic violence were main concerns. Women settlers who had no contact with kin were particularly vulnerable to physical abuse by their spouse. Study among the Mexican women settlers, however, also suggests that over time, if frontier services improve, so can women's lives, in terms of their economic participation and training opportunities. Many of the women interviewed successfully undertook their own agroforestry activities based in home gardens, which allowed them to remain close to their house. The productive potential of their garden activity, though, was limited by a lack of markets for their products. Ecotourism around protected areas in Guatemala, as well as in Mexico also presents new kinds of opportunities for women in handicraft production (Langholz 1999 and Velázquez et al 2003).

There is some detailed information on women's labor participation among settlers in Colombia (Meertens 1993) and Ecuador (Thapa et al 1996). On the Colombian frontier, women's labor burdens increase during early stages of settlement when they coincide with early lifecycle stage. Women in this situation have the double burden of caring for young children and working on the farm (Meertens 1993). Contrary to a trend toward `housewifization`, in early stages of settlement women generally participated more in agricultural activities, as they had done in their area origin. They also maintained this level of participation afterwards, although the intensity of their work declined over the household lifecycle as children helped out. Frontier settlement in the Colombian case led to a greater flexibility in women's labor. The implications for women's welfare are that, over time on the frontier, their labor burdens may decrease. Yet, their repertoire of labor skills may expand providing greater economic flexibility for both themselves and their households.

In Ecuador, there were less flexible women's labor patterns. Households tended to use hired labor instead of women's labor in agriculture. Households were also likely to resort to off-farm labor to earn income rather than intensify farming by increasing women's work on the farm. Younger women with younger children or in households with larger crop areas were more likely to work in agriculture confirming a lifecycle effect similar to that observed in Colombia. In the Ecuadorian Amazon, diversification into cattle raising meant that women were even less likely to be involved in agriculture probably because crop areas were reduced. Study in Ecuador indicates that creating opportunities for off-farm labor may be a positive way of maintaining household income and not increasing labor burdens on women (Thapa et al 1996).

Box 5. Life of A Women Settler In Her Own Words
"Prepare the meal! Grind the maize and then prepare the meal and in the evening…do the washing, the boy's clothes. That's how I used to work. I didn't have a moment's rest, from six in the morning until one in the afternoon on the mill, then I go into my kitchen to prepare lunch and as soon as everyone's finished eating, I get out my tub and to the washing and . . . that was my life. Nothing but work! Maybe that's why I got fed up, because I never got a break. It was too much work . . ."

From the life history of Clara, Age 36, settler in the tropical southeast lowlands of Mexico as quoted in Townsend (1995) Women's Voices in the Rainforest, p.171

Information from the Ecuadorian Amazon (Thapa et al 1996) also provides some insight into the socio-economic background of women settlers. They were on average in their late 30s and divided in terms of urban or rural background. Their educational level was low with most having less than a primary education. In the Ecuadorian Amazon, women settlers may leave the frontier more frequently than men by out-migrating to urban areas; where they take up jobs in non-agricultural occupations One of the effects of this is that second generation women settlers may achieve higher educational levels than their brothers (Laurien et al 1998). But, the higher rates of out-migration among women may also be an indicator of their limited labor opportunities, high labor burdens, and overall lower quality of life on frontier farms. The welfare outcomes for women in tropical frontier areas like Ecuador may be improved by the activity of international agencies and NGOs in frontier regions, which frequently place an emphasis on women and development (Monterro 2003).

In the above discussion, we have tried to survey existing research on the key characteristics and determinants of settler welfare on tropical forest frontiers in the Amazon and Central America. We now turn to consider the link between settler welfare and sustainable development in these frontier regions.

F. Integrating Settler and Forest Welfare: Sustainable Development on the Frontier

Exploring the disconnect between settler and forest welfare in Latin America has been a major focus of study. The example *par excellence* of conflicts between settler and forest welfare is cattle raising. Cattle offer settlers a profitable and multifunctional production option, which can provide cash, savings, liquid assets, food security, and status better than other alternatives, including cash crop production. Most settlers aspire to own cattle and better-off settlers almost always do. The expansion of pasture areas for cattle is a main and unique driver of forest clearing in Latin America compared to its less important role in Asia and Africa (Geist and Lambin 2001, Table 1, p.26). Conflicts between settler and forest welfare that revolve around cattle are a prime example of the "dilemma" (Moran 1983) of tropical forest development in Latin America. Sustainable development in these regions rests on the possibility that this dilemma can be resolved. We consider that possibility further below.

1. Sustainable Development and Settler Welfare in the Amazon

a. The Risks of Productive Deforestation

Several recent studies wrestle with the concept of sustainable development in forest frontiers and what current socioeconomic and land use patterns bode for achieving it (Almeida and Campari 1995; Perz 2001; Hall 1998; Walker and Homma 1996; Wyles 2003; Pasos et al 1994). Table 7 summarizes some definitions, prospects, and policy implications found in these recent studies. Almeida and Campari (1995) define sustainable development as a condition on the frontier where settlers farm a single area of land over time with little plot turnover. If settlers improve their welfare and income, they invest returns from agriculture in intensive rather than extensive agricultural expansion activities (e.g. intensifying output on their existing cleared area rather than clearing more of it for crops or pasture) (ibid, p. 49). They explore the extent to which these conditions of sustainable development exist in the Brazilian Amazon using a panel study from 1981 to 1991 of settlers in a planned settlement along the Transamazon highway in Pará (Easter Brazil) and another in Mato Grosso (Western Brazil).

The welfare of many settlers in the study areas clearly increased in the ten years between 1981-1991. Returns to labor, land prices, and net wealth rose for all settlers during ten-year period (ibid, Table A.12, p. 101) while even those who had low absolute income levels could still earn twice the amount or more than do the rest of the labor force in Brazil (ibid, p. 51). However, their analysis emphasizes that increased settler welfare leads mainly to more rather than less clearing in two ways. First, although land prices rose in the region, actual returns to land for small farmers did not since the price of their food and cash crops were stagnant during the 1980s. The combination of low returns to land, yet high returns to labor and rising land values created high potential capital gains from selling land. This made it worthwhile for less well-off and lower productivity farmers to continue to farm but also to sell their plot and move on to a new one. As a result, many farmers sold their land, reaped the capital gains, and moved on to clear land elsewhere and start the same process again. Although this process of "itinerant accumulation" was salient in the 1980s, Almeida and Campari imply that it had probably been going on for some time (ibid, .47).

