MIGRATION, POPULATION CHANGE, AND THE RURAL ENVIRONMENT

By Richard E. Bilsborrow

Abstract

This article considers issues pertaining to the linkages between rural populations, migration from and to rural areas, and the environment—focusing on developing countries in the latter part of the 20th century. The article concentrates on internal migration, although it does briefly discuss the state of knowledge on the interplay between international migration and the environment. It addresses questions such as: What are the recent—and projected—patterns of rural population growth? How much internal migration in developing nations is towards rural environments? What kinds of rural environments are people moving into, in what countries, and what are the environmental consequences? Are there relationships in the other direction as well—that is, does environmental deterioration play an important role in out-migration from rural areas? And does out-migration from rural areas have environmental effects on the places of migratory origin? The article concludes with policy recommendations.

The movement of human populations across the planet has characterized human societies throughout history. Historically, resource scarcity or depletion has induced this movement.[1] In recent years, rural populations and their relationships to their environment are again attracting growing interest, especially in connection with population change and particularly migration. Rural areas contain most of the world's forested land (tropical rainforests, sub-tropical forests, and temperate forests) and other lands (such as agricultural, semi-arid, and drylands); they supply humankind with most of its food. Such environments also contain most of the world's gene pool. While tropical rainforests and coral reefs have attracted the most attention because they have the highest density and diversity of species per unit area, other biota (such as highland forests, wetlands, savanna, drylands, and deserts) also contain unique floral and faunal diversity. Human population growth and intrusion threaten, to varying degrees, all of these biota.

This article considers issues pertaining to the linkages between rural populations, migration from and to rural areas, and the environment—focusing on developing countries in the latter part of the 20th century. The article concentrates on internal migration, although it does briefly discuss the state of knowledge on the interplay between international migration and the environment. It addresses questions such as: What are the recent—and projected—patterns of rural population growth? How much internal migration in developing nations is towards rural environments? What kinds of rural environments are people moving into, in what countries, and what are the environmental consequences? Are there relationships in the other direction as well—that is, does environmental deterioration play an important role in *out-migration* from rural areas? And does out-migration from rural areas have environmental effects on the places of migratory origin?

The article first reviews the basic demographic facts—based on the latest United Nations estimates and projections—on the size of contemporary rural populations, their density, and their recent and expected future trends in growth. These estimates show major differences between developed and developing countries and among regions within the developing world. The article then considers patterns of population

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Table 1. Rural Population Sizes, Rates of Growth, and Rural Density, 1960 to 2030

Major Areas	Percentage of the Population in Rural Areas			Rural Population (millions)			Rate of Growth of the Rural Population (percentage)	
	1960	2000	2030	1960	2000	2030	1960-2000	2000-2030
World	66.4	53.0	39.7	2005	2925	3223	1.18	0.01
Less Developed Regions	78.4	60.1	43.8	1652	2925	3023	1.43	0.11
More Developed Regions	38.6	24.0	16.5	353	285	200	-0.54	-1.19
Africa	81.5	62.1	45.5	225	487	640	193	0.91
Asia	79.2	63.3	46.6	1348	2331	2272	137	-0.09
Latin America and the Caribbean	42.0	25.2	17.4	254	184	120	-0.81	-1.42
Northern America	50.7	24.7	16.8	111	128	122	0.37	-0.18
Oceania	33.6	29.8	25.6	5	9	11	135	0.51

Sources: (UN Population Division FAO 2000; FAO 2000b)

redistribution through migration, noting the importance of rural-rural migration. Section 2 considers how rural-rural migration may affect several forms of environmental degradation. Section 3 briefly reviews relevant theoretical approaches, especially pertaining to the determinants of migration and the analysis of its environmental consequences. The next section assesses empirical evidence—grouped by region—on the environmental consequences of migration into rural areas, followed by a short discussion of the environmental consequences of out-migration on areas of origin. Section 5 then looks at how environmental degradation might stimulate or force migration, both national and international. Finally, the article considers preliminary policy implications.

1. Rural Populations in the Developing World: Size, Density, Growth Rates and Patterns of Redistribution through Migration

The past century has witnessed a profound shift in the world's population distribution from primarily rural to increasingly urban. Currently only a quarter of the population of the developed world and of Latin America lives in rural areas. But despite similar ongoing trends in population redistribution in both Asia and Africa—home to three-quarters of the world's population—nearly two-thirds of the population still lives in rural places (see Table 1). The pace of rural population decline, moreover, appears to be slowing in many places in recent decades, as rural areas have become depleted and cities increasingly crowded. Still, due to the many advantages of urban

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Table 1. Continued

Major Areas	Land in Arable and Permanent Crops (1 million hectares)		Persons per Hectare of Arable and Permanently Cropped Land	
	1961	1998	1961	1998
World	1346	1512	1.51	2.10
Less Developed Regions	676	855	2.49	3.37
More Developed Regions	670	656	0.52	0.44
Africa	155	202	1.48	2.34
Asia	484	556	2.84	4.13
Latin America and the Caribbean	345	311	0.73	0.60
Northern America	102	159	1.09	0.80
Oceania	35	59	0.15	0.15

areas—including greater human interaction; the store and accumulation of knowledge and culture; and greater accent on modern services, infrastructure, media, and diversions (often facilitated by economies of scale in production or distribution)—the proportion of people living in urban areas is expected to continue to grow. Indeed, over the next 30 years, the world's urban population will likely grow by the same amount (two billion) as the world total, resulting in no net overall rural population growth (UN Population Division, 2000).[2]

Global rural population growth rates for 2000-2030 are also projected to decline from growth rates in the period 1960-2000. However, these rates will remain positive in many sub-regions, significantly so (around 1 percent or more per year) in much of Africa and Micronesia-Melanesia.

Table 2 shows the largest developing countries in the world in terms of rural population size at the turn of the millennium. Three countries currently have over 100 million people living in rural areas—China, India, and Indonesia. Two more Asian countries will join that list by 2030. Of the 27 countries in the table, 16 will continue to experience positive rural population growth over the next three decades. Of the eight countries with the largest rural populations in 2000—each with over 50 million—all but China and Indonesia will experience overall rural population growth in the coming decades.

At a regional level, projections show the highest rural population growth rates occurring in central Africa, which contains countries and sub-regions characterized by not only high population density but also civil conflict. Table 1 shows land in arable and permanent crops in 1961 and 1998 and rural population density measured as rural population divided by agricultural land. As rural populations have grown, they have expanded their agricultural area—a process called "agricultural extensification." Table 1 indicates this increase in agricultural land area (except for a decrease in Europe and a constant land area in North America). Agricultural land area increased by 26 percent overall in the developing world during the 37-year period, but this figure varied dramatically across regions. Extensification explains most of Latin America's increased agricultural production during the period, but it accounts for only a small part of Asia's large increase in agricultural output, which is mostly attributable to increasing land productivity. In Africa, food production per person failed to rise during the period despite an expansion into agricultural land. Still, this expansion was modest, as Africa has much less potentially usable agricultural land available than Latin America.

Table 2. Population Sizes and Growth Rates of the Developing Countries with the Largest Rural Population, 1960-2030

Country	Rural Population (millions)			Rural Growth Rate (percentage)	
	1960	2000	2030	1960-2000	2000-2030
China	552.2	867.6	743.9	1.13	-.051
India	362.9	725.4	749.3	1.73	0.11
Indonesia	82.2	125.3	103.6	1.05	-0.63
Pakistan	38.9	98.5	123.7	2.32	0.76
Bangladesh	48.8	97.5	105.2	1.73	0.25
Vietnam	29.6	64.1	74.9	1.93	0.52
Nigeria	32.3	62.5	72.0	1.65	0.47
Ethiopia	21.3	51.5	82.7	2.21	1.58
Thailand	23.1	48.1	45.1	1.84	-0.22
Egypt	17.3	37.5	40.3	1.94	0.24
Democratic Rep. of the Congo	11.9	36.0	59.8	2.77	1.69
Myanmar	17.6	33.0	32.0	1.58	-0.10
Brazil	40.1	31.8	25.0	-0.57	-0.80

Source: United Nations Population Division (2000).

The last two columns of Table 1 reflect this *combination* of the expansion in the land area and rural population growth. For the developing world as a whole, rural population growth considerably exceeded the increase in agricultural land, with the result that rural population per hectare rose from 2.5 to 3.4, or by 35 percent. The biggest increase occurred in Asia, from 2.8 to 4.1, but Africa also saw an increase from 1.5 to 2.3 (Cleaver & Schreiber, 1994; FAO, 1996). In Latin America, however, the rural population hardly grew, with the result that rural population density actually declined significantly overall.

Most countries of eastern Africa are expected to have substantial future rural population growth—a discouraging prospect given the lack of agricultural productivity increases; the lack of unused lands to exploit (only semi-arid areas with little agricultural potential remain); and the large areas already degraded. Both South Asia and western Asia will experience modest future rural population growth; both regions already have very high rural population densities relative to arable land. In the Western Hemisphere, Central America—the one region expected to experience rural population growth—already has densely populated countries with degraded rural environments (Leonard, 1987) as well as agricultural output that has failed to increase sufficiently enough to achieve much economic growth. Fertility and overall (natural) population growth also remain much higher in Central America than elsewhere in Latin America.

The population figures introduced above show the rural populations of many countries declining already before 2000; by 2030, population sizes are projected to peak in all but a few dozen countries in Africa and Asia. The question thus arises how a *declining rural population* can affect the rural environment, since overall population pressures on the land will increasingly fall. The answer: *rural-rural migration*—that is, migration from one rural

Table 2. Continued

Country	Rural Population (millions)			Rural Growth Rate (percentage)	
	1960	2000	2030	1960-2000	2000-2030
Philippines	19.2	31.4	29.9	1.23	-0.17
Iran	14.2	26.0	25.2	1.51	-0.11
Mexico	18.2	25.3	24.4	0.83	-0.12
Tanzania	9.7	22.5	28.2	2.10	0.75
Nepal	9.0	21.1	29.7	2.14	1.14
Kenya	7.7	20.1	20.2	2.40	0.02
South Africa	9.3	20.0	17.0	1.92	-0.55
Sudan	10.0	18.8	20.7	1.58	0.32
Uganda	6.2	18.7	34.7	2.75	2.06
Afghanistan	9.9	17.7	29.4	1.46	1.69
Turkey	19.3	16.4	11.6	-0.41	-1.16
Uzbekistan	5.7	15.4	18.5	2.50	0.62
Sri Lanka	8.1	14.4	14.1	1.43	-0.08
Yemen	4.8	13.6	25.8	2.63	2.12

area to another—has and will continue to accelerate the decline in rural density in one area while raising it in others, as rural populations leave areas with a scarce supply of exploitable land to seek land elsewhere.

