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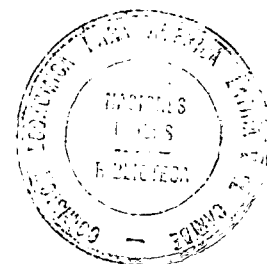
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**POPULATION GROWTH AND DISTRIBUTION: THEIR RELATIONS
TO DEVELOPMENT AND THE ENVIRONMENT**

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INTRODUCTION

The interrelations among population, resources and development have been the object of social concern and scientific study throughout the course of man's history. The earliest recorded reflections of man's place in the world dealt with these themes. In the same way, contemporary concern for promoting development of "underdeveloped" countries has from the beginning taken the natural resource base as a primary factor in planning, and the secular interest has been systematically incorporated into analysis. *Environmental* perspectives, however, have added a new dimension to the study of resources, which are now recognized as more than a basic input in the development equation. This concern has been expressed repeatedly over the last two decades and today enjoys widespread acceptance.

Development planners and students of population, however, have been slow to translate such consensus into models of population, resources, development and environment, capable of orienting governmental interventions. On the one hand, the ghost of Malthus has limited the discussion to a question of the pressure of numbers on resources and has inhibited research and action of the part of those who do not accept such a simple formulation. On the other hand, environmental analysis demands an interdisciplinary or transdisciplinary perspective which has also been slow to evolve. It is not enough to add an ecologist to the staff of planning ministries or to centers of population studies. What is required is nothing less than a complete reorientation of development thinking; among other demands, this implies that basic ecological concepts be absorbed by all of the different disciplines which direct their attention to development problems. Considering the scope of this challenge, it is not surprising that the integration of the population/environment dimension in development planning is still in its early stages.

The present text seeks to outline these relationships in the Latin American context. The first sections are given over to a discussion of concepts with which we may better understand the population/environment/development dimension. Particular attention is given to the idea of "carrying capacity". While the concept has long been used in common-sense discussions of development, the more elaborated versions of carrying capacity (by anthropologists, for example) have not been in a direction which has contributed to policy-making. Suggestions for its reformulation and refinement are presented.

The greater part of the text treats demographic dynamics and environmental change with the help of a simple matrix of basic ecological problems and the components of population growth. This discussion is followed by a brief review of relevant international declarations over the last two decades and a series of specific recommendations for research and development policy.

POPULATION GROWTH AND SUSTAINABLE DEVELOPMENT

The concept of sustainable development, like that of development itself, strikes a resonant chord in contemporary societies —North and South— which gives it a self-evident and unquestioned status as a central *idée force* on the eve of the new millennium. Two major United Nations' conferences (1972 and 1992) and a host of other events, debates, studies and publications have rendered the term a commonplace in today's vocabulary. This fact expresses a growing environmental consciousness joined to a continued concern for economic growth in less-developed countries. The Brundtland Report, *Our Common Future* (WCED, 1987), stands as the most widely disseminated statement of this new consciousness.

It is clear, however, that "sustainable", like "development", does not mean the same thing to everyone. Halting material consumption in developed countries and in elite enclaves of developing countries, faith in technological progress for solutions to environmental stress, calls for zero or negative population growth, an association of social justice as a prerequisite for sustainability, an emphasis on future generations, a reliance on the development of new substitutes for scarce resources versus a vigorous, wide-ranging recycling program: diverse and even conflicting perspectives on "sustainable development" derive from a different mix of such themes. Thus, while the WCED emphasized meeting "the needs of the present without compromising the ability of future generations to meet their own needs", the Latin American response included the need for a development "that distributes the benefits of economic progress more equitably" (Latin American and Caribbean Commission on Development and the Environment, 1990).

Even agreement on the proper term —sustained or sustainable— is lacking. The frequent interchangeability of these concepts masks a fundamental difference in outlook. The notion of "sustained" development calls to mind economic development theories aimed at designing strategies to break the traditional bonds of political, social and economic organization with the goal of attaining self-propelled economic growth. These theories did not contemplate *limits* to growth, sharing Post World War II optimism for expanding material comfort. Environmental concerns have today been incorporated to such thinking, but often as merely a new set of variables to be factored in to the development equation. In such a view, precautions must be taken to assure continued flows of material and energy; the costs of the necessary measures must be built in to the system; and quality of life is seen in the light of environmental balance. There is no questioning, however, of the values placed on continuing the economic expansion characteristic of our century. And concerns for social justice, participatory democracy and non-material satisfactions are often seen as belonging to other spheres of action.

More critical voices —from the environmentalist movement, for example— question the compatibility of such ideas of "sustained" development with "sustainable" development. We have come far from the initial declarations of the Club of Rome (Meadows *et al.*, 1972) which would have frozen material standards of living —with their great international inequalities— at 1972 levels. Today all versions of sustainable development recognize the need to raise living standards —necessarily increasing consumption— in less developed countries. In a situation of extreme poverty, "the individual marginalized from society and the national economy has no commitment to avoid environmental degradation if society does not impede his degradation as a human being" (ECLAC, 1992:17).

But the goal of raising living standards in developing countries is today coupled with a call for decreased consumption in developed countries. The Action Plan of the World Declaration on Survival, Protection and Development of the Child, for example, calls attention to the need for the transformation

of consumption patterns in industrialized countries (United Nations, 1990:15). Increasing energy efficiency and major recycling efforts are seen not as final answers but as initial steps toward redefining progress and well-being. These goals imply that developed countries must seek a steady-state economy and that growth-oriented development does not today represent the model to which developing countries aspire. Gallopin, for example, insists that "... the prevailing development in the region is ecologically unsustainable and therefore not viable in the long run" (Gallopin, 1990:37). Sustainable development *redefines* development and requires long-range changes in both North and South economic organization (Sunkel, 1981:37-41). Major cultural forces centering on Western values of individualism, of the meaning of life and of what it is that provides satisfaction to man are recurrent themes in this discussion. In particular, the concept of human needs (basic/non-basic and material/non-material) requires elaboration and widespread discussion in order to redirect development efforts. The *content* of sustainable development will be found in a better understanding of the needs concept (Galtung, 1979; Sachs, 1980, 1981). Overcoming environmental problems will require fundamental changes in social organization and not merely the introduction of minor technical modifications (ECLAC, 1992).