Another path to more forest clearing linked to improved economic welfare was that of "productive deforestation" (ibid, p.41). In this situation, higher productivity farms have more incentive to remain on their plots due to greater returns to land but they may use their higher agricultural returns to invest in increased land extensive activities (expanding crop areas or areas of pasture for cattle) rather than for inputs that would allow them to use existing land more intensely and thus, clear less forest. Rising welfare indicators among the settlers studied in Brazil were, however, associated with a trend towards increased diversification out of agriculture. This decrease in dependence on agriculture might contribute to less clearing in the long term.

Based on these findings for Brazil, policies for promoting sustainable development on the frontier may need to include locally directed and enforceable efforts (such as collecting capital gains taxes) that encourage settlers to stay on rather than sell their plots, disseminating agricultural technologies (options such as agroforestry) that increase the intensive use of land and enhance forest cover, and exploring the potential for diversification of economic activity (ibid, p.63ff). In all these activities, local NGO`s can

play an important role as brokers between farmers, government agencies, and international organizations.

b. The Possibility for Productive Conservation

Almedia and Campari`s study, defines sustainable development on the frontier in terms of processes such as "productive deforestation" or "itinerant accumulation," which stand it its way. This contrasts with more recent discussions on sustainable development within the revisionist approach discussed in Section C. These more recent studies proactively search out examples of sustainable development rather than only the conditions that prevent it (Perz 2001, p.93ff). These recent studies also pay more attention to the human side of the welfare equation and try to "articulate a concept that more concretely captures both the social and environmental dimensions of sustainability." (Perz 2001, p. 93). Interestingly, although many of these revisionist studies look at the same study area in Brazil as Almeida and Campari (1995), they arrive at quite different insights.

The idea of "productive conservation" (Hall 1997) is a key concept emerging from this recent revisionist literature. Productive conservation can be seen as a more concrete term for sustainable development which means that small farmers and other groups generate acceptable incomes while sustaining the forest resource base (Hall 1997; Perz 2001, p. 93). Productive conservation occurs when the conditions creating `improved` welfare (see Table 5; for example, secure land tenure, later lifecycle stage, more assets on settlement, better community organization etc...) occur alongside more sustainable farming techniques involving more intensive use of pasture and agricultural land, active rotation and fallow management on multiple plots, and the investment of proceeds in agroforestry activities (as opposed to increased number of cattle, for example). Empirical evidence suggests that connections between increased settler economic welfare, intensive production, and less forest clearing do occur among some settler households (Perz 2001).

The question is what determines whether or not settler households, particularly better off settler households, will follow the path of productive conservation? Hall (1997) suggests that the key is knowledge and opportunity. Most settlers are not aware of or do not have access to the technologies needed for adopting profitable sustainable alternatives to cattle raising like agroforestry. He suggests that given other equally profitable options settlers would opt for less environmentally destructive practices since they ultimately value the resource base upon which they depend. He also notes that sustainable production strategies may have the best chance of success in older frontiers because these areas have more developed markets, are better integrated into expanding urban economies and have more developed extension support via NGOs and other groups (ibid, p.204). Local mobilization around conservation strategies including, community management of forests and community participation in plans for resource management, may be key in getting households to actively weigh the short-term needs of households, the risk of resource degradation, the long-term interests of communities, and forest conservation together. NGOs may have an important role to play in encouraging this.

Walker and Homma (1996) extend the range of human welfare issues that may interact with environmental ones to create sustainability on tropical forest frontiers beyond consideration of economic welfare alone. (Their observations are based again on roughly the same study area in Brazil considered by Perz 2001, Hall 1997 and Almeida and Campari 1995 discussed above.). They offer what they call a "largely intuitive" definition of sustainability for farming systems as "the reproducibility of the farm household social unit through adequate economic performance." Although this definition lacks a conservation component, they imply that agroforestry systems may be the most sustainable option available to households in terms of farming systems.

Walker and Homma (1996) conclude that in older longer settled frontier areas such as the Brazilian Amazon, where land concentration processes have been in motion for some time, additional social welfare issues beyond merely income may shape possibilities for sustainable development. They particularly single out land reform and rural violence, two factors which indicate that "sustainable relations with the environment necessarily involve positive relationships between individuals and social groups" (p. 77). Policies that address poverty (extension activity and development of public services) are thus, automatically policies that promote conservation. Because of the importance of wider social factors, such as land distribution and violence, they conclude it is important to "resist temptations to view sustainability in the Brazilian Amazon as an environmental problem requiring only a technical solution." (p.77).

2. Sustainable Development and Settler Welfare in Central America

The question arises, whether the concept of and prospects for sustainable development in the Brazilian Amazon, and specifically the Transamazon area, are similar in Central America? Costa Rica, for example, presents a contrasting picture to the Brazilian Amazon in terms of the much smaller quantity of forest areas available to settlers (See Table 2). Also in Costa Rica, small-farmers reflect a stronger dependence on coffee, a cash crop that is tied directly to global export markets. At the same time, remaining forest areas are largely absorbed into protected areas, which occupy a quarter of the country's land. Because of these conditions, Costa Rica is often used as an example of a `closed` frontier where there is little land or opportunity for small-farmer settlement remaining (Schelas 1996).

Other countries in Central America share similar characteristics with Costa Rica in terms of much smaller size forests and smaller proportions of remaining forests relative to their national area (See Table 2). These smaller areas contribute to higher overall rates of forest change in Central America than the Amazon. Not suprisingly, Central American countries generally have higher portions of their remaining forest in protected areas (see Table 2). In Central American countries like Costa Rica, frontier settlement may more concentrated in the buffer zones around protected areas than it is in the Amazon. The margins or buffer areas around protected areas in Central America also bring settler-farming populations together with more long-settled and often indigenous groups that traditionally depend more on often more sustainable forest extractive activities. Central

America thus, presents some unique challenges and options with regard to sustainable development.