Demographers and other social scientists interested in migration have traditionally focused on *rural-urban migration*—doubtless due to the rapid growth of cities and the important roles they have played in the progress of civilization and economic development. But other forms of population movement have been and even now continue to be *more important* than rural-urban movements. Table 3 provides data (mostly pertaining to the 1980s) on the four mathematically-possible directions of internal migration flows within developing countries. Evidently, the sample of countries is a convenience sample and is not representative of the regions. The data also suffer from wide differences in the definitions of "urban" used by countries, rendering comparisons across countries hazardous.

Nonetheless, Table 3 strikingly indicates that rural-urban migration constitutes the most important movement for *only two* countries in the list, while urban-urban migration is most important for nine and rural-rural for three. Surprisingly, rural-rural migration exceeds rural-urban in 11 of the 14 countries—including the largest three of India, Pakistan, and Brazil.[3] These results suggest that rural areas of developing countries have experienced and continue to experience substantial changes in population distribution. These changes are linked to powerful forces of attraction and (sometimes also) repulsion resulting from wide differences in living conditions and economic opportunities between areas and across regions.

2. Environment Indicators and the Poor

Before we can consider potential linkages between migration and the environment, we need a clear understanding of what we mean by both terms. First, this article will consider as the main measures of *rural* environmental degradation: (a) deforestation; (b) declining soil quality (including soil desiccation); and (c) loss of biodiversity.[4] This analysis excludes other forms of environmental degradation (such as water contamination and shortages, air pollution, global warming, toxic and nuclear emissions, and salinization

Table 3. Migrants by Type of Flow, According to Urban or Rural Origin and Destination

Country	Census Year	Type of Data	Percentage			
			Rural-Urban	*Urban-Urban*	*Rural-Rural*	*Urban-Rural*
A. Africa						
Botswana	1988	Place of Birth	60.0	8.0	29.0	3.0
Cote d'Ivoire	1986	Previous Residence	14.8	44.2	20.3	20.7
Egypt	1976	Inter-state	26.0	55.2	12.0	6.8
Ghana	1988	Previous Residence	4.6	48.5	9.5	37.3
B. Asia						
India	1971	Place of Birth	14.6	10.4	69.1	5.9
India	1981	Place of Birth	16.7	11.9	65.4	6.1
Malaysia	1970	Residence in 1965	8.8	20.0	38.8	32.4
Pakistan	1973	Residence in 1965	17.3	38.8	32.6	11.4
Philippines	1973	Residence in 1965	39.3	25.2	19.7	15.8
Republic of Korea	1966	Residence in 1961	36.6	32.0	21.2	10.2
Republic of Korea	1975	Residence in 1970	43.5	28.7	14.0	13.8
Republic of Korea	1995	Residence in 1990	12.8	85.7	1.5	7.0
Thailand	1980	Residence in 1975	15.4	18.5	56.0	10.2
C. Latin America						
Brazil	1970	Place of Birth	17.4	50.4	26.5	5.6
Ecuador	1982	Residence in 1977	16.0	46.0	18.0	21.0
Honduras	1983	Residence in 1978	26.0	32.0	28.2	13.9
Peru	1986	Previous Residence	11.6	51.6	13.6	23.2

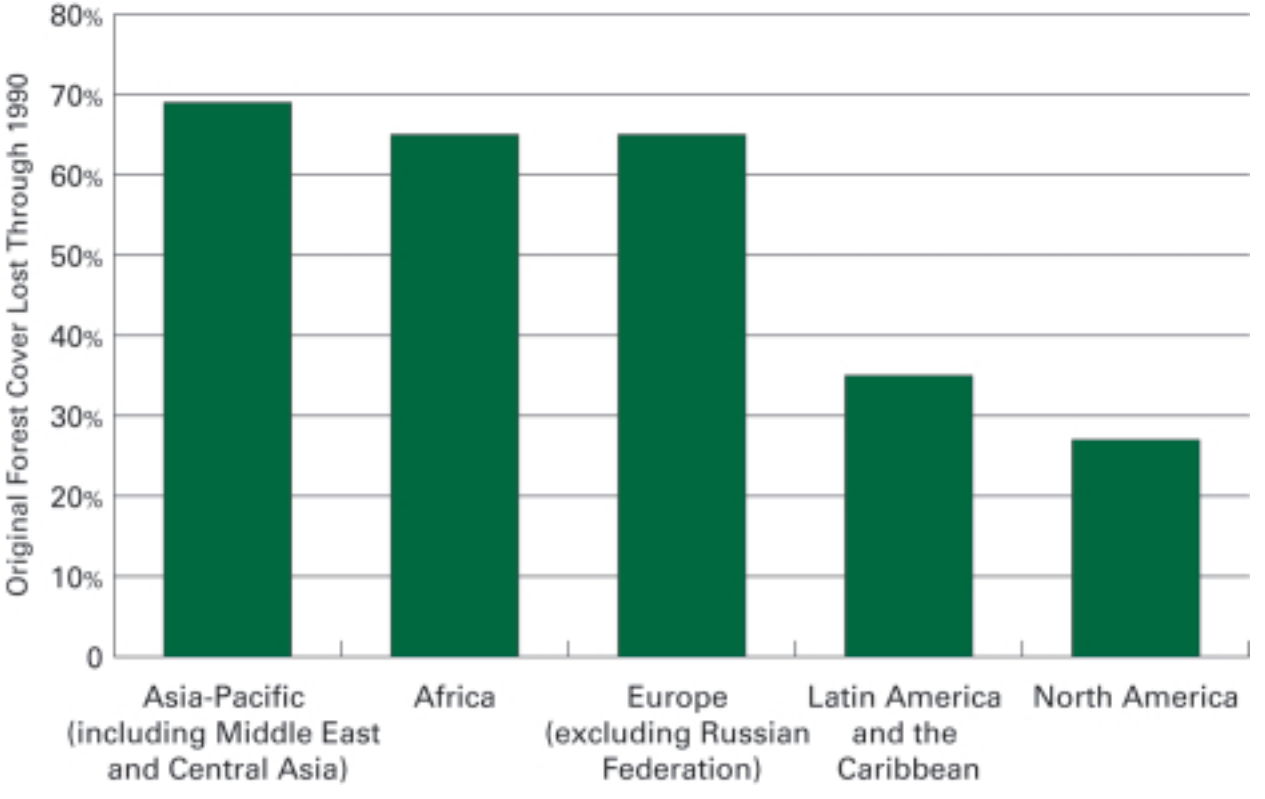
Sources: See UN Population Division (2000), except for Botswana, Cote d'Ivoire, Ghana, Ecuador, and Peru, see original sources in Bilsborrow (1992), which are based on population census data (except for Peru, based on the Living Standards Measurement Survey supported by the World Bank).

from continual irrigation with insufficient flushing of salt buildups from evaporation). These problems are either (a) more pertinent to developed countries and/or urban areas, or (b) have received little attention in the specific context of population–rural environment linkages.

Deforestation. The latest FAO data (FAO, 2001) indicate that, from 1950 to 2000, developing countries lost half of their forest cover. (See Figure 1). And the pace of deforestation accelerated in the 1990s. The *annual stock* of forests lost was highest in Latin America in the 1990s (at 4.8 million hectares/year, compared with 3.7 and 2.9 for Africa and Asia); but the *annual rate* of forest loss was often largest in countries where so little of the original forests remained due to centuries of dense habitation and exploitation for human use. Thailand and Costa Rica lost about half their extant stock of forests in the 1980s. Deforestation removes the protective vegetation, which usually leads to further consequences, such as: flooding; soil erosion from water and wind; and decreased replenishment of underground water aquifers (because of the lack of vegetation to slow water runoff and the lack of tree roots to channel the water downward).

The World Bank (1991) has attributed about 60 percent of recent deforestation in the developing world to the advance of the agricultural frontier; 20 percent to logging operations (including mining and petroleum); and 20 percent to fuelwood use.[5] There are no reliable estimates, however, and the importance of each factor varies greatly across regions and countries as well as within countries. But demographic factors appear to be of importance in both agricultural extensification and fuelwood use (FAO, 2000a). A study by Bilsborrow and Carr (2001) on Latin America based on cross-country data identifies pasture expansion as the major factor in deforestation in most countries of the region, although the expansion of annual crops also played an important role in Central America. Crop expansion is much more closely linked to population growth and its increasing food demands. However, there has not been

Figure 1. Loss of Original Forest Cover by Origin



Source: Loh (2000).

an adequate quantitative assessment of the relative shares of pasture expansion versus other agricultural expansion in relation to forest clearing across developing countries and over time.

Migration linked to the extension of the agricultural frontier directly contributes to the ongoing process of deforestation on the agricultural frontier, though the subsequent *natural population growth* of migrant populations *becomes increasingly important over time*. The vast majority of the literature fails to even consider the role of fertility and natural population growth *in situ* on the loss of forest cover.

Most migrant colonists to agricultural frontiers are poor and have traditionally been implicated in deforestation. But the poor migrate to tropical rainforestsand semi-arid land frontiers because they lack access to land or other capital (e.g., human) to sustain themselves. Furthermore, road construction has usually facilitated their migration to such ecologically fragile environments—supplied by logging or mining enterprises, often by multinational corporations to gain access to resources for the global market.[6] Similarly, the poor throughout the developing world—particularly sub-Saharan Africa, rural Asia, and parts of rural Latin America—use fuelwood (or charcoal, its derivative) for their domestic energy needs.