Without attempting the elaboration of a comprehensive theory of sustainable development, reconciling the diverse concerns mentioned above, it is possible to set out several pertinent aspects in the Latin American context (ECLAC, 1991, 1992). These aspects will serve as background for the population/resources discussion which forms the major part of this text. Sustainable development implies growth directed to the fulfillment of basic human needs, using technology and materials in ways which guarantee that natural resources will continue to be available for the enjoyment and productive use of future generations. Sustainable development implies a confidence in science and technology which will continue to find new uses for known resources; to discover new resources in the uncatalogued genetic wealth of the region's forests, oceans, swamps, rivers, mountains and plains; and to develop techniques for the maintenance and reproduction of these resources. Sustainable development requires a democratic political culture in which multiple ideas may arise and compete with each other, refining human capacity to deal with resource problems. This political culture will flourish to the extent that individuals participate in the decisions which affect their lives. In Latin America, the existence of military regimes in recent decades has demobilized society through its authoritarian and extreme nationalist posture. Environmental concerns have been submerged by policies which encouraged armament industries —some countries have even become armament exporters— and did little to relieve the great gulf which separates rich and poor (ECLAC, 1992).

This understanding of democracy is related to another fundamental tenet of sustainable development: the *decentralization* of decision-making and of productive activities. The preservation of natural resources will be served by greater participation, implying smaller-scale solutions to resource problems. Reducing the scale of development activities reduces their environmental impact and increases the possibilities of local participation. In this context the attention given to greater social justice acquires a double significance: it is important in itself as a basic social value and it promotes a community of interests necessary to the definition of a society's priorities. Thus, the discussion of limits to material consumption is facilitated when gains and sacrifices are equally distributed. These basic tenets of sustainable development —fulfillment of basic human needs, solidarity with future generations, the importance of science and technology, decentralization of economic activities and participatory democracy— are common elements in the general discussion of this question. Particular emphasis on one or another element in this mix leads to more or less radical diagnoses of the current situation in the region. More importantly, however, these different diagnoses have much in common at the level of the basic policy measures they imply. It is not necessary to reconcile the diverse understandings of sustainable

development to begin taking the necessary measures. There is much to be done and it is more important at this time to emphasize this common program.

POPULATION, SUSTAINABLE DEVELOPMENT AND CARRYING CAPACITY

The concern for sustainable development represents an important, indeed fundamental, reordering of priorities and emphases of development practice. It cannot be said, however, that these concerns have been entirely absent from discussions of development. In the field of population studies, these concerns have been expressed in the concept of *population carrying capacity*. Implicit in the idea of carrying capacity is the idea that natural resources are limited —and limiting. Only recently has the concept begun to be extended to include the scope of concerns known as sustainable development. In the context of the environmental debate, carrying capacity has generally been seen in its unidimensional sense of the pressure of population on resources. Since demographers have a much more complex understanding of population dynamics, the concept has not found favor as a useful analytical tool.

In the context of the concern with sustainable development, it is worthwhile to reexamine the concept of carrying capacity. Used by anthropologists to understand strategies of territorial occupation of indigenous groups, the concept appears in demographic studies in the context of the debate on population control. In this literature, carrying capacity is nearly always used simplistically and at high levels of aggregation to arrive at the conclusion that population growth is too high. In this way, the mechanisms of the relation between population and resources are not identified, especially since these authors take the relation as obvious. The demographic community has not found in the concept a basis for its analyses, rejecting its ideological content.¹ The idea of population growth as the principal factor of poverty and environmental degradation has given way to a vision that incorporates technology and resource distribution. If the 25% of the world's population which lives in developed countries consumes 75% of the world's energy, 79% of fuels and 85% of wood products, the population/environment relation must be sought in a more complex perspective (UNFPA, 1991).

The environmental crisis challenges demographers to discover these mechanisms and to elaborate analytical schemes which go beyond the idea of the pressure of numbers on resources (Hogan, 1989a). An emphasis on the components of growth as a more fruitful path will be discussed below. Studies on morbidity and mortality (e.g. Hogan, 1990) and on migration (e.g. Hogan, 1989b) offer fertile terrain for an environmental demography, and the discipline will find here its richest contribution. But the concern with absolute population size, if it does not exhaust the contribution of demographers, still requires attention. Simple resource per capita ratios, however, do not advance our comprehension of this relation. When is a population too large? On what basis do we evaluate this size? At what levels of consumption? What cultural pattern? At what standard of living? How may we study this phenomenon without falling into the same simple and sterile debate on too much population for too few resources?

¹ A preliminary search in the major demographic journals (*Demography*, *Population and Development Review*, *Population Studies* and *Population*), for example, has not found a single article in the period 1970-1990 which uses "carrying capacity" in its title. Citations in *Population Index* for this period are generally to anthropological or biological journals.

A more complex understanding of the concept of carrying capacity may advance our ability to deal with this relation. Including numbers, resources, technology and levels of consumption, UNESCO furnishes us with an appropriately broad definition:

"Carrying capacity expresses the level of population that may be supported by a country at a given level of welfare. More precisely it may be defined as the number of persons sharing a given territory who can, for the foreseeable future, sustain a given physical standard of living utilizing energy and other resources (including land, air, water and minerals) as well as enterprise, skills and organizations, ... [It is] a dynamic concept which may be extended or restricted in numerous ways: through changes in cultural values, technological discoveries, improvements in agricultural husbandry or land-tenure systems, changes in education systems, modifications of fiscal and legal arrangements, discoveries of new mineral resources, or the emergence of a new political will. There is never only one solution to the population/natural resource equation, for it is not population alone that determines the pressure on resources (and potential associated ecological effects) but also individual consumption which in turn is determined by value systems and perceptions of life style" (UNESCO 1984:357).

Does the evaluation of values and perceptions of life style not threaten to turn the question overly subjective? How may we arrive at a figure which represents carrying capacity if the solutions are multiple? *Whose* values should direct notions of optimal population size? Is our goal to arrive at this number, or do multiple solutions imply a range of appropriate sizes, in balance with other goals? In the following paragraphs we will discuss some definitions of carrying capacity. Our hypothesis is that the concept, to be useful, must be used at the level of ecosystems which make sense from the point of view of the social organization of a given territory. The analysis of the set of these *socio-ecosystems*² will not produce the magic number environmentalists desire for carrying capacity. It is perhaps more important to consider the concept (as it will be broadened below) as a matrix of possibilities. If it is possible to make more explicit the trade-offs implicit in this process, we will have contributed to the scientific and political understanding of the question.

On definitions of carrying capacity

The concept has an intuitive attraction for those who try to think about the limits which the natural world sets for the welfare of men. In the environmentalist literature, it is a commonplace to affirm that the greatest challenge and the greatest threat to humanity is to exceed carrying capacity. Nearly always the concept has a self-evident quality which dispenses rigor in its definition. Kirchner *et al.* (1985:45) offer a definition which differs very little among scientific or political writers:

The *carrying capacity* of a particular region is the maximum population of a given species that can be supported indefinitely, allowing for seasonal and random changes, without any degradation of the natural resource base that would diminish this maximum population in the future.