Pasos et al (1994) carried out a multi-country study in Central America (Mexico, Guatemala, Honduras, El Salvador Nicaragua, Costa Rica and Panama) of sustainable forest use in areas around protected areas a decade ago, which still provides some of the only substantial, empirical, and comparative insight on the issue for Central America. Sustainable development on the expanding agricultural frontier is viewed as a process where with common pool resources, such as forests, individual needs and interests need to be integrated with the imperatives of economic development and conservation. However, the interests of all groups may not be given equal weight in this process and the state may need to play a mediating role.

Communities linked to conservation projects in protected areas considered in the study include: Quintana Roo, Mexico; Bosque Latifoliado, Honduras; Rio San Juan, Nicaragua; the Llanuras de Tortuguero, and the Peninsula de Osa in Costa Rica. Projects in these communities involved efforts to encourage small farmers around the protected areas to diversify into different food crops, and agroforestry as well as to expand into ecotourism. They also encouraged experimentation and exchange between farmers and technical training in environmental practices and education. Support was also given to meet labor requirements at harvest time as well as the processing and marketing of crops grown. Also alternative sources of credit were opened up to allow farmers to increase their income in the short term for farm activities.

An analysis of the results of these efforts reflect several successes with regard to increasing both human and forest welfare for settlers (and indigenous groups) around the parks. These include: increasing community control over extractive resources; increased links to markets for selling these resources; the effective dissemination of experimental or innovative intensive agricultural practices (e.g. use of green manure, “frijol abono,” or mulch plants on fallow fields) as well as other intensive technologies; the creation of successful incentives for undertaking conservation measures in farming and extractive activities; and the establishment of a germplasm bank (ibid, Table (Cuadro) No. 15, p. 94-95). Challenges encountered, included: the need to regulate extractive activities and define what sustainable levels of extraction are; encouraging more diverse economic strategies; developing weak market structures; and increasing community articulation with protected areas.

The study identifies several key elements that are necessary for advancing human and forest welfare together in the protected areas considered. The Costa Rican and Guatemalan areas suggest that there is very good potential for diversification through agroforestry activities. The Petén in Guatemala, and Darién area in Panama suggest that ecotourism also represents an important and ecologically sustainable area for households to diversify into including the production of artisanal crafts. The Guatemala, Costa Rica and Nicaragua study areas, in which coffee growing is important, suggest that the promotion and marketing of organic coffee may increase both income and conservation outcomes among small farmers in buffer zones.

The buffer zones also raise the need for special attention to interactions between settlers and indigenous groups. As the authors observe, "En Centroamérica virtualmente todo el escenario de la frontiera agrícola, corresponde a zonas de población indígena." (In Central America almost the entire agricultural frontier is an area of indigenous population) (Ibid, p. 101 and Map (Mapa) No.3, p.20). Decentralization of forest and protected area management activities to local communities would also facilitate better outcomes in terms of human welfare, conservation and community participation by allowing more grassroots local-level assessments and policy responses.

3. Secondary Succession, Cattle, and Settler Welfare

We look briefly at two special areas of interest in the current research relevant to sustainable development and settler welfare on forest frontiers: secondary succession of forest cover and cattle raising. Patterns of secondary succession of forest cover or the regrowth of vegetation in cleared areas on settler plots have important connections to settler welfare as well as conservation outcomes. In recent years longitudinal analysis of satellite imagery for frontier areas has revealed the development of secondary succession areas in settlement areas on forest frontiers in both the Amazon and Central America (see Alvarez and Naughton-Treves 2003, Coomes et al 2000, Smith et al 1998 on Peru; Brondizio et al 2002, Dunkhorst et al 2003, McCracken et al 2002, Moran et al 1996 and 2002, Perz 2002, Uhl and Nepstad 2000, Walker 1999 on Brazil; and Velásquez et al 2003 on México). This regrowth is generally seen as a positive outcome in terms of forest welfare in that it reestablishes some degree of the original cover.

Secondary succession also appears to be associated with higher household welfare and later lifecycle stages, which in turn lead to the greater maintenance of fallows leading to secondary succession. However, these trends occur alongside expansion into other activities such as cattle raising making the conservation implications mixed. The prevalence of secondary succession and pasture management has also been linked to the age of the frontier. In a country, like Costa Rica, where the frontier is old or `closed` and primary forest is scarce, increased secondary succession linked to management of secondary fallow and active reforestation may be more common (Coomes and Grimard 2000; Schelhas 1995).

An important question raised by secondary succession with regard to settler welfare is whether it occurs as the result of active fallow management, active reforestation, or land abandonment. If succession results from fallow management or reforestation it implies some degree of active participation by settlers in conservation practices that have potential positive implications for forest cover. However, if it occurs because of plot abandonment, secondary succession is the positive outcome, from the forest perspective, of a negative process from the human welfare perspective or the failure of settler households on the frontier. Current research has yet to fully explore the comparative prevalence of each of these causes of secondary succession.

Cattle ranching is of particular concern in the context of sustainable development and human welfare on the frontier since, as noted above, it brings conflicts between settler and forest welfare into clear outline. It is also a major common driver of deforestation across the Amazon and Central America. Most studies confirm that cattle raising in the short-term is positively associated with welfare. It is better off households that undertake cattle raising or expand this activity and those who undertake it become better off (see McCracken et al 2002, Moran 2002, Pacheco 2004, Porro 2002, Vosti et al 2001 and 2002, Walker et al 1996, 2000, and 2002 on Brazil; Humphries 1998, Pineda 2002 on Honduras; Pichon et al 2002, Rodrigo 1999; on Ecuador; Roebeling and Ruben 2001 and Schelhas 1996 on Costa Rica; Swinton and Quiroz 2003, and Yanggen and Reardon 2001 on Peru). Given the economic benefits of cattle, several studies do point to the possibility of making cattle raising more sustainable among frontier farmers through better pasture management and more intensive use of pasture areas (Faminow 1998 on the Amazon in general; Fearnside on Brazil 2002; White et al 2001 on Colombia, Peru, and Costa Rica).