Soil desiccation. Soil desiccation is often mislabeled as "desertification."[7] The removal of protective vegetation—whether of trees, shrubs, or savanna grasses—renders the soil vulnerable to water and wind erosion. Sudden vegetation removal may both destroy remaining vegetation and lead to drying of the soil. Postel (1997) and Falkenmark (1994) describe the process and its possible linkage to the population growth of humans and ruminants (pastoralists and their herds), most notably in the Sudano-Sahelian belt across Africa. Nevertheless, desiccation on a smaller scale is also occurring in many parts of Asia, Mexico, and even in areas of the Amazon that are denuded of vegetation, trampled by cattle, and experiencing declining rainfall due to micro-climate changes.

Soil degradation. Soil degradation takes various forms—including erosion, desiccation, salinization, and declining fertility. Although this degradation is difficult to determine on a large scale, the noted Wageningen Institute of the Netherlands has conducted a global assessment of the extent of human-induced soil degradation (Oldeman et al., 1990). The study estimated that 20 percent of all the vegetated land in the developing regions is degraded—much of it moderately to extremely degraded. Deforestation is seen as one of the major causes of soil degradation, estimated to account for 40 percent of the degradation in Asia and South America, 22 percent in Mexico and Central America, and 14 percent in Africa (with the overall extent of degradation greater in the latter two regions).

Land Inequality and Environmental Degradation

Land is unequally distributed throughout the world. Latin America's extreme land inequality is characterized by the control of most of the land by a few farms (the *latifundia*) while most of the farmers have very little land (*minifundia*). Moreover, as Leonard et al (1989) noted, the poorest 20 percent of developing country populations also tend to live on "low potential" lands—that is, marginal agricultural lands with inadequate or unreliable rainfall, low soil fertility, and/or steep slopes. In country after country—even those such as Mexico and Bolivia, where some land redistribution has occurred—the relatively well-off still control the better lands. Three-quarters of the poorest 20 percent in Latin America live on marginal lands. Fifty-seven percent of Asia's poor and 51 percent of Africa's also inhabit marginal lands. Not just the lack of land but also its *quality* contributes to rural poverty.

And the low potential of these lands makes it likely that the poor will also degrade them through use.[8] Once the poor have degraded lands in one area, they often migrate to other marginal areas (such as tropical rainforests or semi-arid areas) and deforest and degrade those areas, creating a "cumulative causation" circle linking rural poverty, deforestation, and land degradation.[9] Section 4 presents examples.

In the Brazilian Amazon, poor migrant settlers clear marginal land, which yields only a few years of adequate crops. The settlers then sell the land (mainly to ranching interests) and move to new areas that they similarly degrade. Ranchers also have taken over such land through violence or threat of violence (Schmink & Wood, 1993; Cowell, 1993).

Analysts now believe that population growth and migration linked to vegetation clearance has led to micro-climate changes in rural areas—declines in rainfall and therefore in agricultural potential due to deforestation—in the Andean valleys of South America, in the Himalayas, and even in the Amazon Basin. A debate also continues about whether population increase and overuse of marginally productive drylands for farming and grazing in the Sudano-Sahelian belt across central Africa has led to dessication of soils and a southern expansion of the Sahara.

Rural-Rural Migration and Biodiversity

Finally, up to 55 percent of all species on earth live in the tropical rainforests, so that recent large-scale intrusions of rural-rural migrants have had a devastating effect on biodiversity and on the world's gene pool, with possibly dire consequences for future human food production and medicines (Cincotta & Engleman, 2000). Human population increase and human activity also affect biodiversity through the devastation of species for food or pleasure (such as a number of fish species the past century). But the biggest human impact on rural environments comes through the conversion of areas for human habitation, agriculture, energy production, transportation, and recreation—all of which can destroy ecosystems and natural habitats. Migration plays a fundamental role in these processes, either by inducing or following them.

3. Conceptualizing the Linkages Between Migration and the Rural Environment

Linkages between migration and the (rural) environment are complex and may take several different forms. So it is useful to break down these linkages into distinct types by drawing on theory that deals with (a) the *determinants of migration*, including the role of environmental factors on stimulating or forcing out-migration or on attracting in-migration; and (2) *the effects of migration on destination and departure areas*, particularly focusing on their effects on the environment.

The Determinants of Migration

Where do environmental factors fit into theories of the determinants of migration? In essence, migration is affected by: (a) *differences* in economic opportunities and living conditions between places (and countries, for international migration); (b) people's *awareness* of those differences and desire to improve their lives by moving; and (c) their *ability to act* upon those desires. The main factors influencing desires to migrate include differences in employment opportunities, wage rates, and living conditions (which geographers describe under the umbrella term "place utility"—see Wolpert, 1965). At the same time, psychological/emotional attachments to home/family, friends, and community keep most people from migrating. Distance to the potential destination, communication and transportation, educational levels, and (for international migration) state policies each strongly influence the awareness of differences from one place to another, the ability to migrate, and the cost of migration.

The factors that affect migration have been categorized (Lee, 1966) as "push" factors (in the place of origin) and "pull" factors (in the place of destination). Environmental variables are an element in both. Environmental push factors include both natural disasters (earthquakes, volcanic eruptions, hurricanes/cyclones) as well as human-induced environmental degradation (e.g., flooding resulting from deforestation of watersheds, salinization of soils due to prolonged irrigation, soil degradation from improper land-use practices). Environmental pull factors may include the attraction of good farmland or of a more attractive natural setting or climate.

Traditional empirical research on migration decisions has focused on the individual characteristics of persons that do or do not predispose them to migrate—such as a person's age, sex, or education (Sjaastad, 1962). Starting with Mincer (1978) and essays in DeJong and Gardner (1981) among others, the standard view focusing on migration decisions as made by individuals changed to view most migration decisions in developing countries as *household decisions*—that is, households decide whether to send a household member away or to move the whole household with the migrant. Migration theory has recently also recognized that the *community or context* of the household also plays a role (e.g., Wood, 1982; Bilsborrow et al., 1984; Findley, 1987; Massey, 1990). The local community-contextual factors may themselves be seen as affected by higher level provincial and national policies, and the latter by international factors. For example, the living conditions of coffee farmers depend on the farm-gate prices for sacks of coffee offered by intermediaries—prices that, in turn, depend on government tax, subsidy, and export policies pertaining to coffee and inputs used in its growing, as well as prices and demand in international markets. Changes in factors such as international prices therefore filter down through political levels and institutions at each stage until they reach local farmers. Figure 2 illustrates the hierarchical nature of migration decisions and the relevance of both origin and destination conditions to these decisions.

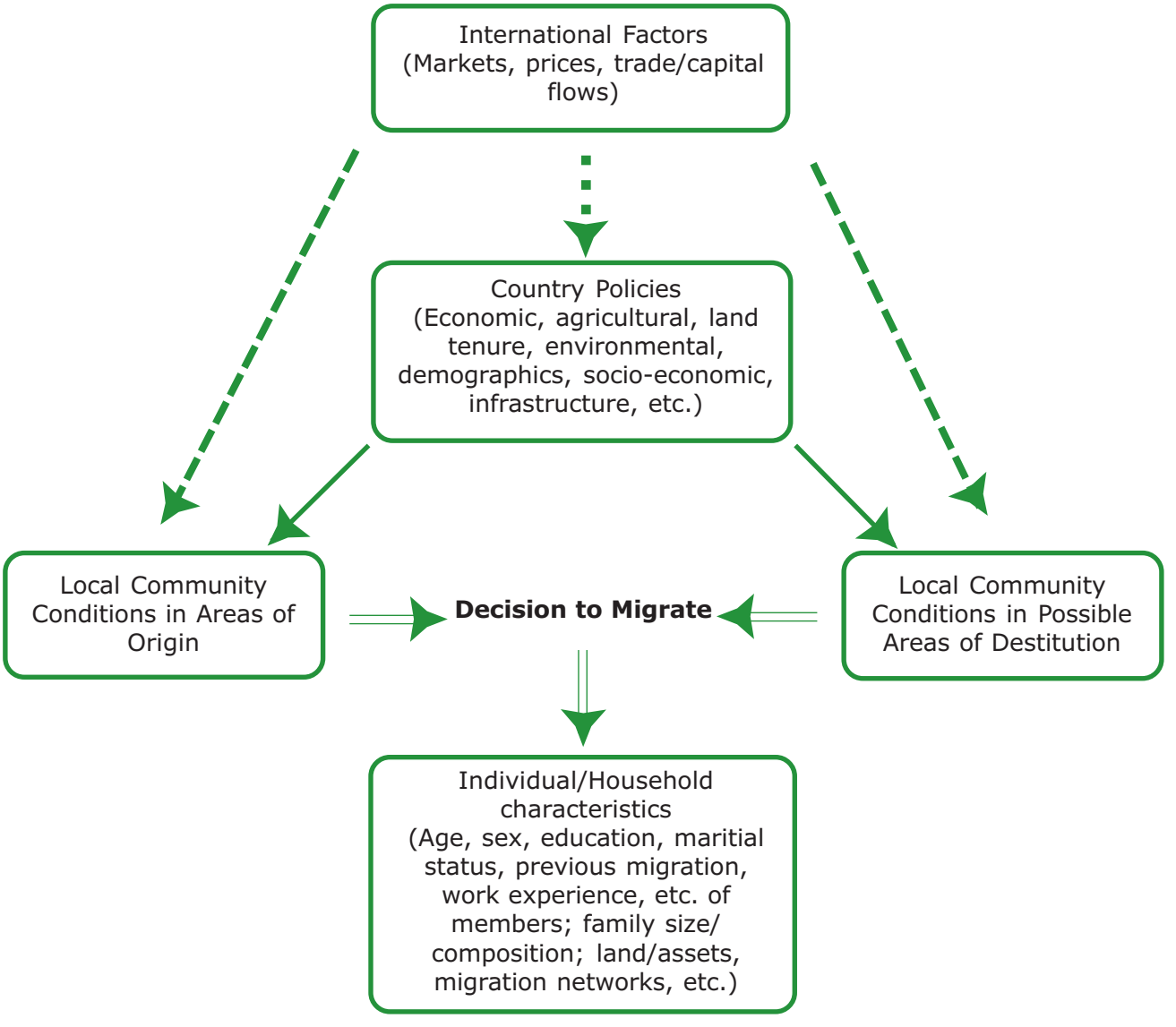
Figure 2 also shows the relevance of *environmental* factors in influencing out-migration from rural areas in the context of household and community-level contextual factors. Environmental factors may operate either (a) by affecting income-earning opportunities of household members at the level of the household farm or business (e.g., the amount and quality of land available); or (b) through their effects on economic opportunities in the community. For example, soil degradation from

excessive or improper use or from the ash of a volcano may provoke a household to consider migrating. Environmental factors may also disturb the entire community: natural disasters or soil degradation in the community reduce agricultural prospects and therefore the derived demand for labor and agricultural wages in the area. Human practices may sometimes also make the place of origin less desirable in other, non-economic ways (such as via water pollution, air pollution, or deforestation). Indeed, *any* form of environmental change that adversely affects land productivity will tend to reduce agricultural incomes and stimulate out-migration. In fact, where household surveys show people migrating because of low incomes, an *underlying* environmental factor likely exists. In such cases, the environmental degradation may constitute a "root" cause of out-migration and the decline in crop yields only the proximate cause (Shaw, 1989).