Much of the bibliography, when giving a precise definition of *degradation*, seems to emphasize food production (Dewar, 1984). Demographic growth is sustained only with the growth in food production, and the decrease in production per capita leads to the deterioration of the natural environment and indicates that carrying capacity has been exceeded. Ever since the now classic text of Boserup (1965), no one fails to mention that technological progress can alter the relation between numbers and resources. If it is growing demographic pressure which requires or permits technological progress —as Boserup

² This admittedly redundant expression is used here to call attention to the social component of ecosystems, frequently treated in reductionist fashion by environmentalist writers.

holds— or if it is the latter which permits the expansion of population, continues to be debated. Does population growth produce technological leaps? Or do the two processes advance together, slowly, maintaining and increasing standards of living?

Different authors mention other variables, among which a society's consumption patterns are especially important. Yet other texts remain on an abstract level, such as the UNESCO definition cited above, or reduce the concept to an indicator such as energy use per capita (Masarang, 1976). This procedure has the advantage of being quantifiable and comparable and international studies such as Masarang's have invested in this direction. A major FAO study (reports published 1978, 1982, 1984) explicitly incorporated these factors, on a regionalized basis, in estimating countries' abilities to be self-sufficient in food. Building on a 17-year FAO/UNESCO project to elaborate a Soil Map of the World, and on the earlier *Agriculture: Toward 2000* study which provided other data (for example on irrigation), agro-ecological zones were determined and estimates of crop-specific potentials of soil and climate zones were produced. The first regional report to be published (for Africa) led the UNFPA to ask: "can the agro-ecological zone crop potential estimates be converted into estimates of potential population supporting capacities; if so, can these population potential estimates be compared with data on present and projected populations to identify critical areas where land resources are insufficient to meet food needs" (FAO, 1982:5). Estimates were made under low, intermediate and high technology scenarios. The trade-offs between population size and level of agricultural technology are explicit, and indicate wide ranges of *carrying capacity*. These ranges (at the world level) are within UN projections for stabilized population sizes.

Thus, different scenarios were produced, demonstrating the diversity of possible solutions. The study avoided the premise of homogeneity of conditions across national territories, an inevitable procedure for studies of the universe of nation-states, such as Masarang's. It is recognized that carrying capacity refers to *regions*, not to a country as a whole. Such research, however, produces sets of correlations whose level of generality does not contribute a great deal to understanding the *mechanisms* involved in the land/technology/population relationship.

Anthropology's long tradition of *human ecology* measures the production and consumption of energy in primitive groups, a procedure which also favors comparability. An entire tradition of quantitative models on the topic has been developed (Dewar, 1984, Keegan *et al.*, 1985). The Massai of the Great Rift Valley (Talbot, 1986) or the Bushmen of the Kalihari (Kirchner *et al.*, 1985); however, do not offer us sufficiently complex situations to sustain analogies with the modern world. Without entering the intradisciplinary debate on this tradition, it is important to qualify its usefulness for the understanding of modern and complex societies. Several key factors have little variation in primitive, compared to modern, societies. This does not imply the absence of social differentiation in such groups, but only recognizes that their limits of wealth and poverty are much narrower. In the same way, power relations exist in primitive groups, but the distance between the powerful and the weak is much greater in modern societies. The Boserup hypothesis, for example, originally developed to explain advances in primitive agriculture, is much more forcefully presented in the 1965 book than in her more recent attempt to generalize these relations in much more complex situations (Boserup, 1981). Such complex situations require that the model's verifiable hypotheses be specified at lower levels of generalization. These examples suggest the pitfalls of reasoning by analogy. Muscat calls attention to other aspects of the fallacy of analogy:

In the long run it is evident that the advancing technology and accumulation of capital, and the declining importance of agriculture in the structure of production and distribution of the labor force, greatly reduce the dependence of human populations on the inherent fertility and raw material endowment of their particular environments (Muscat, 1985:10). My emphasis.

Another problem common to these studies is their tautology at the level of indicators. Population growth leads to exceeding a region's carrying capacity. Growth is measured by the rate or volume of population. Excess carrying capacity is indicated by the decline of the resource/population ratio (e.g. tons of grain per capita or the consumption of calories per capita). In the equation "population growth leads to the decline of carrying capacity", population enters on both sides. Overpopulation is measured by overpopulation. As for environment, the same problem exists. Keegan *et al.* (1985), for example, when they move from the simpler abstract study of carrying capacity to practical means to use the concept in general situations, fall into the same trap. If everything is included on the environmental side of the equation (resources, technology, culture, consumption styles etc.), it is impossible for population to be an independent variable.

The complex matrix which results from the specification of all these factors will not serve to verify that population (volume or rate of growth) is "density-dependent" nor to calculate optimal size for a population. This matrix can, however, show us the field of relations in which human activity operates in its continuous effort to balance numbers and resources. The analysis of the set of ecosystems would permit society to establish the trade-offs necessary for sustainable development. The objective is not any magic number of optimum population size, but clearer conditions for decision-making. As all values cannot be maximized in all ecosystems, society and its planners need to be able to weigh these trade-offs. Verifiable hypotheses will be derived within the population/environment matrix but the matrix itself is not verifiable. This is perhaps the greatest difficulty with a large part of the literature on carrying capacity: the effort to establish direct causal chains by means of what is fundamentally a tautological statement. Tautology is not always a useless or inappropriate tool in science. Clarifying the complexity of a phenomenon and defining it with tautologies may be constructive. The difficulty resides in attempts, through statistical correlation, to prove the tautology as though it were a hypothesis.

Between common sense views of environmentalists on the one hand and the anthropological tradition on the other, demography has failed to occupy its proper ground. Besides generic references in the context of introductory discussions of the environmental question, demography has all but ignored the question of carrying capacity. It certainly has not assumed an important place in the conceptual rigor which characterizes the discipline. Today, when demography seeks to remedy its distancing from the environmental question, it needs to refine concepts from the realm of common sense and integrate them to analyses of demographic dynamics. From the same structural/institutional perspective which has characterized demographic analysis in the region, and where neomalthusianism has been replaced by other visions, it is today necessary to invest in a "post-neomalthusianism". The challenge today is how to conceive the population/resource relation in a context where the terms of this debate have been significantly broadened. Following the anthropological tradition, it will be useful to work with delimited regions where the relations between demographic dynamics and environmental change may be observed. If we wish to understand the distinct processes and identify the mechanisms of the relations between them, international studies with enormous data banks will not be the first step. Considering the need to understand the relations between natural and social processes, we propose to use the ecosystem as a unit of study.