As discussed in Section C, changes in labor over the household lifecycle that increase household labor and welfare also work to facilitate cattle production (McCracken et al 2002). At the same time, the dynamics linking settler welfare and cattle raising may extend beyond the constraints of household labor. A main determinant of cattle raising may be not household labor, in the end, but hired labor. Settlers frequently use hired labor in their cattle raising rather than agricultural activities (Walker and Moran 2000). Most of the above studies also indicate that the expansion of cattle raising on the frontier parallels, over the long term, processes of land concentration and growing inequities in land distribution as larger, better off household or commercial ranching operations accumulate the land of failed farms. The possible long-term negative implications cattle-raising may have for frontier settlers are therefore, important to distinguish from the short term benefits. Also, the primacy of cattle among settlers on the frontier may be seen as an extension of the dominance of this activity across the entire agrarian sector in Latin America (Walker and Moran 2000, p. 696). Altering current patterns of expanding cattle raising activities on tropical forest frontiers may mean addressing "the underpinnings of the cattle economy itself" while continuing "the search for viable agricultural alternatives" (Walker and Moran 2000, p. 696).

G. Conclusions

Because of the breadth of potential issues that `settler welfare` may encompass, it is important to note the limitations of this review. The majority of studies reviewed come from published articles and books. The 'gray' literature (dissertations, thesis, presented papers), which often captures the most cutting edge or emergent research may not have been extensively covered. In particular, the gray literature in Spanish was probably insufficiently reviewed. The literature in Portuguese was also not covered at all which may result in the omission of important recent studies on the Brazilian Amazon, particularly studies that may shed light on health, education and the status of women on the frontier. As in any study looking at frontier settlement, the literature on the Amazon and particularly the Brazilian Amazon dominates findings. An effort has been made to introduce studies from other Amazon countries, as well as Central America, but research

and coverage is, for better or worse, proportional to forest size. It is difficult to escape the biases that may arise from the fact that most information on frontier settlers has come from Brazil. Also, only literature from the most obvious and direct social science disciplines involved in settler studies were surveyed. This may have limited the identification of studies on settler health, education, and women. If the medical literature, women's studies, and education literatures were surveyed, particularly in Spanish and Portuguese, additional information on these topics could be uncovered.

Some important areas affecting settler welfare that were not addressed by this report bear highlighting. These include factors affecting peace and security on the frontier. The military has a strong presence in most frontier regions in Latin America and is often the most salient face of government authority there. In regions such as Colombia, the drug war leads to continual confrontations between the military, paramilitary agents and guerilla groups, which have important implications for setter welfare (see for example Cortez 2004 and Gonzalez Posso 2004 on this for Colombia; FAO 2000 on Bolivia). This issue remains to be more fully explored in relation to settler welfare. Violence linked to conflicts over land is also an important area to consider further given the importance of land tenure in shaping settler welfare. Interactions between settler welfare and other important actors on the frontier such as frontier industries (oil industry activity in Ecuador, gold-mining in Brazil, and timber industry activity throughout) are also important to consider further.

Another important political trend that merits consideration is the current shift towards decentralization of forest management in Latin America (Andersson 2003 and 2004a and b; Gibson et al 2000; Larson 2004; Pacheco 2004; and Silvel and Sittman 2004). This trend has important potential for improving settler welfare through the empowerment of local groups and decision-making structures. A related area that merits additional attention in relation to settler welfare is that of land tenure type or communally managed versus privately held land areas on the frontier. As noted frequently above, land tenure is a key structural factor shaping settler welfare outcomes. Several recent studies suggest that not only security of tenure but also tenure type may also be important. Settlers that are part of settlement areas with communal access to land and forest resources, for example in frontier areas in the Mexican lowlands where "ejido" systems exist, may in some instances have better welfare outcomes and more sustainable forest use than settlers that depend on privately held plots (Barbier 2002; Boege 2001; Bray, Merino-Peréz, and Barry, in press; Deininger and Minton 1999 and 2002). This outcome is linked partly to the fact that communal arrangements may provide greater land tenure security and greater access to agricultural assistance. There is limited evidence from the Petén that suggests the same positive links between communal land ownership, welfare, and forest use outcomes (Carr 2004a). Settler welfare and sustainable development on the frontier, needs to be thus, considered further in the context of current general debates on the welfare, development, and environmental outcomes of common property resource management (see, for example, Burger et al 2001; Gibson, McKean and Ostrom 2000; or Ellsworth 2004).

Within these limitations, this review has tried to examine factors shaping the welfare of settlers. The aim has been to look at current research in a 'people' as opposed to forest-centered way. Table 8 summarizes some of the main insights gained regarding settler welfare and their productive activity, changes in the frontier and households over time, health and education, women's welfare, and prospects for sustainable development.

Although agricultural activity (especially subsistence production) is the centerpiece of most settler strategies, diversification into other activities (cash crops, cattle raising, off farm work) is an important part as well. Structural factors and conditions of the frontier may or may not evolve over time. If they do, settlers will be better off. If they do not, the welfare implications are significant. If the frontier fails to develop, settler welfare will not either. The structural conditions of the frontier, particularly with regard to land tenure, and farm-level characteristics are the most important determinants of settler welfare and act like a ¨straightjacket¨ on it (Pichon 1997a and 1997b). The changing social and demographic characteristics of households over time, in particular changes linked to the household lifecycle and evolving labor supply and consumption needs in he household, may tighten or loosen the straightjacket of frontier conditions and farm characteristics. Overtime some households will improve their labor and productive capacity, and thus, chances for diversification, and economic welfare. Other households, particularly at early or late lifecycle stages, will have the constraints of their own demography (few workers, many dependents) added to those of frontier conditions and farm limitations (e.g. less productive soils). At the extreme, these households may fail, abandon their plots, and leave the frontier. In between, "Most settlers are neither destitute nor particularly affluent but are making a difficult living" (Murphy 2001, p.74).