The Consequences of Migration

While a substantial body of theory now examines the determinants of migration, theory on the consequences of migration is limited. Consequences are also usually studied only in terms of a wide range of indicators, including: migration's effects on household size or composition (such as by increasing or decreasing the education level or productivity of the labor force, or the supply of labor); access to employment or higher wages; and better access to services and amenities. These

Figure 2. The Migration Decision



are effects at individual and household levels, although impacts also exist at the community level on both communities of destination and origin (in terms of population size, growth, and density; wage rates; crowding; and stock of human capital). The consequences may be viewed from the perspective of: (a) individuals, households, and/or communities; (b) migrants and/or non-migrants; and (c) communities of origin or destination.

In terms of the consequence for rural areas of destination, Malthus (1798) and Boserup (1965) serve as useful starting points, despite their focus on population and land use (specifically, on how population growth affects population density and whether that increase in density lowers per-person living standards). Because Malthus could not foresee the vast changes in agricultural technology, he erroneously argued that greater population density would cause declines in living standards. However, in a rarely cited passage, Malthus also states that rural farm families under appropriate conditions would respond to population pressure by *out-migrating in search of land*, which would extend the agricultural frontier—either nationally or internationally (Malthus, 1798, pp. 346ff). In contrast, Boserup (1965) hypothesized that, under certain circumstances, rising population density (by increasing living standards) would stimulate farm families to use land *more intensively* through adaptive technology, thus avoiding the need to migrate. Davis (1963) and Bilsborrow (1987) subsequently formulated a broader "multiphasic model" that viewed out-migration as only one possible response to the growing pressures on a farm family's living standards resulting from population growth.

The models above can be usefully incorporated into an overall conceptual model of the linkages between the rural household's migration decision and the possible environmental consequences in areas of destination. Figure 3 illustrates such a model.

According to this model, the household continuously evaluates conditions in the place of origin and elsewhere to determine how to survive or cope in difficult times or whether to move to improve its standard of living. The possible forms of adaptation include, as a first option, further land clearing *in situ* if any untapped land exists on the family's plot or in the local community, including "open access" lands available to anyone (Bilsborrow & Geores, 1992). Of course, the latter becomes untenable when many farmers compete for open land, leading to resource degradation through a "tragedy of the commons" (Hardin, 1968). In addition, families may subdivide their agricultural plot among the children, resulting in land *fragmentation* and increasingly inadequate plot sizes (i.e., too small to support a family). Both of these options tend to lower living standards and eventually stimulate further responses. Short of out-migration, families may also opt for *land intensification* via: (a) shortening fallow periods, (b) increasing labor per unit of land (through more weeding and/or the building and maintaining of terraces and windbreaks), or (c) increasing use of irrigation or fertilizer (Boserup, 1965). The dotted arrows in Figure 3 identify ways in which government policies can encourage these methods to increase land productivity.

However, the above responses may also lead to environmental degradation. Soil overuse without compensatory practices (such as fertilizer or crop rotation) decreases soil fertility. The runoff of excess chemical fertilizers and pesticides causes water pollution; mining depletes underground water aquifers; and irrigation may lead to salinization (build-up of salt deposits) of soils if insufficient water is available.

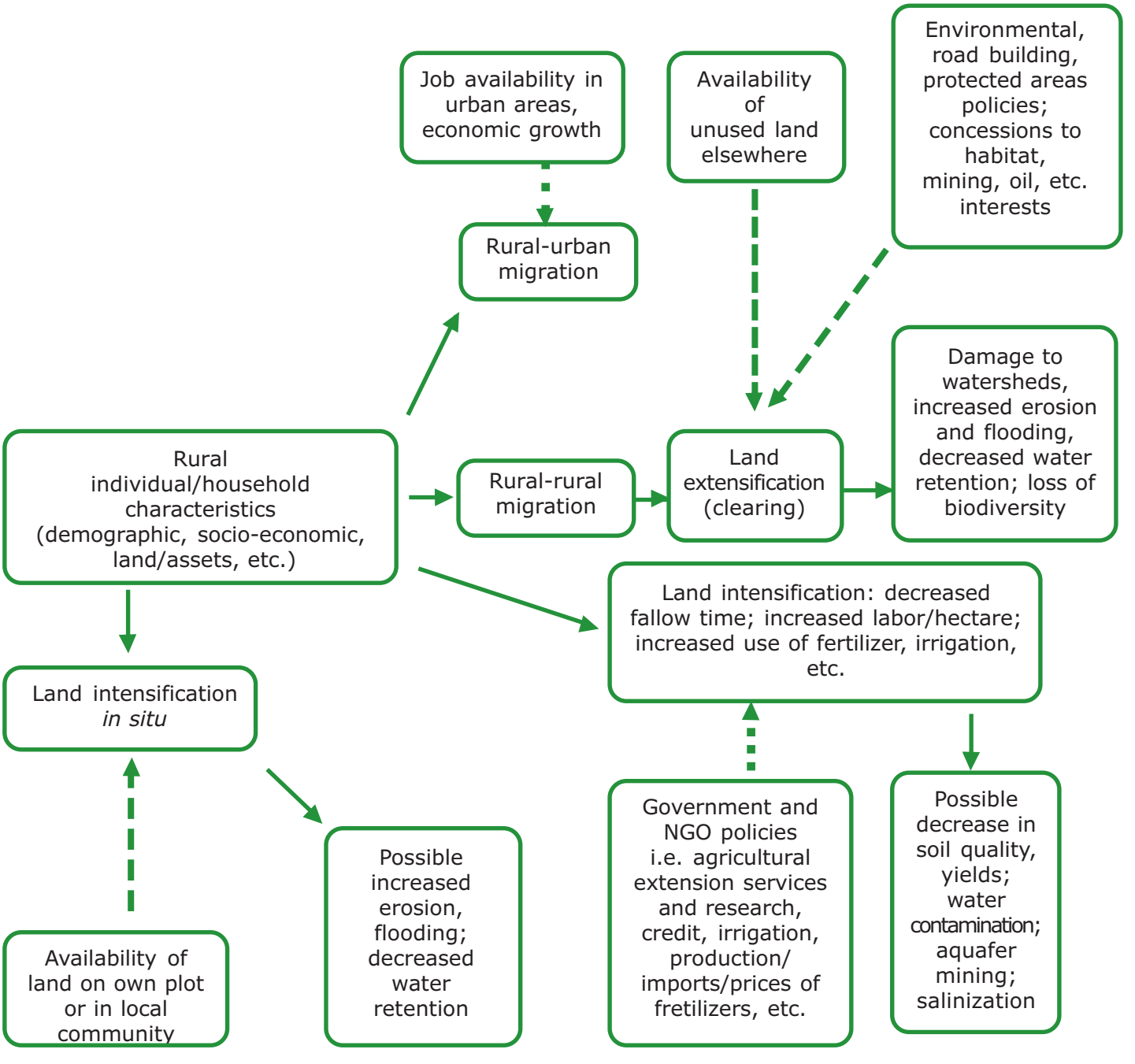
Developing countries have a strong "urban bias" in their development policies, resulting in a policy context that does not favor agricultural intensification (Lipton, 1977). Without such intensification, however, rural families have no alternative but to migrate. As noted in Section 1, rural-rural migration remains a major aspect of population redistribution in many countries, and it may be linked to agricultural extensification and extending the agricultural frontier through land clearing even when rural population size in the country as a whole is falling. This rural-rural migration also has significant environmental implications when directed predominantly to marginal, fragile areas that have often been made accessible recently through extensions of road networks. Through clearing of forests or other vegetation to establish croplands or pasture, the extensification process may: (a) damage watersheds; (b) reduce water retention and replenishment of underground aquifers; (c) increase surface runoff, flooding, soil erosion, and siltation of dams downstream; and (d) decrease soil fertility. While appropriate policies can control or moderate many of these consequences, most developing countries do not have the necessary resources and technology to implement such policies.

Note that the arrows in Figure 3 indicate *alternative* pathways. The more one type of response occurs, the less pressure or tendency there is for the other responses (Davis, 1963; Bilsborrow, 1987). These alternatives also do not exhaust the types of household decisions intended to maintain or improve welfare, which also include fertility decline and either temporary labor migration or permanent out-migration by one or more family members. The allocation of household labor in such a

way across space and among more than one form of economic activity spreads risks, as seen in the "peasant household survival" theory (Arguello, 1981).[10]

More important, the dotted lines in Figure 3 indicate the crucial roles played by *contextual factors* in determining rural household decisions about migration or intensification. These factors include: local and national natural-resource endowments; social and economic infrastructure; national and local government policies that determine land ownership and access to land; environmental policies and set-asides for protected areas; road construction; and the regulation (or lack thereof) of logging, mining, and petroleum companies. These contextual factors and policies establish the physical context and rules of the game for household responses to population pressures and environmental degradation.