River basins are one such ecosystem, and a strategic choice for the observation of the analysis of socio-demographic-environmental relations. Not being delimited by strictly political-administrative criteria, they are a sufficiently large "natural" unit to reveal the environmental consequences of human action and the socio-demographic consequences of natural limits. At the same time, economic activities, though they may be diverse, tend to have a certain homogeneity as to level of development. The comparison of river basins, then, would permit us to understand better the dynamic of the relations to be studied in the interior of each of them.

At the same time, this comparison may shed light on the relations of ecosystems which compose a political unit (a region, province or nation) with their inclusive society. A primordial feature of complex contemporary societies is their level of regional interdependence. The social and territorial division of labor in the modern nation-state means that each region (or each ecosystem) must be understood in its relation with the whole. The nation-state may not be a distinct ecosystem, but it is an inescapable socio-political reality. The importance of national frontiers may be greater than those of ecosystems in the determination of man's relations with a specific biome. It is this importance which leads us to study the ecosystems which compose a nation.

Within this nation, "total" carrying capacity is not the sum of carrying capacity of these components. No country has as its only goal to maximize population size. For a specific level of welfare, in a specific country, some ecosystems will have distinct destinies: agriculture, mining, industry or leisure, for example. This means that an ecosystem's carrying capacity is determined not only by its natural resources, but by the social definition which it receives. Consequently, a nation's population supporting capacity depends on its regional development policy which will allocate specific roles to specific regions (See Box 1). The whole, in short, is less than the sum of its parts. In many cases, such as the Guayaquil example (Box 6) population/ environment analysis will reveal the tensions implicit in these vocations. Whether the reordering of development priorities will resolve these tensions or require more difficult choices can only be determined through a region by region analysis. Calculations of carrying capacity found in the specialized literature do not take such factors into consideration.

Box 1

POVERTY, WEALTH AND CARRYING CAPACITY IN SÃO PAULO

The Piracicaba River Basin (PRB), in the Campinas region of the State of São Paulo, with a population of 4,673,542 in 1991, has been marked by a development process which combines a policy of industrial decentralization with profound modifications in Brazilian agriculture. This process, particularly intense in the last 25 years, did not include provisions for the increased workforce attracted by the increase in job opportunities, and infrastructure improvements in health, housing, education, transport and water and sewage treatment have not kept pace with growth.

Concern with industrial decentralization began in the sixties and industries were stimulated to leave the São Paulo Metropolitan Area for the Interior (Barjas Negri, 1988). This policy has been maintained with variable intensity since then. During this period agriculture has also assimilated forms of management and production analogous to those of industry. The agro-industrial complex which has resulted is characterized by the excessive use of mechanical, chemical and biological practices. One of the most productive regions of the State of São Paulo, the PRB is responsible for approximately 20% of total state agricultural production. The region also enjoys an excellent transportation network, adequate energy distribution and a privileged urban system, important both for reaching the consumer market and for permitting access to temporary migrant labor on urban peripheries (Tartaglia and Oliveira, 1988).

The pressure on the region's natural systems is affected by these various activities. They include the petrochemical complex of Paulinia, major sugarcane production and its agroindustrial complex spurred by the demand for alcohol fuel beginning in 1975 and production and industrialization of oranges encouraged by a vigorous export policy beginning in the sixties. They also include such specific sectors as textiles in Americana and metallurgy in Santa Barbara d'Oeste and Piracicaba. Other important agricultural products include sub-tropical fruits such as grapes, figs, peaches, strawberries, plums, persimmons, melons and truck garden crops. This diversified picture produces a complex of pollutants equally diversified.

Neither local populations nor state government gave the necessary attention to the environmental limits of this urban-industrial expansion during the first phase of the interiorization of economic development. Only with the consolidation of this development policy have the specificity and quality of the region's environment begun to be taken more seriously (Sevá and Ferreira, 1989). Water supplies have been the focus of this debate, and it is to this concern that most state environmental investments and the creation of agile structures like the Intermunicipal Piracicaba Consortium have been directed.

The hydrological network is formed, in addition to the Piracicaba River, by the Capivari and Mogi-Guaçu Rivers, which drain, respectively, 12,400 km², 1,655 km², and 115,390 km². Among residential, industrial and agricultural users, it is the industrialization of sugar cane which imposes the greatest organic discharges to the hydrological system (CETESB, 1986). A second major factor is the detour of water from the PRB to the Cantareira System which supplies the city of São Paulo. Thus, a region in which both quantity and quality of water are problematic is deprived of a significant portion of its potential supply due to the demands of the metropolis.

The real prospect of a crisis in water supply, principally in the city of Piracicaba (282,402 inhabitants in 1991) in the next few years, has moved governmental and environmentalist action. There is no guarantee of a solution, since it is unlikely that São Paulo will surrender its quota, and the situation appears to be an exemplary case study of exceeded *carrying capacity*.

But carrying capacity for whom? Responsibility cannot be laid to regional population pressure. The region's dense settlement pattern was not an obstacle to the high standard of living of its population: the region is known as the "California brasileira", and is the third major consumer market in the country, after São Paulo and Rio de Janeiro. Water resources would be adequate (at least in the immediate future) were it not for pollution and the significant detours to the metropolitan area of São Paulo city. If water scarcity brakes the region's economic development, it will be necessary to look to political-economic factors as the root of the problem.

Box 1 (concl.)

The Ribeira Valley (RV), formed by the Ribeira do Iguape River, is a poor and underdeveloped area, and includes 24,980 km² in the State of Paraná (39% of the area) and São Paulo (61%). A mountainous region, the RV includes the largest intact portions of the Atlantic Forest and 200 km of coastline with estuaries, lagoons, mangrove swamps and beaches. The area has maintained its pristine quality due principally to its isolation from the economic development process which characterized the rest of São Paulo, though the regional capital of Registro is only 191 km from the city of São Paulo. With a population of 229,830 inhabitants in 1991, approximately 50% urban (vs. nearly 90% in the state as a whole), the valley is marked by a subsistence economy. Small scale agriculture and the extraction of forest products occupy a major part of the economically active population. Social and demographic parameters are consistent with this economic profile: infant mortality, water and sewage treatment, housing and educational facilities all represent a contrasting image to that of the Piracicaba Basin. With the accelerated development of other regions of the State, the local population now demands its own opportunities for economic growth, desirous of the same consumption patterns and quality of life.