Education and health services, are an example of other structural conditions on the frontier that significantly determine settler welfare. However, there is little information on them. The limited information that does exist suggests that settlers may be subject to numerous unique health threats and particular patterns of disease. In any case, weak health services make illness on the frontier both a health and development problem. Illness reduces daily quality of life but also labor productivity and ultimately settler success on the frontier. Women's welfare on the frontier appears to be mixed. In some cases their range of economic activities and empowerment narrows into the domestic sphere (e.g. in Bolivia, Mexico, Ecuador). In other settings, they may expand their activity and potential contributions to the household (e.g. in Colombia and in agroforestry activities). In either case, they likely have high labor burdens, particularly in young recently settled households, poorer reproductive health outcomes, and possibly experience high levels of domestic violence.

Some specific policy findings emerge. In terms of the determinants of settler welfare (Table 5), investments in improving the basic infrastructure of frontier areas is key. These include strengthening legal systems that regulate land titling, providing credit and incentives for intensifying production, fair pricing, encouraging the growth of locally geared NGO and community based organization activity, and improving infrastructure and access to basic services in health and education. Farm characteristics are not easily changed but measures can be taken to ameliorate the situation of households that do not

have a good resource base in terms of soil quality and location. These include zoning of land quality, providing opportunities for diversification in terms of production and off-farm work., and improving road infrastructure. The constraints imposed by the sociodemographic characteristics of settler households as they change over the household lifecycle may be addressed by offering support to young households at early duration of settlement (in terms of start up capital and extension support) and encouraging diversification in their income sources. All the above measures would help households absorb the shocks or, alternatively, take advantage of the benefits offered by period events or `history` such as commodity booms and busts, short-term economic and political changes, and violence on the frontier. Vulnerable subgroups such as women and children merit particular measures and consideration in any policy activity.

The potential for sustainable development on forest frontiers, which reconciles human and forest welfare clearly exists. However, a lack of awareness of alternatives to cattle raising is a significant barrier. Policy measures highlighted in Table 7, which can support sustainable development, include measures reinforcing more sustainable land use and agricultural options. This can involve making agroforestry more profitable or subsidizing timber planting and the use of intensive farm inputs (e.g. fertilizer). Also, although conflicting evidence exists regarding the connections between cattle and higher welfare, any measures that reduce poverty among settlers are likely to improve conservation outcomes over the long-term.

The above review suggests that frontiers are a process, not a place. Similarly settler welfare is a dynamic function, not a static state. What settlers do may change significantly over time as they adapt or not to the frontier and as their households develop or not demographically and strategically. Time is important on the frontier and the recent literature emphasizes that longitudinal analysis of settler households is essential. This kind of longitudinal study reveals that neither frontiers nor households develop along any set or progressive trajectory. Some settlers do better over time, others do not, and most struggle. On the community-level varying household and frontier processes may drive economic differentiation on the frontier and the possible replication or permutation of inequalities, land concentration, and poverty from areas of origin.

Important regional similarities as well as differences exist between settlers in the Amazon and Central America. Some similarities are: the importance of subsistence agriculture in settler production, diversification of production to mitigate risk, and the common "straightjacket" effects that structural conditions and farm characteristics have on shaping settler welfare. Even though all frontier settlers experience unique conditions of land abundance, they meet with differential economic success on the frontier. This economic differentiation is a feature of tropical forest frontiers in both regions.

In the Amazon, forest areas are larger and take up a more significant part of national areas and are given more important priority in overall national planning and development. For this reason, the Brazilian Amazon may have received longer-term investments by the government and may present settlers with more developed markets and greater chances for success. Cattle raising, although a common feature of settler

production strategies overall, may be even more important in Central America. In Central America, however, smaller remaining forest cover has led to a situation where more remaining forest is in protected areas. This has important implications for settler production in terms of diversification. Options for diversification into ecotourism, and possibly extractive activities may be greater in Central America due to the prevalence of protected areas and more interactions with indigenous groups involved in extractive activities. Proximity to large developed country markets in the United States, for example, may also mean that the production strategies of settlers in Central America articulate more with international markets and cash crops such as organic coffee, which can be a profitable component within more sustainable agroforestry systems.

The people-centered findings on settler welfare discussed in this review offer a start at balancing our increasingly extensive understanding of the environmental costs and benefits of forest conversion processes with a greater knowledge of the human ones. Greater insight into the welfare of people on forest frontiers, as we have attempted to undertake above, can provide a more complete definition of what sustainable development means on the frontier, in terms of both human and forest welfare. Existing forest-centered research on the causes of deforestation suggests that, in many cases, it is precisely the disconnect between human and forest welfare which drives continued forest clearing. Current research on the determinants of forest loss has afforded us detailed insight into these kinds of conflicts. A lack of equally detailed information on the welfare of frontier populations, though, may have prevented a better comparative sense of alternative scenarios or cases where rising standards of living on the frontier coincide with more sustainable forest use, forest conservation, and even forest regeneration.

This review finds that studies of both the Amazon and Central American forest frontiers indicate that some settlers improve their standard of living and welfare on the frontier while conserving forest resources. Also, improved human welfare indicators like greater income and education can engender less forest clearing indicating a positive feedback loop between human and forest welfare is possible. Further insight in the future into these kinds of positive outcomes may redress any negative bias regarding the connections between forest and human welfare in the existing literature. In any case, it will allow a more holistic assessment of the human and environmental costs and benefits of forest conversion processes in Latin America. From a policy perspective, information on settler welfare and the ways in which human and forest welfare may positively interact will, undoubtedly, improve the lives of settlers. As indicated in the policy conclusions in Table 7, it also points to specific paths of sustainable development in tropical forest regions in Latin America. These are the paths that the small farmers, who make the extraordinary choice of coming to the frontier, must find if they are to realize their hope of a better life and preserve the forest resource base on which it all depends.