Figure 3. Rural Household Decision-Making, Migration, and the Rural Environment



While the discussion in this section focuses on situations with *growing* rural populations, Section 1 notes that in the future more developing countries will have declining rural populations in the aggregate. Standard microeconomics predicts that declining populations cause increases in land available per person/household—raising rural wages, demand for and prices of agricultural output, and therefore rural family living standards (as well as possibly permitting natural reforestation in "origin" areas to the degree less land is used). However, to the degree that only the more educated and motivated out-migrate from rural areas, the decline in the average *quality* of the labor force may more than counter the positive effects of a lower labor-land ratio. In addition, international factors or a strong urban bias in government policies may further counter this population decline, particularly since a declining rural population will have even less political power, possibly resulting in an even stronger urban bias. As more countries begin to experience declining rural populations, this issue will become an important research topic.

The discussion above takes population growth as the initiating factor in the sequence of change, but economic forces or environmental degradation in the rural region of origin could also create pressure on living standards and thereby stimulate the original response(s), including out-migration. Such forces are considered in Section 5.

The next section critically reviews a number of empirical studies of particular countries and communities to identify linkages between migration and the rural environment observed in recent decades, including the roles played by contextual factors in determining the relationships and decisions adopted.

4. Impacts of Migration on the Rural Environment in Developing Countries

How migration and environmental degradation interact varies by situation and depends on such factors as natural-resource endowments, local institutions and infrastructure, and government policy. While each study described below may have some broader applicability for other countries in the same geographic region or elsewhere experiencing similar processes, each type of situation is not necessarily equally common or important.

Migration of Agricultural Colonists to the Rainforest Frontier

Settler migration to rainforest areas and the subsequent destruction of that habitat are a topic of rapidly growing concern. Because of their numbers and their access to increasingly effective (and destructive) technology for land clearing (such as chainsaws), migrant colonists are linked to a significant proportion of the developing world's tropical deforestation. Although important cases are available from Asia and Africa, this discussion will focus on Latin America, the region undergoing the most rapid tropical deforestation.

Brazil, the country most studied in the context of migration and deforestation, has 35 percent of the world's tropical rainforests. Extension of the agricultural frontier in Brazil has resulted in the largest annual volume of forests lost in recent decades (see Section 1). However, many other countries (in Latin America and elsewhere) that had smaller initial forest stocks than Brazil have experienced higher *annual rates* of deforestation. Indigenous tribes initially and sparsely settled the Brazilian Amazon, and rubber tappers (*caboclos*) exploited parts of it during the rubber boom a century ago. But most of the region remained untouched and without "permanent" settlements until road construction began in the 1960s. In a country characterized by high rates of both population growth and industrial growth, national policy at the time promoted a westward expansion of people to: (a) tap the Amazon's vast wealth; (b) assert Brazilian sovereignty in border areas; and (c) provide a release valve for peasants who had insufficient land and lived in densely populated areas elsewhere (especially in the drought-stricken Northeast). Several government-sponsored programs initially provided free land and food for six months in Brazil's Rondonia state and elsewhere to attract migrant settlers, but spontaneous settlers soon completely overran the effects of these programs (Henriques, 1983; Hecht & Cockburn, 1990). Tax incentives for cattle also added to a speculative land boom. While initial settlers could lay claim to large (200 and above hectares) plots, the size of new settlement plots made available fell to 100 hectares in Rondonia in the 1970s and to 50 hectares in the 1990s. Poor soils, transportation difficulties in marketing the produce over long distances, lack of land titles and long delays in getting titles, and lack of credit for all but the big ranchers led many of the original settlers to experience declining yields over time on the marginal soils. These settlers then sold out their holdings or even abandoned them in order to migrate further into the rainforest to begin the clearing process on a new plot or to move to the region's boomtowns.

Rural-rural migration within the Amazon Basin has thus continued to lead to further deforestation, even as the region's total rural population has ceased growing

since the 1980s. In addition, ranchers (benefitting from generous Brazilian tax subsidies) often bought out the small farmers or forcefully removed them from the land (Hecht, 1985; Hecht & Cockburn, 1990; Schmink & Wood, 1993). The conversion of cleared small farms and abandoned lands into pasture for large cattle ranches—which use more land than crops—has contributed to continuing deforestation in the 1990s.

Because of: (a) the Brazilian government's expansionist policies in the Amazon (including road building and the creation of a new capital in the interior close to the rainforest); and (b) Brazil's relatively low population density in the country as a whole, some argue that demographic factors have played no significant role in the deforestation of the region. While increasing rural population pressures cannot be considered a major proximate cause of recent deforestation in the Brazilian Amazon (since the rural population of the Amazon, as well as in Brazil as a whole, has been declining), this agnostic view disregards the effects of high fertility and population growth *in areas of origin* of many of the migrant settlers to the Amazon. Given Brazil's extreme land ownership inequality, high fertility in Northeast Brazil led to increasing population density and pressures on the land. Landholdings of most families became even smaller due to the division of plots among children. When combined with a series of droughts, this increased population pressure exacerbated rural poverty in the Northeast, pushing out-migration from that region to the Amazon region, where migrants were pulled by available land. Although many migrants from the Northeast initially moved to Sao Paolo and other cities in search of work, they moved on to the Amazon with the construction of its new roads. The later replacement of coffee farms by large, mechanized soybean plantations in southeastern Brazil also forced many additional farm families to migrate to cities or to the agricultural frontier in the Amazon.

In both instances, rural-rural migration led to the deforestation in the Brazilian Amazon through (a) the driving forces of population growth, (b) a highly-unequal land distribution in areas of origin, (c) misguided government policies that subsidized cattle ranching up to the 1990s, and (d) changes in agricultural crops and technology in the South. High fertility and high population growth in areas of origin no longer contribute significantly to out-migration to the Amazon Basin. Fertility has substantially declined in most of Brazil since the 1970s, reaching essentially a replacement level of 2.2 for 2000-2005 (UN Population Division, 2000).

Similar processes of migration to the rainforest frontier accompanied by large-scale forest clearing have been documented in a number of other countries in Latin America. In *Guatemala*, migration into the northern Peten resulted in the clearing of half the forests in the region during the period 1950-1985 (Leonard, 1987). More than in Brazil, high population growth in areas of origin may have played an important role in this Guatemalan deforestation. The combination of agricultural-plot fragmentation into economically unviable sizes and the lack of local alternative sources of employment pushed out-migration from rural areas—especially to Guatemala City and the Peten, the country's last agricultural frontier. The process of deforestation in the Peten observed by Leonard (1987) has continued since that time, as seen in satellite imagery and as documented on the ground in recent household surveys, even in and around national parks and the Maya Biosphere Reserve (Sader et al., 1997). Rural-rural migration appears to continue to drive this process of deforestation. Policymakers need information on the origins and motives of this migration in order to develop policies to better direct this migration in Guatemala. Otherwise, the ecologically important remaining forests of northern Guatemala will disappear within two decades.

Elsewhere in Central America, important studies have been carried out in Panama, Costa Rica, and Honduras. In *Panama*, migration to the forest frontier (mainly to establish cattle farms) led to deforestation along new roads (Heckandon & McKay, 1984; Joly, 1989), a process that extended southward in the 1990s to near the Colombian border in the Darien Gap. Decades ago in *Costa Rica*, migrants to the canton of Sarapiquí colonized forest areas and cleared them to plant cash crops or grow cattle. As a consequence, the population of Sarapiquí grew fourfold between 1963 and 1983, while the forest cover decreased from 70 percent to 30 percent, and pasture increased from 24 percent to 57 percent of the land area (Schelhas, 1996).

Indeed, increases in pasture area have played a major role in most deforestation in Latin America (Bilsborrow & Carr, 2001). For example, in southern *Honduras*, the government promoted the expansion of cattle ranching and cotton and sugar cane plantations on lowland areas with good soils to expand export earnings. This policy enabled large commercial landowners to force smallholders into migrating to adjoining mountain slopes, where they established new farms. The migrant farmers had to clear the forests on the slopes, leading to additional environmental consequences of increased soil erosion and flooding downstream as well as low

agricultural yields (Stonich, 1990; DeWalt, 1985; DeWalt & Stonich, 1999; see also Humphries (1998) on cattle ranching in northern Honduras).

Apart from Brazil, the main research on migration and deforestation in South America has focused on *Ecuador*, perhaps partly due to drug production and insecurity in its Andean neighbors' Amazon regions (and the resulting paucity of road construction). In Ecuador, migration to its northern Amazon provinces and the subsequent deforestation by agricultural colonists began in the early 1970s with the construction of roads by petroleum companies to lay oil pipelines. Those roads facilitated an influx of migrant colonists, 75 percent of which originated in the highlands (Pichón, 1997; Pichón & Bilsborrow, 1999) and 83 percent in rural areas. The population of the Amazon region grew at annual rates of 8 percent in 1974-1982 and 6 percent in 1982-1990 (the latest available intercensal periods), increases that in both cases were more than double the country's growth rates. At the same time, deforestation in Ecuador (mainly in the Amazon) proceeded at a rate of 1.8 percent per year, the highest among the seven Amazon Basin countries (FAO, 1997). The overall estimated rate of deforestation in the country of 1.2 percent per year in 1995-2000 (FAO, 2001) remains the highest in Latin America. This loss has particular ecological significance because the western Amazon region straddling southern Colombia, Ecuador, and Peru is one of the world's most biodiverse areas.[11]

The data obtained to date from specialized household surveys in 1990 and 1999 permit detailed analyses of the factors responsible for changes in land clearing and land use by migrant households in the Amazon region; these analyses facilitate the development of better demographic, agricultural, environmental, and socioeconomic policies for that region. However, these data do not suffice to determine *why the migrants left their places of origin* in the first place, and therefore they tell us little about what policies are needed to alter (e.g., reduce or redirect) those migration flows. To model the migration decision-making process and determine why migrants left, researchers need data on non-migrants in places of origin (see Bilsborrow et al., 1984; 1997). Evidently, the Ecuadorian government policy of according priority to the extraction and export of petroleum from the region led to the building of roads linking the Amazon to other parts of Ecuador, allowing large-scale access to the region. The high concentration of landless and near-landless families in Ecuador's Sierra or Highlands—which resulted from high fertility and extreme inequality in the distribution of landholdings—left a ready pool of persons ready to migrate in search of land. Thus, population pressure on existing agricultural land and the distribution of that land appear to have been key factors responsible for the out-migration from the Sierra—and hence ultimately for much of the deforestation in the Amazon Basin of Ecuador.