This demand must today confront the fact of the preservation of valley's natural resources. The Atlantic Forest which ranges from the state of Rio Grande do Norte to Rio Grande do Sul is today reduced to less than 5% of its original area. Encompassing a biodiversity more threatened than that of the Amazon Forest, the Atlantic Forest is today the target of preservationist campaigns, among which is UNESCO's Man and the Biosphere Program (MAB). The Brazilian Committee of the MAB has proposed that this region be incorporated in UNESCO's network of biosphere reserves, and this is under discussion at national and international levels. As a result of the environmentalist movement, the region today includes a large number of protected natural areas. These include one *Natural Preserved Area* (Maciço da Juréia), three *Environmental Protection Areas*, one *Area of Ecologically Relevant Interest*, one *Special Protection Area*, four *Ecological Stations*, and five *State Parks*. This situation reflects a growing environmental consciousness among opinion-makers in São Paulo. These diverse protected areas, each type with its limits to access and to economic activity, represent obstacles to small farmers who live from forest products. They are also obstacles to development plans of local officials who seek to pull this poverty pocket out of its secular stagnation.

The conflict over the destiny of the Valley arises from these two simultaneous processes. The last region to be incorporated into the advanced economy of São Paulo voices its demands in an era marked by the environmental consciousness of urban middle and upper classes. Today, when development acquires the status of a basic human right, and local development forces threaten the integrity of this ecological treasure, development has also acquired an environmental cast. The environmental movement, which has already transformed a large part of the Valley into protected areas, restricting its economic use, continues pressuring for the enlargement of these areas. The conflict between development and preservation is perhaps not without solution. Proponents of sustainable development are currently elaborating projects for the extraction of forest products and for ecotourism.

What is carrying capacity in the Piracicaba River Basin and the Ribeira Valley? This question presupposes another. What is to be preserved in each case? How does society decide the balance between preservation and development? In one case, the question poses the dilemma of the recuperation of degraded natural conditions and conciliation of the twin demands of environmental quality and economic growth. In the other, the challenge is to preserve an as yet undegraded environment while promoting the social and economic development of local communities. What planners must recognize is that both questions must be examined simultaneously. Not all variables are to be maximized in all cases. The sine qua non of development is the promotion of human dignity, and how resource-intensive activities are to be spatially located will depend on socially defined priorities. The population supporting capacity of each region will depend on a policy of regional development which recognizes the socio-environmental vocation of the others.

Source: Barjas Negri, 1988; Tartaglia and Oliveira, 1988; Sevá and Ferreira, 1989; Cetesb, 1986.

In most countries of the region socio-environmental conditions are extremely diverse. On the one hand there are densely occupied and environmentally degraded areas, with a socioeconomic infrastructure similar to that of many developed countries. National societies have invested much in these areas and expect a return on that investment. While environmental concerns receive continually greater attention, no one suggests that brakes be applied to such development. At most, efforts are directed to seeking models of growth compatible with ecological limits. On the other hand, there are still nearly virgin areas, which society now defines as reserves of plant and animal species expelled from or non-existent in the rest of the territory. What is carrying capacity in such distinct areas? The question leads us beyond considerations of locally available resources but at the same time ties us to an analysis of these resources. The analysis of the concept does not dispense a local perspective nor can it be restricted to this perspective. The carrying capacity concept may be a useful element for this purpose.

A broad definition, then, of carrying capacity, including not only food supplies, but other basic and non-basic human needs (Galtung, 1979) —as determined by cultural standards, and which may be expanded or reduced by technological progress, by greater social equality, by increases in levels of education and health, by discoveries of new mineral resources or by political or ideological forces— may map the field of relations between population and environment. Progress in our ability to understand these relations and to plan for sustainable development requires comparative and ecosystem-specific local studies. Neither isolated case studies nor aggregate national or continental data will be sufficient. The present text necessarily relies on such sources of information in its attempts to exemplify some central questions. More satisfactory treatment awaits in-depth and cross-national studies.

Environment and the components of population growth

Turning our attention to the relations between the *components* of population growth and environment, we find a promising area for research little explored by population specialists. In the discussion that follows, attention will be given to population carrying capacity considerations and to the principal components of demographic growth. Among these components, fertility is the least-studied in terms of environment, and our analysis will focus principally on migration and health. It would be an exaggeration, however, to affirm that this theoretical space is virgin territory. Studies of the physiology of reproduction and of ecotoxicology have identified chemical agents which are mutagenic and teratogenic, without, however, giving a balance of the actual or potential consequences for fertility. In his review of research on nutrition and fecundity, Bongaarts (1980) evaluates the scientific knowledge on this relationship and its impact on fertility. What is most noteworthy is the lack of studies and the precariousness of conventional wisdom. Truly comparative research is rare and there exist many lacunae. Establishing a distinction between malnutrition and famine (where the effect is strongest and most evident), and concentrating on the former, Bongaarts concludes that "Moderate chronic malnutrition has only a minor effect on fecundity, and the resulting decrease in fertility is very small" (Bongaarts, 1980:568). This conclusion is significant because many of the environmental factors which affect man do so through nutrition and because this is one of the most researched aspects of the question. If our knowledge of the nutrition/fertility link is tenuous, what must it be for the many other environmental factors?

In his discussion of biological factors which can limit natural fertility, Gray (1979), besides nutrition and lactation, refers to menarche, menopause and to sterility resulting from syphilis, gonorrhea and malaria, without mentioning chemical substances. In all these cases, it is remarkable how precarious is our knowledge. It is nearly always impossible to evaluate the effects on a population of any of these

factors. Commenting on the work of Gray, Belsey (1979) adds to the causes of sterility other illnesses such as mumps and schistosomiasis. The latter is a clear example of the proliferation of an illness through environmental factors:

Although both *Schistosoma mansoni* and *haematobium* may be found in the genitals, the importance of schistosomiasis in infertility and pregnancy wastage is at best unknown... A recent report by Bullough (1976) suggests a greater role of *bilharzias* in infertility than has heretofore been recognized (Belsey, 1979:264).

A recent WHO study, based on tests of 20,000 healthy men on five continents, concluded that a 40% decline in sperm counts over the last 50 years is due to stress and environmental factors such as pollution. Agricultural chemicals, for example, can reduce male fertility.

Estimates by teratologists vary from 2 to 10% as to the share of congenital defects attributable to environmental factors, including drugs and alcohol. Another 20% is attributable to genetic factors, while 70% are of unknown origin (Monteleone, 1986). The potential margin for environmental causes is obvious. But statements on the question are approximate and partial, and research in this area is full of lacunae, as a recent report concludes:

While there is no doubt that drugs, radiation and environmental pollutants can cause birth defects in individual cases, statistically they don't *seem* (my emphasis) to have contributed to much of an increase (*Newsweek*, 16 March 1987).