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Table 1. Literature Review on Settler Welfare: Number of Studies Considered by Region and Country

Region and Country	Number of Studies
Amazon	**75**
Brazil	23
Bolivia	12
Ecuador	11
Peru	11
Colombia	7
Belize	1
Multi-country	10
Central America	**33**
Mexico	11
Guatemala	10
Costa Rica	4
Honduras	4
Nicaragua	1
Multi-country	3
Total	**108**

Table 2. Forest Areas[1], Change in Forest Area, and Forest and GNP Per Capita for Amazon Countries and Central America

Country	Total Land Area 1995 (1000 hectares)	Total Forest Area 1995 (1000 hectares)	Forest as % Total Land Area 1995	% Change in Forest Area 1999-2000	Forest Hectares /per capita 1995	Per Capita GDP 2000 (US $)
Amazon						
Brazil	845 651	551 139	65.2	-0.4	3.4	4 624
Peru	128 000	67 562	52.8	-0.4	2.8	2 368
Bolivia	108 438	48 310	44.6	-0.3	6.5	952
Colombia	103 870	52 988	51.0	-0.4	1.5	2 301
Venezuela	88 205	43 995	49.9	-0.4	2.0	3 300
Ecuador	27 684	11 137	40.2	-1.2	1.0	1 425
Tropical South America	*1 385 678*	*827 946*	*59.8*	*-0.4*	*3.1*	
Central America						
Mexico	190 869	55 387	29.0	-1.1	0.6	3 784
Nicaragua	12 140	5 560	45.8	-3.0	1.3	466
Honduras	11 189	4 115	36.8	-1.0	0.7	711
Guatemala	10 843	3 841	35.4	-1.7	0.4	1 558
Panama	7 443	2 800	37.6	-1.6	1.1	3 279
Costa Rica	5 106	1 248	24.4	-0.8	0.4	3 705
Belize	2 280	1 962	86.1	-2.3	9.1	3 330
El Salvador	2 072	105	5.1	-4.6	--	1 751
Central America	*241 942*	*75 018*	*31.0*	*-2.0*	*0.6*	

Sources: FAO (1997) State of the World's Forests 1997. Oxford, United Kingdom: FAO and World and Publications, Annex 3, Table 2.
http://www.fao.org/docrep/W4345E/w4345e0n.htm#.; Forest, Grasslands and Drylands and Economic Indicators Table, World Resources Institute,
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[1] Total Forest Areas is used as a proxy for tropical forest areas

Table 3. Settler Production Strategies in Tropical Forest Frontiers in Latin America

Activity	Settlers Undertaking Activity	Characteristics	Regional Differences
Agricultural Production • Food crop/annual crops • Cash crops/ perennial tree crops (coffee, fruit trees, coca)	All Many	Focus on food crops during initial years of settlement; later expansion into cash crops. Work mainly done by adult males. Average plot size 'large,' 20-100 ha. Low levels of technology; little inputs	Generally similar pattern in both Amazon and Central America. What varies in different settings are crop mixtures and degree of diversification between crops.
Animal Husbandry/Pastoral Activity • Cattle and pasture • Small livestock (pigs, chickens)	Many Many	Many households aspire to cattle ownership and move progressively toward it. Work mainly done by adult males but women may be involved in small livestock management	Drive to cattle raising may be stronger in Central America than Amazon.
Agroforestry (Endogenous or Project-based) • Intercropping of food and cash/perennial crops • Fruit tree growing • Other tree crop growing	Many Some Some	Intercropping of perennials (fruit trees or palm) and food is a common practice. Formal agroforestry efforts are generally associated with special projects	May be more potential for this in Central America where remaining primary forest is absolutely more scarce than in Amazon where it is less scarce
Extractive Activities • Extraction of non-timber forest products (NTFP) (nuts, rubber) • Timber extraction/small scale logging	Some Some	Less common among settler households than long-term and indigenous residents on the frontier. Small-scale timber extraction mainly for home consumption such as firewood.	Extractive activities may be more prevalent in Central America where settlers interact more frequently with extractivist indigenous groups. Also may be more frequent where there are developed markets for NTFP (e.g. for rubber) and small-scale timber supplies.
Household Reproduction • Childcare • Household chores: laundry, water collection, food preparation	All All	Work carried out by women and children	Insufficient comparative information on this.
Ecotourism • Handicraft production • Services (restaurants, hotels, guides)	Some Some	Opportunities for this exist mainly around protected area `buffer` zones.	May be more prevalent in Central America, which has greater prevalence of protected forest areas and settlement areas around protected areas
Off-Farm Labor • Agricultural: other farms or plantations • Non-agricultural: frontier industries or jobs in frontier urban areas	Many Many	Households use off-farm labor both to make ends meet and increase wealth.	Developing urban areas of the older frontiers in the Amazon , especially in Brazil, may present greater opportunities for this

Table 4. Phases of Frontier Settlement Among Settlers on Tropical Forest Frontiers in Latin America

Phase	Settler Welfare Outcomes	Frontier Characteristics
Pioneer : 0-5 years on frontier Adaptation phase, attempt to replicate agricultural patterns from origin; risk averse; few innovations; risk minimization	Negative: • lower productivity and lower capitalization in agriculture • stress and uncertainty • moving costs, • loss of social/political/economic networks • coping with new environment, • little knowledge of soil capability, climate or crops, • poor access to basic services like health and education Positive • have land	• Lack of social cohesion and weak political organization • High turnover or abandonment of plots and creation of landless labor • Subsistence economy • Weak off-farm labor markets • No urban areas and few basic services • Greater land availability • Recent and continual settlement • Weak land-titling mechanisms
Experimentation: 5-10 years Risk taking; experimentation in farming activity; diversification of economic activity	Negative: • Same factors as in pioneer phase but less intense • Farms unproductive for farming become obvious and are abandoned Positive • expansion through buying more land and equipment • higher farm productivity • less agricultural labor/more hired labor and more opportunities for off-farm work • sale of land to capitalize on increased value • more secure land tenure • market orientation increases • greater knowledge of farming in area • greater use of credit and increased capitalization in agriculture	• Same trends as in pionner phase but less intense • Real estate market develops and rise in land prices • Labor market develops • Business development takes off • More political and community organization • Economic differentiation among settlers as some do better than others
Consolidation: 10 years or more Continued risk taking and diversification or concentration in cattle raising. Generational transfer of land between parents and children	Negative: • Increased land concentration and reduced land availability Positive • Enhancement of factors listed in experimentation phase	• Enhanced trends from experimentation phase • Development of urban centers • Increased commercial and industrial activity • Developed government and infrastructure