In virtually all cases of environmental degradation caused by migrant forest clearing in Latin America, most colonists have been low-income families migrating in search of land. However, the land in tropical rainforests is usually of such poor quality that migrant farmers tilling it have rarely risen above the poverty level. Despite the considerable environmental loss suffered on the continent through deforestation, poverty rates have not fallen (Murphy et al., 1997; Ozorio, 1992; UN Population Division, 2000). Other agents—including cattle ranching, mining, and logging—can also claim direct responsibility for deforestation. Indeed, Wood et al. (1996) found (a) rates of deforestation in the Brazilian Amazon were linked to levels of in-migration, and (b) that deforestation was much more attributable to large farms and ranches than small farmers growing crops. A subsequent study of Walker et al. (2000) found that, along Brazil's Transamazon Highway, a decline in the prices of major cash crops (cacao, black pepper, rice, etc.) relative to the price of beef contributed to small farmers switching land to cattle production. The average ratio of land in pasture to land in crops in the region rose from 2.5 to 9.1. As Figure 2 indicates, household behavior regarding migration and environmental degradation must be linked to larger forces such as markets.

Household behavior regarding migration and environmental degradation must be linked to larger forces such as markets.

Significantly, populations seeking fuel wood for energy can also cause deforestation. The poor in developing countries (especially Africa) and certain migrant groups (such as displaced persons and refugees) depend on fuel wood. Conflict and major natural disasters often force large numbers of rural dwellers to move and seek refuge in other parts of their own country (displaced persons) or in another country (refugees). In central and eastern Africa, west-central and Southeast Asia, and parts of Central America, large populations of internally

displaced persons and refugees have had to live for long periods in recent years in makeshift camps. These migrants have used nearby forests for fuel wood, resulting in deforestation and depletion of surface and underground water deposits (Sessay & Mohamed, 1997).

Migration and Impacts on Desiccation in Dryland Areas

Population growth due to both (a) the difference between fertility and mortality—known as *natural population growth*, and (b) in-migration has also been linked to vegetation loss in dryland areas. Most research in this area examines sub-Saharan Africa, but many Asia and Latin America cases also provide examples. For instance, colonists settling in communal farms (*ejidos*) around the Calakmul Biosphere Reserve in the Yucatan Peninsula, Mexico have caused environmental degradation through the use of crops and technologies inappropriate for the area (Ericson et al., 1999).

African cases are numerous. In Tanzania, 45 percent of the country was considered desiccated by 1980, largely due to the in-migration of people with their animals to semi-arid regions (Darkoh, 1982). The Sudan's Gezira project, the world's largest agricultural irrigation scheme, has displaced pastoralists from their traditional seasonal grazing ranges, while the draining of wetlands to create other irrigation schemes has attracted migrants to eastern Sudan. The Sudan has lost three-quarters of its original forests (mostly since 1950) and continues to lose forest cover at a high rate. While some deforestation results from the extensive use of fuel wood for cooking, the arrival of refugees and other migrants to previously unexploited lands has played an important role as well (Ibrahim, 1987; Little, 1987; Bilsborrow & DeLargy, 1991).

Non-migration factors also often precipitate environmental degradation. These factors include: the actions of governments; national and multinational corporations (logging and mining enterprises); and large-scale ranchers responding to national and international demands for high quality wood, beef, and other forest and agricultural products. As noted previously, the roads and infrastructure these actors construct have usually facilitated the arrival of migrants. More generally, governments have often altered areas with the specific goal to attract migrants: governments have undertaken dam construction for irrigation in the eastern Sudan, northern Mexico, northern India, central China (the huge Three Gorges project), coastal Peru, and many other places. (Such projects may displace other populations, however.) And the creation of national parks and protected areas often leads to higher pressures on resources in other nearby areas (including buffer zones), resulting in increased deforestation or desiccation in those areas.

Impacts of Out-Migration on Areas of Origin

Theory suggests that out-migration should have positive effects on rural areas of origin because of a decrease in the person-land ratio. (Reduced pressures on resources might even facilitate natural reforestation, though little research exists on this subject.) In the Camacho valley of Bolivia, out-migration led to less intensive grazing and environmental improvements (Preston, 1998).

But in several contexts, out-migration has *negatively* affected areas of origin. In the Peruvian Andes, out-migration depleted the labor supply, which made it hard to maintain terraces and which led to increasing soil erosion (Collins, 1986). A Lake Victoria island community in Kenya experienced similar difficulties (Conelly, 1994). Finally, in Gabon, near the Gamba Complex of Protected Areas, the out-migration of young persons searching for employment in cities and in the oil sector reportedly disrupted community-based conservation projects (Freudenberger et al., 1999). The usual positive selectivity of migrants also may contribute to negative effects in general in areas of origin, not only on the environment but also on the lives of those remaining. A number of studies on southern Africa find the out-migration of males to work in the mines and cities of South Africa has disrupted family lives and led to ecological degradation of origin area farms, even as it has also led to increased autonomy and decision-making by the women left behind.

A Note on Migration and Biodiversity

The relationships between human migration movements and biological diversity on the planet are attracting growing interest because of: (a) the increasing size and mobility of the human population; (b) the ongoing loss of biodiversity; and (c) the rapid creation of "protected areas" such as national parks, nature reserves, and forest reserves. The global area under such protection has doubled in the past decade—although the area outside of Antarctica has decreased (Harrison & Sheppard, 1997). And a report of the International Union for the Conservation of Nature-World Conservation Union (IUCN) released in September 2000 stated that (a) 11,000 species of plants and animals face imminent extinction, and (b) the current human-induced extinction rate is 1,000 to 10,000 times that which would

occur under natural conditions ("11,000 Species," 2000). Indonesia, India, Brazil, and China have the most threatened mammals and birds, mostly due to habitat destruction by human intrusions. Major international environmental organizations such as Conservation International, The Nature Conservancy, and the Worldwide Fund for Nature have supported looking into the linkages between migration movements and intrusions into protected areas as well as how to measure and monitor migration impacts.

But this is hardly a new theme. Throughout human history, migration movements have been linked to biodiversity losses. A recent study by Cincotta and Engelman (2000), although focusing primarily on population size, growth, and density (but not defining "migration" in its glossary of demographic terms), provides a brief overview of the effects of past human migrations: "There is clear evidence that human hunters played a role in extinctions as far back as 10,000 years ago, and perhaps even 50,000 years before the present…[even though] there may have been only 5 million humans" (pp. 24ff). Within 1,000 years after the first settlers purportedly crossed the Bering Strait land bridge about 12,000 years ago, people had hunted 73 percent of large mammals to extinction in North America. When the migrants continued into South America, 80 percent of its large mammals may have disappeared. Similar losses occurred earlier in Europe and Asia.

More recently, substantial evidence suggests that human migration into and near many new protected areas contributes to degradation and biodiversity loss. Protected areas in Madagascar, East and South Africa, Indonesia, Thailand, India, the Amazon, the Galapagos Islands, Mesoamerica, and many other places demonstrate such degradation and loss, though documenting the loss or disappearance of specific species is difficult and expensive and linking it to intrusions of human populations is not always straightforward. The Forest Fragments Project of Lovejoy (Cincotta & Engelman, 2000, p. 40) in the northern Brazilian Amazon sheds light on the impacts of migrants by showing the relationship between the size of the protected area or plot (varying from one hectare to 1000 hectares) and species presence. While small areas can preserve most species, large species require much larger areas for their protection. Thus, while small and fragmented areas may often suffer only limited biodiversity loss in terms of number of species because of human migrant intrusion, key species may be lost. Cincotta and Engelman observe that a number of studies have linked migration to habitat loss, including the destruction of tropical rainforests. They also examine the demographic dynamics of the planet's 28 main biological hotspots (as determined by Conservation International) and note higher than average population density and growth for these areas. (See Figure 4 for a Population Action International map of similar population growth findings in global biodiversity "hotspots.") Some areas with low density, such as the Amazon and Congo basins, have extraordinarily high population-growth rates. As Cincotta and Engelman conclude, "habitat disturbance, fragmentation, and outright habitat loss, taken together, currently constitute the leading direct cause of extinction" (Cincotta & Engelman, 2000, p. 42).

Since migration is an important potential factor affecting protected areas, conservationists should have monitoring systems for keeping track of migrants and their effects around such areas. Ericson and Bilsborrow developed such a monitoring system for the Calakmul Biosphere Reserve in the Yucatán Peninsula of Mexico. The Calakmul Biosphere Reserve constitutes a significant part of a larger system of protected areas known as the La Selva Maya, which joins Mexico, Guatemala, and Belize to form an ecological corridor of over two million hectares stretching from the central Yucatán and the Belize forests south (Bilsborrow et al., 1998). Created in 1989, the system covers 800,000 hectares, including core and buffer zones. Ecologically-sustainable production activities are allowed in the buffer zone, but not in the core zone. A heavy influx of migrants (some fleeing Chiapas) and a high natural population growth rate have spurred rapid population growth in the buffer zone as well as in nearby towns since 1990. Some communities are expected to double their population in three to seven years. The population living around the reserve is estimated at about 25,000 people (Bilsborrow et al., 1998). Many people living in and around the reserve are rural-rural migrants, *pushed* from their places of origin in recent years by lack of land, unemployment, displacement by commercial agriculture, ecological catastrophe, and social unrest (as in the case of Chiapas). A new wave of in-migration—mostly of government and service-industry workers—is underway now with the recent establishment of Calakmul and its nearby administrative center of Xpujil, the strengthening of infrastructure, and the development of tourism.

While population density remains low around the Reserve, population growth has a high potential ecological impact because the area has a semi-arid climate, poor soils, and hence a low carrying capacity. A methodology for monitoring population growth

(especially in-migration) and its environmental impacts was proposed to the World Wildlife Fund (Bilsborrow et al., 1998), based on the administration of short questionnaires to samples of key informant households every 12 months in representative "sentinel" *ejidos*. The system aims to enable an inexpensive assessment of population change, the contribution of migration, and changes in land use and the environment, with implications for policy/ameliorative measures. If adapted to country/local community conditions, such a methodology could be used broadly around other protected areas in Mexico and elsewhere.