There are, then, two reasons why fertility is the largest of the lacunae in our knowledge of population/environment relationships. First, there is very little research and affirmations are always qualified, pointing to possible but unproven relations. The need for medical and demographic research in this area is enormous. In the second place, environmental factors apparently account for little in levels and patterns of fertility. When it is possible to quantify a relation, it is not large compared to other determinants. *Qualitative* aspects, however, gain in importance as fertility rates decline and will be more and more important in the future. Sterility, subfecundity, premature births, spontaneous abortion and birth defects are related to environmental factors and these will require serious research efforts in the future.³ In this text, the experimental nature of the studies to date does not permit a specific Latin American analysis.

³ Students of human reproduction have begun to address these issues in more systematic fashion. Two international conferences, one held in 1991 and a second planned in 1993, have focussed on the impact of the environment on reproductive health. The WHO Special Programme of Research, Development and Research Training in Human Reproduction held an "International Workshop on the Impact of the Environment on Reproductive Health" in Copenhagen in 1991. Particular attention was given to the nature of environmental factors affecting reproductive health; environmental factors blamed for declining sperm quantity and quality; the effects on reproductive health of natural and man-made disasters; how the environment damages reproductive health; and on the need for better research methodologies and surveillance data (Progress in Human Reproduction Research, 20, 1991). The New York Academy of Sciences has programmed a conference on "Human Reproductive Ecology: Interactions of Environment, Fertility and Behavior" in May 1993. Such issues as effect on fertility of amelioration of the industrial environment or of nutrition and health, the response of fecundity and fertility to environmental change and the roles of seasonality in human fertility will be dealt with.

When we consider migration, it is intuitively obvious that resource questions affect the direction, volume and composition of streams. Whether in terms of the availability of resources, of *carrying capacity*, or in terms of environmental degradation, these considerations were always present in migration analysis. Population/environment studies, however, still require a systematic review of how these factors affect the pull of competing destinations. It is also necessary to evaluate environmental degradation as a *push* factor. Substitution of small farmers by cattle, rural exodus from recently settled lands, and rapid soil impoverishment in tropical forest regions offer examples which deserve attention.

A complex set of migratory mechanisms contributes to the composition and direction of migration streams, to the aggravation of environmental stress at origin and destination and to the focussing of the environmental burden on the poor. Such mechanisms, embedded in the social structural features of the region, have been the object of much population analysis over the last decades. But their relations with environmental change are not well understood and require more intense research.

Migrant selectivity has often subtracted from rural areas the farmers most successful in meeting the requirements of environmental sustainability, leaving the most defenseless and resource-poor on degraded and erosion-prone soils. On the other hand, better qualified migrants have occupied jobs in more specialized sectors of the economy, located in urban centers or districts less plagued by pollution, lack of water and sewage systems or deficient garbage collection. The region's most degraded cities, and the most degraded districts of these cities, are occupied by the poorest of the poor, adding an environmental quotient to the burden of social inequality (Hogan, 1992b).

Commuting has emerged as a significant inter- and intra-metropolitan mechanism which permits qualified workers to reside in neighborhoods with greater environmental infrastructure, while the least skilled occupy the least equipped districts. Thus, even *within* the metropolitan grid *residential segregation* directs the onus of the environmental burden to the poor; furthermore, this residential segregation is locked into place by commuting patterns which permit even good jobs in degraded areas to be held by residents of better-equipped areas (Hogan, 1992c).

Turnover rates are another factor which serves to maintain the status quo in degraded urban areas. The lack of urban amenities leads to short duration of residence patterns compared to better served districts. This constant turnover means that local community development or neighborhood improvement efforts suffer lack of continuity and are slow to gather the momentum necessary to affect public policy (Hogan, 1992b).

Seasonal migration often means that agricultural workers leave their eroded, worn-out lands which barely support subsistence production, for temporary work in modern agricultural sectors. On the one hand, impoverished soils no longer permit independent farming in these areas; on the other hand, the availability of seasonal wages in the modern sector dampens pressure for corrective measures. Backward areas (arid lands in Northeast Brazil or Mexico) are left to degrade even further while large-scale modern agriculture in richer regions (e.g. Southern Brazil) or countries (the United States) are served by the resulting low labor costs.

Urbanization in itself is not inimical to environmental quality. Indeed, population concentration should serve to rationalize access to health and sanitation services and to education. Total land availability is increased, permitting —together with gains in agricultural productivity— the maintenance of larger areas in forest and other natural ecosystems. (See Dasmann, 1971 for the United States case.) If Latin American cities suffer serious environmental problems, these must be attributed to inattention to

environmental infrastructure during the decades of high-growth of the region's economy and of its cities. Land and income concentration hindered investments in urban sanitation, housing, public transportation and pollution control. Institutional obstacles to coping with rapid growth have also been important factors.

In the analysis that follows, it will be clear that the most urbanized countries and sub-regions are also those where urban environmental improvements have been most successful. The ills of population concentration are aggravated in "mega-cities", and there is no doubt that the dimensions of their problems are magnified by the difficulty of implementing public policy in such large and diverse settings. The World Bank has identified the protection of urban environments as one of three major areas requiring attention of urban policy and development planners in the 1990s (the others are raising urban productivity and alleviating poverty). The impacts of the environmental crisis of towns and cities are short-term, resulting "from congestion, air and water pollution, inadequate sanitation, erratic waste collection and disposal, and the destruction of marginal lands" (World Bank, 1992b:6). These factors also contribute to such long-term problems as the intensity of energy and resource use and the concentration of wastes and emissions. But if four of the ten largest cities in the world are in Latin America (Mexico City, São Paulo, Buenos Aires and Rio de Janeiro), it is important to remember that others on this list (New York and Tokyo, for example) have made much progress in urban environmental improvements.

If population concentration and even city size are not intrinsically problematic, they nonetheless encompass major problems for Latin America. Even with adequate programs and public investments in urban areas, however, population distribution will remain a fundamental concern for development policy. Solutions exist for the most pressing environmental problems found in the region's cities, and a combination of political will and financial resources will go a long way toward establishing a better population/environment balance. But these remedial solutions must necessarily be implemented in currently existing cities. The challenge which long-range planning must face is to integrate ecological considerations with future location decisions of major economic activities.

Coastal regions in large parts of Latin America, for example, are characterized by two features which deserve special attention. In the first place they are ecologically fragile, i.e. their natural cycles are easily disrupted by man's activity and difficult to restore. They play essential roles in the reproduction of many species, especially crustaceans, and are the unique homes to many others. Secondly, they are also of surpassing beauty and have been the sites of large-scale tourist development, with much potential for expansion. Preservation of this tourist potential requires preservation of the natural coastal beauty; it is precisely such "natural" features that urbanized populations seek:

"Adequate environmental management together with harmonious tourism development must be part of an integrated national development policy; otherwise, tourism may lead to environmental deterioration, turning tourists and local residents into victims" (CLACSO, 1983:8).