Table 5. Determinants of Economic Welfare Among Settlers on Tropical Forest Frontiers in Latin America

Determinants	Improve Welfare	Detract from Welfare	Policy Implications
(1) Structural socioeconomic, political, organizational, and institutional conditions on the frontier	• Strong legal institutions to assure rapid and secure procurement of land tenure • Agricultural credit and technical assistance available • Developed,strong markets for farm goods, favorable prices • NGO, extension agency, grassroots, and other community-based organizational activity • Access to basic services to improve human capital e.g. in health and education	• Insecurity of tenure leads to lack of investment in agriculture, declining yields, conflict and competition over land • Lack of investment opportunities or access to agricultural technologies to intensify production (e.g. fertilizer, farm equipment) • Weak community and political organization • Limited investments in public services and human capital	• Strengthen land titling procedures • Provide credit with incentives for intensifying production • Support fair pricing • Encourage NGO activity and community based organizations • Develop basic services in health and education and increase access to them
(2) Farm characteristics	• Larger farm size allowing more cash and food crops and cattle • Better quality land • Land near roads and transport networks	• Small plot size restricting absolute areas of crops that can be planted • Poor land quality with low agricultural potential • Remote location creates high transport costs and logistical problems in transport	• Encourage diversification • Develop road infrastructure • Target special measures at households whose land quality may not be high • Zoning of agricultural land on the frontier according to quality
(3) Household socioeconomic and demographic characteristics	• Greater initial wealth, capital, and assets • Longer residence on the frontier (5-10 years) and greater familiarity with the environment • More adult male labor • Diversification within agriculture (in terms of crop mixture, food and cash crops) and outside it (in terms of extractive activity, ecotourism, urban employment) • Later household lifecycle; older household head, lower consumer/producer ratio • Better educated household head • Previous experience in farm management	• Poor upon settlement • Little start-up capital upon settement • Recently arrived (< 5 years) on frontier and inexperience with environment • Chronic illness which limits productivity in labor • Limited adult male or unreliable labor • Dependence on one primary crop, generally food • Early stage of household lifecycle. • High consumer/producer ratio • Household head less educated	• Support to settlers at recent durations of settlement and early lifecycle stages and those with little start up capital • Encourage larger farmers to undertake intensive farming rather than extensive cattle ranching • Enhance diversification of economic activity (e.g. agroforestry)
(4) Significant Historical or Period or Events	• Commodity boom opportunities • Being in early wave of settlement procures best road access, land quality, and larger plot size • Positive change in government and government policy toward frontier	• Commodity busts • Coming late in the settlement process and getting plots of poorer quality and limited road access • Adverse economic changes (rapid inflation) • Armed conflict, guerilla attacks, civil unrest, violence or strikes • Death or illness in the family • Negative change in government and policy	• Reinforce all measures above as a way of cushioning households from sudden social economic shocks as well as positioning them to take advantage of positive period changes

Table 6. Settler Household Lifecycle, Welfare, Agricultural Strategy, and Labor

Household Lifecycle Stage	Welfare Status	Agricultural Strategy	Labor
Young Households • Small household size • Nuclear Structure • Young Children • High dependency ratio • Limited economic means • Younger household head (20-30 years old)	Constrained and Precarious	• Meet subsistence needs • Concentration in food crops • Risk averse • Higher discount rates • Food security is a priority • Aim at secure income rather than profit	• Off-farm labor by household head to make ends meet • High labor burdens on women and men • High level of exploitation of household labor since few laborer
Stable Maturing Households • Larger Household Size as number of children increase or as new members join • More diverse and extended structure • Older children • Lower dependency ratio • Greater economic means • Older household head (30+ years old)	Improving	• Less constrained production • Production for subsistence and sale • Diversification into commercial perennial cash crops and cattle • Less risk averse • Aim at making a profit • Investment in profit making activities	• Increased amount of household labor • Use of hired labor to reduce household labor constraints • Diversification into off-farm labor to enhance income or for non-agricultural labor • Lower labor burdens
Challenged Maturing Households • Continue under 'young household' pattern due death of members, low-labor productivity due to illness, or out-migration	Constrained and Precarious	• Continue to follow young household patterns	• Continue to follow young household patterns
Stable Mature • Stable large household size: some children stay and some leave; other family members come to frontier to join household • Diverse or extended household structure • Children mature and take over farm through plot subdivision • Lower dependency ratio • Greater economic means • Older household head (50+ years old)	Improving but may not be sustained due to land fragmentation; next generation plots are smaller due to subdivision	• Subdivision and transfer of plot to next generation • Production for subsistence and sale • Continued diversification into cash crops and cattle • Risk taking • Aim at making a profit • Direct Investment in more profit making activities like cattle raising	• Stable household labor • Use of hired labor to enhance household labor • Continued diversification into off-farm labor to enhance income or into non-agricultural labor • Lower labor burdens since have more laborers
Challenged Mature • Continue to follow 'young household pattern' due death of members, low-labor productivity due to illness, or out-migration,	Constrained and precarious	• Continue to follow young household patterns	• Continue to follow young household patterns

Table 7. Sustainable Development on the Frontier: Definitions, Prospects, and Policy