5. Effects of Environmental Change on Out-Migration from Rural Areas

The effects of the environment on migration have received less attention than those of migrants on the environment; but these effects are now also attracting research interest (Kane, 1995; Myers, 1997). Today, interest in environmentally induced migration has focused on the issues of: (a) "environmental refugees"[12] (*international* migrants compelled by environmental conditions to seek temporary asylum in another, usually neighboring, country); (b) "displaced persons" (people forced to migrate within their country by environmental disasters or civil strife); and (c) other persons who migrate from rural areas within their own country *at least partly* for reasons of environmental deterioration. The latter, not referred to as environmental refugees except in the sensationalistic literature, account for the largest number but have received little attention, both because the international funding community has generally neglected *internal* migration in low-income countries and because the issue does not usually involve persons in desperate need of assistance.

Two factors may cause a deterioration of the environment that impels people to leave: (1) a major natural disaster (such as an earthquake, flood, volcanic eruption, or hurricane); or (2) a gradual, cumulative deterioration in the productivity or livability of a place. Most of the time, major natural disasters produce *internally* displaced persons, but sometimes—because of the magnitude of the disaster, the poverty of the country and its inability to provide assistance, and its closeness to an international border—people cross that border seeking refuge and are accepted as international refugees.

The Dominican Republic provides an interesting case study on the effects of *cumulative* processes of environmental degradation on internal migration (Zweifler, Gold, & Thomas, 1994). A time series of air photographs was linked to survey data to examine the processes influencing land-use change in a hill community called Las Ayumas. Settled around 1900, Las Ayumas was a vibrant (albeit poor) frontier community until 1940, with rice, plantains, maize, beans, and other crops raised in food gardens known as *conucos*. But as early as the 1940s, settlers had cleared most of the original forest, and soil fertility began to decline. Farmers responded first by reducing the cultivation of nutrient-demanding crops such as peanuts, tobacco, and rice and switching to less demanding perennials such as pasture and coffee. The village also became more incorporated into the market economy, which spurred crop intensification. A boom in world coffee prices led to an expansion of the land area in coffee to 40 percent by 1959, at which time forests still covered 23 percent of the land area. But forest area fell to 7 percent by 1968 while the main local urban center, Santiago, grew rapidly, attracting young adult male labor from the village. This urban growth led to even greater dependence on land uses such as coffee and pasture that demand low labor inputs and can tolerate depleted soils. From 1968 to 1983, the area in coffee further expanded, reaching 63 percent of total land use while food gardens shrank. Cassava, bananas, and sweet potatoes, all of which tolerate degraded soils, also replaced the earlier basic foods grown in *conucos*. Thus, over the past 50 years, the decline in soil fertility has led to both out-migration as well as land-use changes in favor of crops with lower demands on labor and soil nutrients.

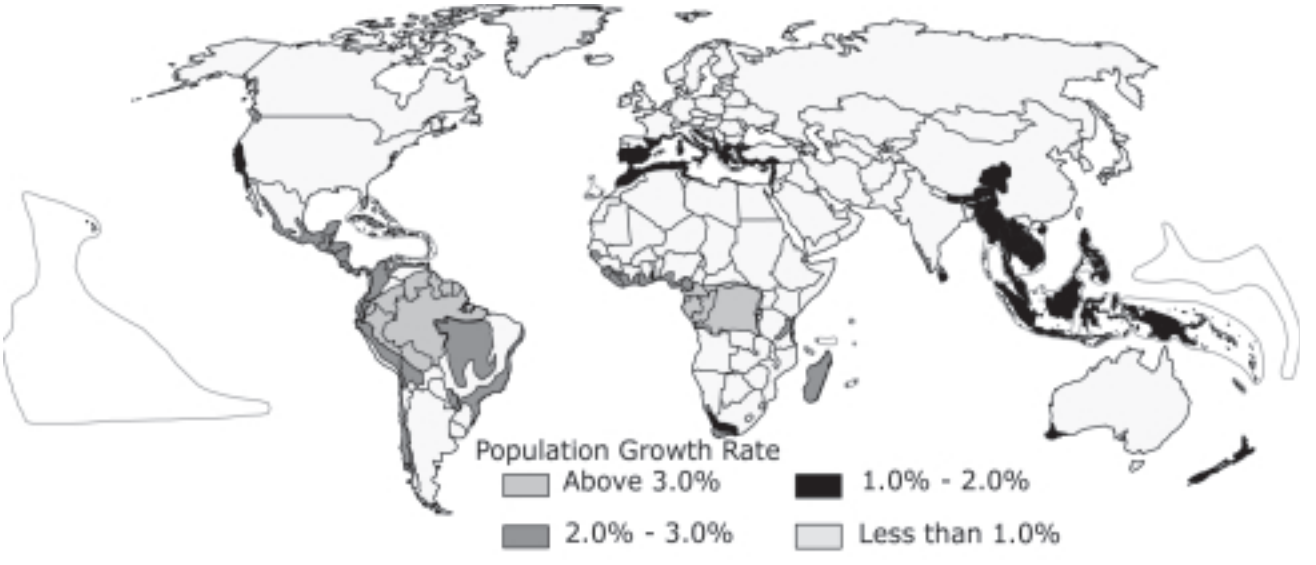
Similar processes of adaptation (including out-migration) have likely occurred and continue to occur widely in the developing world, although survey questionnaires rarely bring out the underlying, long-term processes of environmental degradation such as declining soil fertility. For example, in both Brazil and Ecuador, major waves of migrants to the Amazon originated in areas (from Northeast Brazil and the southern Ecuadorian Sierra province of Loja) characterized by not only periodic climatic droughts but also recurrent droughts that may be related to earlier deforestation, desiccation, declining availability of water, and nutrient-depleting agricultural practices in areas of origin. In Guatemala, the virtually complete deforestation of the Altiplano led to high soil erosion, which must have reduced soil fertility (Leonard, 1987). While fertilizer can restore nutrients to soils, the loss of soil itself cannot be compensated except over millennia. Since most farmers in developing countries cannot afford fertilizers, populations will tend to continue to migrate away from areas with depleted soil fertility.

Although sudden environmental disasters or cumulative degradation reportedly play an important role in the internal displacement of an estimated current stock of 6.5 million displaced persons, the precise role of environmental factors is hard to establish, especially where political, civil, religious, or ethnic conflicts also intercede (Lonergan, 1998). Lonergan describes (see also Black, 1999) with acuity how many studies have greatly exaggerated both the numbers of persons affected and the purported role of environmental factors as "the root cause" of both international migration in general and of refugees and internally displaced persons in particular. (This exaggeration is perhaps driven by the need to promote the wider acceptance and use of the concept of "environmental refugees" as well as to stimulate funding). Some of these studies even report numbers higher than the *total* numbers of refugees and displaced persons. As Lonergan notes, while there is indeed growing interest in studying the specific role of environmental factors in generating both international and internal migration, little direct empirical evidence on this linkage exists.

The relevance of poverty and inequality in access to and use of resources as well as to out-migration decisions is well-known. Consequently, researchers must disentangle the relationships between the environment, migration, and poverty—especially in environmental "hot spots," those places with highly vulnerable ecosystems and growing human populations. This applies especially to the many countries that already have large numbers of internally displaced persons—including Afghanistan, Iran, Pakistan, Cambodia, Indonesia (of recent vintage), Angola, Rwanda, Burundi, Mozambique, Somalia, the Sudan, Democratic Republic of the Congo, Ethiopia, Eritrea, Guatemala, and Mexico. Vulnerable populations also coexist with severe rural poverty, policies of agricultural neglect, and declining soil fertility—dynamics which apply to even more low-income countries and regions within countries, and to most indigenous populations and many minority groups, (such as in the Amazon region and Southeast Asia). Lonergan (1998) concludes that "the key factor is that certain populations are becoming more vulnerable to environmental change because of other factors, primarily poverty and resource inequality..." (p. 11). Interactions of environmental degradation and poverty thus may have particular importance in inducing out-migration.

In general, despite the growing interest in the topic and, the increasing number of studies that deal with environmental impacts on migration decisions, the quality of research remains weak—surely weaker than that in the other direction, on the effects of migration

Figure 4. Population Growth in the 25 Global Biodiversity Hotspots and Major Tropical Wilderness Areas, 1995-2000



Source: Cincotta & Engelman (2000), p. 61.

on the rural environment. Moreover, despite growing interest in the topic of "environmental refugees," even fewer studies examine the linkages between environmental conditions and *international* migration than those that investigate environmental impacts on internal migration movements in developing countries.

6. Summary and Policy Options

According to the latest UN projections, rural populations will continue to grow for several decades more in most of Africa and much of Asia, even as they decline in Latin America. In addition, internal migration movements—notably, rural-rural migration—are likely to continue to play prominent roles in population dynamics and environmental change in much of the developing world, including Latin America. These two factors ensure that rural population dynamics will continue to be a potentially important factor in environmental change.

The literature offers much more discussion of the effects of migration on the environment than the converse. It provides numerous examples in which the migration of farmers to the agricultural frontier has resulted in tropical deforestation or the desiccation of land in dryland areas. This growing area of scholarly research relates to the international community's concern about tropical deforestation and its implications for global warming and biodiversity loss. The case studies also indicate the crucial roles of natural-resource endowments, local/community and national institutions and policy, and (in some cases) international markets and cultural factors in determining the manner and extent to which migration has caused environmental degradation (as well as economic success or failure for the mostly poor migrants themselves). Road building and expansion have played a major role in opening up vast areas for exploitation and despoliation in various Amazon Basin countries, Central America, Thailand, and elsewhere. Extractive enterprises such as lumber, mining, and petroleum—usually from foreign countries but with domestic government approval—have usually initiated this road building. Government policies to promote cattle ranching or the expansion of cash crops for export (usually by large landholders) have been key factors in Brazil, Honduras, Panama, the Philippines, Kenya, and other countries. And the lack of environmental policies or of their enforcement has played an important role everywhere.