Both population dynamics and environmental conditions vary dramatically within Latin America. From densely settled and environmentally degraded mega-cities like Mexico City and São Paulo to the nearly virgin forests of the Ianomami reserve on the Brazilian-Venezuelan border and from humid tropical forests to the extremities of Patagonia, human populations have occupied the most diverse of natural ecosystems. Man's inherent adaptability has permitted him to live and work on reed islands in Lake Titicaca, in the cold humid tropics above Bogotá, in the lush islands of the Caribbean and in the pampas of Argentina and Southern Brazil. Demographic conditions also vary considerably. It will be useful, in this analysis of the relations among population, environment and sustainable development, to organize the data according to basic demographic differences. In this regard the typology suggested by

León (1990), which groups nations according to the period when they initiated their demographic transition, availability of renewable natural resources and urbanization rates, is particularly helpful.⁴ The decline of population growth rates in Latin America in recent decades, a result of declining fertility rates, is accompanied by continued growth due to the large number of women of childbearing age. Even more important is the rapid urbanization in this period —promoted by generalized rural poverty— and the transfer of major environmental stress to cities (CELADE, 1992).

Focussing on age structure, León separates countries according to their potential growth (demographic demand in the proximate future) and to the resource base available within national territories (especially the presence of an agricultural frontier or not) capable of satisfying this demand. Especially important are urbanization rates, which require levels of infrastructure investment and political-administrative capacities not found in these societies. Institutional response to the environmental requirements of fast-growing cities is hampered not only by antiquated governmental structures but also by the sheer scale of the challenge. Currently developed countries never had to provide services at these rates, and available administrative techniques are not adequate to the task.

The consequent short and long-term environmental damage and challenges for sustainable development are very serious. Much of the damage done in periods of accelerated urbanization is impossible or prohibitively expensive to remedy. Open land in metropolitan areas has been occupied; forests protecting watersheds have been destroyed; rivers have often been canalized and buried; and residential patterns established. Changes in microclimates, long daily commuting, lack of green space, or construction on erosion-prone or flood-prone land will not be easily undone.

The challenge is especially great for rapidly urbanizing countries and in those which are yet to experience the full thrust of high growth and rapid urbanization. The problem to be faced is whether only urban areas will respond to the need for job creation or whether access to land —through land reform or the existence of an agricultural frontier— will permit the rural sector to absorb population growth. In this case, the question becomes what the environmental costs of increasing agricultural populations would be.

In the following discussion, illustrative data will be presented according to five groups of countries, ranked by a combination of these factors. For the purposes of exposition, the environment is considered in the light of the four classical natural elements of water, air, fire (energy) and earth (soils and minerals).

⁴ "This typology differs from others elaborated at CELADE, on the basis of the demographic transition in two aspects: we consider that all countries had already initiated their transition before 1970; and what matters is the period in which they initiated it and not the path which the transition has followed. In this sense, the fact that Argentina or Jamaica has had fertility differences during two decades is not a reason for changing their place in the typology. From the analytic perspective adopted in this work, what is relevant is the evolution of age structure" (León, 1990:14).

Water

Among world regions, with the exception of the United States and Canada, Latin America suffers the least from water scarcity. In terms of current rates of use as well, only the United States, Canada and sub-Saharan Africa have lower ratios of annual water use to total water resources. If water supply is not a serious problem at the continental level, this is not uniformly the case across all national territories. Several Caribbean and Central American countries, as well as Mexico and Peru, have replacement rates lower than the world average (Table 1). Periodic droughts in relatively densely settled areas, such as the Brazilian Northeast, impose serious consequences on older settlement patterns. Whether human activity has exhausted or diminished water supplies or whether increased population density has rendered supplies inadequate (and most likely both factors have been at work), today's population and its projected growth cannot always be accommodated in their present locations. Often, even basic human necessities and the most impoverished subsistence agriculture are threatened. More dams, more aqueducts and deeper wells will not necessarily resolve the long-term problem. Human activities in such areas are subject to basic ecological constraints, and water is the most fundamental of these. As the ecological consequences of earlier experiences —and of experiences in other continents— have shown, withdrawing water from underground reservoirs or transporting it from distant regions has serious costs. Construction and maintenance of these systems is expensive, though often justified in terms of promoting greater regional equality. Ecological costs, more serious in the long run, include ground water depletion and disruptions of natural cycles in regions from which water is exported. The large-scale construction efforts necessary for such projects also produce environmental effects. It is also worth mentioning that growing environmental consciousness has raised the political costs of bringing water from one region to another. Residents of water-rich areas are increasingly reluctant to see their resources drained to supply other regions.

This last factor is of particular concern to the region's large metropolises. As in all large cities, water supplies are sought from greater and greater distances. In a highly urbanized area like São Paulo State, for example, this has meant that São Paulo city has siphoned off supplies from watersheds which serve other large cities and an irrigation-intensive agriculture. The resulting water shortages have generated public resistance in the affected areas. Economic and demographic growth is expected to be limited by this constraint in the near future, fueling the conflict between metropolis and hinterland.

If continental supplies are relatively abundant, then, such is not universally the case. Both rural and urban areas, especially the latter, have chronic water shortages. The implications for long-term development planning are clear: effective population distribution policies must be developed and these must take into account long-term water availability. Engineering efforts will no longer solve such problems. More challenging yet for planners are water demands of populations whose original locations were sufficiently endowed but whose growth has exceeded local water capacities. Directed, decentralized settlement patterns will be required. The region's metropolises, long favored recipients of such urban infrastructure as water supplies, can no longer monopolize these investments.

Water quantity, then, will increasingly be a factor in directing location decisions of economic investments. A history of solutions based on long-distance transportation of water will not provide answers in the future.

If population distribution is the major long-term demographic consideration raised by water availability, immediate consequences for morbidity and mortality patterns are more urgent. Even basic hygiene is threatened on the peripheries of the region's large cities, where water supplies are precarious. Equally as important—or more so—for health is water *quality*. It is here that we see the single most pressing environmental problem of Latin America. In a predominantly urban region, sanitary infrastructure is a fundamental determinant of health. Water purification and distribution and sewage collection and treatment are perhaps the most significant contributions to health for urban populations.

In only a handful of countries does the total urban population have access to safe drinking water (See Graph 2). In general, in the least urbanized countries access is lower, but deficiencies are widespread. Urban sanitation services (Graph 3) follow the same pattern. (Rural populations have much more restricted access to safe water and sanitation services and, with the exception of Group 1, follow the same pattern across the different groups of countries (Graphs 4 and 5).) Since urbanization was one of the criteria of the typology, the proportion of total population in cities of one million or more inhabitants (1990) declines regularly from Group 1 to Group 5 (Graph 6, Table 6). The two most highly urbanized countries have somewhat lower urban access to water and sanitation and much lower rural access.