Study	Definitions of Sustainable Development	Prospects	Policy Implications
Almeida and Campari (1995) on Brazilian Amazon (Pará)	Majority of settlers farm a single area of land with little plot turnover and reinvest in intensive agriculture	Limited. Due to prevalence of "productive deforestation" geared toward cattle raising and "itinerant accumulation"	• Improve land tenure security • Encourage use of one plot by capital gains tax on land sales • Exploit potential for diversification in activity • Disseminate intensive agriculture technologies
Perz (2001) and Hall (1998) and "revisionist literature" on Brazilian Amazon (Pará)	"Productive conservation": Small farmers generate acceptable incomes while sustaining the forest resource base	Good. Settlers can adapt to the frontier environment, lifecycle effects can facilitate more labor and greater investment in agriculture, and organizational structure on the frontier can promote productive conservation. However, potential for agroforestry may be limited due to negative effects on income	• Encourage development of community and other organizations on frontier to secure minimum prices • Subsidize timber planting to make agroforestry more profitable • Subsidize intensive inputs • Improve roads and thus, markets
Walker and Homma (1996) on Brazilian Amazon (Pará)	The reproducibility of the farm household social unit through adequate economic performance and integration of more sustainable options such as agroforestry	Uncertain. Process of land concentration and violence related to that limit opportunities. Sustainable relationships with environment necessitates sustainable relationships between social groups	• Address poverty through extension and basic services. This will also positively affect conservation outcomes • Sustainable development requires social as well as technical measures
Pasos et al (1994) on protected areas and buffer zones in Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama	Individual needs and interests are integrated with the imperatives of economic development and conservation. State may need to take measures to facilitate this	Good. Community control over forest resources can result in higher welfare and better conservation outcomes. Evidence of endogenous intensification through 'green manure' practices. Good potential for diversification in agriculture (if markets exist) and in ecotourism	• Need to take into account relationships between settlers and indigenous groups in protected areas • Decentralization to the local level of forest management • Strengthen land tenure security

Table 8. Conclusions and Regional Differences in Welfare Among Settlers on Tropical Forest Frontiers in Latin America

Factor	Conclusions	Regional Differences
Basis for welfare: settler economic activity	• Agriculture is the centerpiece of settler strategies • There is shift from subsistence production to more diversified production (food, cash crops, cattle, off-farm work) over time among settlers • Diversification in and out of agriculture is a common strategy among settlers as a means of mitigating the risk of settlement • Unique opportunities for diversification on the frontier exist with respect to ecotourism, extraction of forest products, and agroforestry • Overall standards of living among most settlers are low but economic differentiation exists	• More developed markets in longer settled and more urbanized frontier areas like Brazilian Amazon may promote more diversification among settlers, particularly into off-farm work • Cattle raising may be more prevalent and important in Central America • Diversification into ecotourism may be more possible in Central America due to prevalence of protected forest areas • Settlers in Central America may articulate more with the global economy, e.g. growing organic coffee for international markets
Frontier development over time and settler welfare	• Frontier development should involve: increased basic services and infrastructure (road, health, education), developing markets for farm goods and labor, increased legal systems to ensure land tenure, growth of urban areas, increased availability of credit and technical inputs, and greater community and political organization • No frontier in the Amazon or Central America has developed 'ideally'; even in older frontiers basic services, roads and other infrastructure remain weak • Land concentration occurs over time with settler turnover and the appropriation of land by more successful producers • Land fragmentation occurs as settlers subdivide their plots for the next generation	• Forest areas and proportion of forest area of national territory are much greater in Amazon countries, thus forest regions may be more central concern in national policies • Rates of clearing are higher in Central America because of small forest size; frontier is more 'closed,' and more forest is in protected areas • Amazon frontier is more 'open,' has more forest, and less in protected areas • Older frontiers subject to waves of planned settlement (Brazil) may have more developed infrastructure

Table 8. Continued

Factor	Overall Conclusions	Regional Differences
Settler household dynamics over time and welfare outcomes	• Shift from being risk averse and subsistence focused to risk-taking and diversified • Economic differentiation occurs among settler households; some households do well; some do not; most struggle • Farm characteristics and structural conditions, especially related to land tenure and soil quality, act as a "straightjacket" on settler welfare • Changes in labor and consumption needs over the household lifecycle may tighten or loosen this straightjacket. • Younger households with high consumer/labor ratios and little initial capital are particularly vulnerable to failure • More mature households with more labor and lower consumer/labor ratios do better and are more likely to diversify into more profitable activities such as cash crops and cattle • Some households continually shift resources toward cattle raising due to economic benefits • Many households fail and abandon their plots; successful households may also sell their plots for capital gains and move on to new plots in a process of "itinerant accumulation"	• Most studies are for settlers in the Amazon • Not clear if patterns observed in Amazon hold for Central America
Education, health and settler welfare	• Little information on this • Weakly developed health and education services • Disease vectors particular to Amazon affect settlers in the absence of health infrastructure (e.g. 'frontier malaria patterns') • Pollution by frontier industries adversely affects settler health (e.g. oil industry in Ecuadorian Amazon) • Low school attendance by children • Positive links between educational level of head, welfare, and conservation	• Longer settled frontier areas with developing urban areas may have more developed basic services

Table 8. Continued

Factor	Overall Conclusions	Regional Differences
Women's welfare on the frontier	• Participation in agriculture and overall status of women may be reduced on the frontier (eg. cannot hold land titles). • Women may become more diversified in terms of the labor they do • Women have double labor burden of farm work and childrearing especially in young, recently settled households • Women have poor access to reproductive health services on frontier • Women settlers may be subject to high levels of domestic violence • Women's welfare may increase as the frontier develops • Agroforestry and ecotoursim may offer women opportunities for contributing to household welfare while improving their economic power	• Roles of women may vary and be more flexible in some countries (Colombia) and more limited in others (Ecuador).
Prospects for sustainable development and settler welfare	• Productive deforestation may limit propects for sustainable development • Settlers have a lack of alternatives to the profitable yet less sustainable option of cattle raising • Possibilities for productive conservation and integration of settler welfare with forest conservation also exist • Agroforestry, diversification into off-farm activity, and ecotourism represent potentially profitable and more sustainable alternatives to cattle raising • There is evidence of endogenous forest-conserving techniques among settlers (e.g. use of green manure in Central America and agroforestry/multicropping of fruit trees and food crops in Ecuadorian Amazon). • Secondary succession indicates conservation efforts by settlers in terms of fallow management and reforestation; on the other hand, may also indicate failure and plot abandonment • Given the choice of a equally profitable sustainable alternatives to cattle raising settlers may adopt them because of concerns for protecting the resource base	• Potential for agroforestry may be greater in Central America where primary forest is more limited • Interactions between settlers and indigenous groups and thus, more sustainable extractive activities may be more frequent in Central America • Secondary succession may be more prevalent in Central America which has more active reforestation efforts