Nevertheless, empirical research has barely touched upon how many factors at the household, local community, and national levels work to induce either (a) out-migration from places of origin, or (b) environmental degradation in places of destination. Among the factors that theory suggests may be important to these two issues are: (a) *demographic factors at the household level* (e.g., family size or composition) *and community level* (such as population density, previous migration, and migration networks); (b) *socioeconomic factors at the household level* (such as education, employment experience, migration origin, land plot size, and quality of soil) *and community level* (e.g., presence of markets, location relative to major cities, international borders, transportation infrastructure and linkages, rules governing access to land and natural resources, availability of schools, health and family planning facilities, employment structure and opportunities, wage and income levels, availability of credit and technical assistance, and social mores and cultural practices and beliefs); and (c) *natural-resource endowments* (land availability, including forests and unowned or common property lands; quality of land; availability of water; topography; altitude and temperature; and risk of area to flooding, drought, or other natural disaster). However, only a few studies have quantitatively examined several of these factors together, and many have not yet been tested at all.

Most household and community factors listed are in turn influenced by national policies and institutions (regarding land tenure and distribution; security; credit; agricultural development programs and technical assistance; lumber and mining concessions; fiscal policy and subsidies; and export-import policies, including tariffs and quotas). Ultimately, local governments and institutions filter the effects of such policies in terms of their potential effects on household decision-making processes. It is a formidable task indeed to trace through and quantify these many complex and hierarchical linkages, but software has advanced faster than attempts at applying it—again, partly because of the lack of attention of research-funding agencies to migration. Perhaps this will change as it comes to be recognized that some of the most salient population-environment linkages occur via migration.

Despite the limitations of present research findings, policy decisions need to be made *now* by both governments and NGOs in developing countries and by international agencies. Existing studies do indicate numerous instances in which migration to the agricultural frontier plays a major role in tropical deforestation, the desiccation of landscapes, and land degradation. Given the extraordinary biodiversity of the

areas being settled and the importance of tropical forests for world climate patterns and reducing global warming, the international community should address the root causes of the migration that leads to deforestation *as well as* how to reduce this deforestation *in situ*, at the frontier. Dealing with these two issues involves a full range of interlinked population, development, and environmental policy considerations that go beyond the scope of this article and which will vary from country to country. Nevertheless, the theoretical approaches and case studies discussed above suggest some broad implications.

It is important to first distinguish those policies relating to *origin* areas from those pertaining to the populations in areas of *destination*. If we are concerned about the effects of migration (e.g., extensification of agriculture) on the environment of destination areas, we must also address the factors that stimulate migrants to leave in the first place. Some policy measures that might reduce pressures to migrate from rural areas include improving access to: (a) agricultural land, (b) technical assistance, and (c) inputs (especially water—perhaps through irrigation—and fertilizer). Such measures facilitate land-use intensification and increase yields. Access to adequate land is likely the most important factor, but international funding agencies and political leaders in developing countries (given the vested interests of the latter in most cases) bend over backwards to avoid confronting the issue of extreme inequality in landholdings. Policymakers need to initiate *major* (not token or paper) land redistribution or at least land taxes to stimulate land use (for Guatemala, see Bilsborrow & Stupp, 1997); this step would at least generate employment. Many studies have shown that concentrated land distribution is directly linked to rural poverty, and poverty in turn to out-migration. Other pertinent policies include improving the provision of (a) socio-economic infrastructure; (b) transportation and communications linkages; and especially (c) economic production and employment opportunities in areas from which people are migrating (or improving them in alternative destinations).

These are tall orders, and go to the heart of development policies generally—which have been characterized by "urban bias" in developing countries (Lipton, 1977) (though a better term may be "rural neglect"). However, even if national policies are reformed to redirect resources from urban to rural areas, out-migration is still likely to occur in situations in which the origin environment is degraded and population density is high.

Government efforts to directly settle migrants—whether primarily to reduce population density and lack of land access in areas of origin (as in Indonesia) or to exploit untapped resources in destination areas (as in Brazil and elsewhere in Latin America)—have generally not been successful (Oberai, 1988). One reason for this lack of success is the nature of migration itself and the dominant role of networks. In both Indonesia and Brazil, the number of sponsored migrants was soon overwhelmed by much larger numbers of spontaneous migrants,[13] attracted by word-of-mouth via migrant networks as well as by the roads built to provide access for the sponsored migrants. The environmental consequences of the original directed-settlement policies thus became much more negative than expected. (Indeed, governments in countries with great inequality in landholdings and access as well as high rural poverty need not allocate substantial resources to recruiting initial settlers. Just providing access to land through roads will be sufficient to attract migrants.)

The international community should address the root causes of the migration that leads to deforestation *as well as* how to reduce this deforestation *in situ*, at the frontier.

In regions of destination, countries need to develop policies to improve the livelihoods of migrants, who are mostly poor. But such policies should take into account the desirability of protecting areas of particular ecological value while at the same time encouraging land-use practices that are sustainable and appropriate for the climate and soils. Improving access to family planning in regions of destination is also critical, since high natural increase among migrant populations already settled in frontier areas is also adding substantially to demographic pressures on the environment.[14] These frontier areas have been neglected by both government agencies and private-sector nongovernmental organizations. Policies to encourage less *extensive* (including clearing of pristine areas) and more *intensive* land-use practices are also desirable—both in places of origin and destination. In tropical-forest environments, these policies should include promotion of: (a) agro-forestry; (b) native species and nitrogen-fixing plants; and (c) credit (for intensification—not for cattle purchase or pasture expansion, which provides little employment and

requires large areas to be cleared). Programs to pay farmers for preserving forests on their plots—thus preserving the "environmental services" of the forests—have been tried with success in Costa Rica and Brazil and proposed in Ecuador and other countries.

In addition, road building and extension must be carefully monitored, with the recognition that providing road access is an *immediate* threat to ecosystems. Road extension policies should instead focus on rationalizing access to areas (a) already opened up or degraded, or (b) where biodiversity is limited. Such policies will require more and better assessments of the ecological value of areas (and the desirability of protecting them) and of the soil quality of areas (and of their agricultural potential) *before* new roads are built, so that they can be directed into the latter areas.

In summary, since most migrants to the agricultural frontier are poor, the challenge is to find ways of combating rural poverty in areas of origin while at the same time promoting a more sustainable use of the rural environment in both areas of origin and areas of destination.

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Notes

[1] A striking pictoral-textual view of human migration processes in history is presented by Davis in a 1972 issue of *Scientific American*, subsequently reprinted (Davis, 1974).

[2] The latest UN projections prepared in 2000 are based upon trends in fertility, mortality, and international migration. These projections should never be considered forecasts; they are contingent on a continuation of recent past trends and incorporate assumptions about future paths of fertility and mortality. The most important of these assumptions is the level of fertility at the end of the projection period and the pace of decline towards that level for each country. See UN Population Division (2000).

[3] Trends over time are available in the data only for Korea and India. Korea underwent a striking transformation from a low-income economy to a middle-income economy in the period (1966-95), which was linked to its population redistribution: while prior to 1966, rural-urban, urban-urban, and rural-rural migration movements were all significant in Korea, by the 1990s most of the population was living in cities and urban-urban migration was dominant.

[4] The reliability of environmental measures has been subject to much debate. For example, with respect to deforestation, World Bank and FAO estimates of deforestation in Indonesia in the 1980s differed by a factor of three (see Bilsborrow, 1992). A recent paper has questioned high FAO estimates of deforestation rates in seven countries of West Africa by pointing out that the "original" base year (1900 or 1950) estimates of forest cover were too high (Leach & Fairhead, 2000). The growing availability of satellite imagery promises to lead to much better estimates in the future, but substantial data processing and analysis is needed to convert satellite images to reliable measures of cleared forests.

[5] Indeed, the search for wood has led to a virtual elimination of vegetation around human settlements in some areas of the world. This deforestation progresses in concentric circles that steadily widen with population growth and increase the time it takes people (usually women) to collect fuelwood. A classic example is around the water holes in the Sudan, which followed from a misconstrued World Bank policy of promoting shallow wells for water extraction, which led to mining of underground water aquifers (Bilsborrow & DeLargy, 1991).

[6] The effects of roads on facilitating in-migration to fragile ecosystems have been documented in a number of studies. See Rudel (1983), Rudel & Richards (1990), Chomitz & Gray (1995), Brown & Pearce (1994), and case studies reviewed in Section 4.

[7] I am grateful to Malin Falkenmark for pointing this out some years ago.

[8] Repetto (1986) describes a six-fold increase in sedimentation in a West Java watershed since 1911 due mainly to the poor population moving up steeper mountain slopes to clear forests to create farms as population grew. The most severe erosion was found on subsistence upland holdings of under 0.4 ha.

[9] The concept of cumulative causation was proffered by Myrdal (1963) in his political economy classic.

[10] The *peasant household survival theory* views poor households as engaging in a wide range of behavior and allocating household members to diverse tasks to ensure survival in a precarious world. The theory sees household decision-making

as made by the household as a whole for the overall benefit of the household rather than for the benefit of individuals within it. The dynamic described by the theory has implications for both fertility and migration behavior. It favors large families, which permit more diversification; migration also becomes a mechanism for spreading a household's risk over space and across economic activities. In a composite example, a household may have one member working a small plot of land to provide basic food subsistence, while another member works elsewhere during part of the year as a seasonal migrant laborer, another may work in non-agricultural work, and yet another migrates away to live and work but sends remittances back to the household.

[11]Myers (1997; 2000) has called this region one of the world's 11 ecological "hotspots."

[12]According to the 1951 Geneva Convention, refugees are persons outside their country of citizenship who are unwilling or unable to return to their country because of a "well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion."

[13] Bilsborrow (1992), based on World Bank and other sources, found spontaneous migrants to be at least double the number of sponsored migrants in the Indonesia transmigration program.

[14] Fertility levels of populations along the agricultural frontier are generally quite high. An important exception is Brazil, where total fertility levels on most of the Amazonian frontier are between three and four births per woman in her lifetime.

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