Waterborne diseases play a large role in urban morbidity patterns, especially for infant health. The extension of treated water to the city's farthest reaches has been directly related to declining infant and child mortality rates. Sewage collection has lagged further behind and treatment remains a rare privilege. Even where treated water is available, rivers and streams crossing metropolitan areas are virtual open sewers and contact with these water sources is difficult to avoid. Waterborne diseases such as diarrhea and schistosomiasis continue to find conditions for their dissemination. Infant mortality rates (Graph 7) follow the opposite curve of access to safe drinking water and constitute the most common indicator of the health consequences of untreated water. Group 1 countries, for example, have lower urban access to safe water and higher infant mortality rates than Group 2 countries. The irregularity of this general relationship is evidence of the importance of other variables involved in determining these rates.

Upstream effluents contaminate downstream water sources. In highly urbanized regions, these points are very often too close to permit natural cleansing processes to function, elevating the requirements for water treatment downstream. In the most extreme cases, water flowing through the metropolis is polluted beyond technical capacities for treatment.

While both production activities and residential use contribute to water pollution, the former are more amenable to control. Industrial polluters are identifiable, and a combination of recycling and treatment of waste may require considerable political will to effect, but it is not beyond current technological or socioeconomic capabilities. Agricultural wastes—runoff of fertilizers, pesticides, fungicides and herbicides, and the dumping of primary processing residues into nearby streams—are more difficult to control. Especially problematic is the proper use of agricultural chemicals which, if properly applied, would greatly diminish the negative consequences for water supplies.

In general terms, average annual fertilizer use (kilograms per hectare of cropland, 1987-1989) in Latin America is less than half the world average. In Costa Rica, Cuba, El Salvador and Jamaica, however, use is much higher. These national averages do not reveal the localized character of agricultural practices. Especially in the larger countries, such areas are in the more developed and urbanized areas. Since high fertilizer use is accompanied by high use of other agricultural chemicals in a technological agricultural package, the consequences for water supplies of densely settled areas are multiplied.

Other considerations —exposure of agricultural workers to various toxic substances, chemical residues in food, impoverishment of soils— also recommend a more sustainable agriculture. But the pollution of rivers, streams and lakes from agricultural activities constitutes a major problem in itself. In addition to contamination of drinking water, animal life supported by local water sources has been seriously affected in many regions. Declining availability of fish —and their contamination— has had direct consequences for health. Not only is nutrition affected, but the concentration of mercury and other heavy metals through the food chain means that when fish are available, they are often contaminated.

With few exceptions, Latin American countries have extensive coastlines (Table 8), making water quality of oceans a major concern. With growing population densities in coastal areas (Table 9), dumping untreated waste directly into the ocean has produced considerable damage. Breeding grounds for crustaceans in mangrove swamps —also affected by draining and filling to "reclaim" land for residential or productive use— have been destroyed. Again, nutrition in communities dependent on these food supplies has deteriorated. Division of labor within the family and sources of monetary income to supplement subsistence agriculture are other consequences. Commercial fishing activities are also affected, especially in close-to-shore waters.

In recent years extended underwater emissary ducts have been built to discharge waste at greater distances from shore. This has alleviated pollution of coastal waters but has unmeasured consequences for ocean life. In recent years the spread of cholera throughout the region is due to the absence of sewage treatment. Not only freshwater but oceans as well have been the means of disseminating the disease. Thought to be eradicated from most of the world in the twentieth century, cholera began to spread again in the early sixties. As long ago as 1977, Eckholm warned that "Health officials fear that an infected traveler may soon introduce the blight to Latin America, where poor sanitation would give it wide scope" (Eckholm 1977:30). Such early warning did not inspire widespread sanitary reform.

Air

While air is virtually unlimited, not constituting a constraint on human settlement patterns, earlier location decisions have aggravated air pollution in many of the region's cities. Broad river valleys which permitted extensive agriculture to support nascent urban centers in colonial times today concentrate noxious fumes from industry and automobiles. Many Latin American cities are surrounded by mountains which diminish the effect of wind in dispersing pollution.

A second location-related factor is city size. Independently of eventual pollution control policies, large cities will always represent greater challenges as to air quality. At any point on a scale from no air pollution control to state-of-the-art technology, the larger the city the greater the problem and the poorer will be air quality.

Population distribution patterns, then, if they have not been influenced by air "supplies", have contributed to accentuating air pollution. Within metropolitan areas, air quality has also been a major determinant of land use. Where municipal zoning exists, polluting activities are directed to non-residential, or poor residential, neighborhoods. In any event, once production activities have been installed and become sources of air pollution, residential land use is directly affected. These distribution patterns operate to concentrate the health consequences of air pollution on the poor, since those segments with greater financial resources will live farthest from polluting activities (Hogan, 1992b).

Box 2

THE AIR WE BREATHE

As debt and economic stagnation discourage the adoption of cleaner fuels and emission-controls on automobiles in Latin American cities, deteriorating air quality has produced emergency measures. In winter of 1992, authorities in Santiago (population 4,500,000) declared a state of environmental emergency with restricted traffic, closed factories and delayed school classes. The Anti-Pollution Commission considered pollution levels dangerous to human health and banned 40% of the city's 600,000 motor vehicles from circulation. In the industrial belt around Santiago 103 major factories were idled.

In São Paulo, where 5,000 tons of pollutants are released to the air each day, automobiles are responsible for 90% of the city's pollution. Following the experience of Mexico City, local officials launched Operation Winter 1992 and planned limiting automobile circulation from 7 a.m. to 7 p.m. in an area of 100 square kilometers limited by the Pinheiros and Tieté Rivers. The intention is to remove 300,000 cars—a 20% reduction—from the city streets each day on a rotating basis according to license plate numbers. In a coordinated effort to integrate mass transit, compensating for the numbers of people transported in private automobiles, firms operating bus lines, subway and trains guaranteed that 100% of their fleets would be in operation.

These consequences of air pollution are perhaps the most observable influence on population dynamics. Impact on morbidity and mortality patterns is significant, but still difficult to quantify or generalize for large populations. While laboratory studies have demonstrated the relationship of toxic substances present in urban-industrial atmospheres with a wide range of diseases, including cancer, it is respiratory illness which is the clearest and most documented problem. Most susceptible are the very young and the very old, for whom respiratory illness is often fatal. Deaths from respiratory illness (as a proportion of all causes) are much higher in Latin America than in developed countries. The relative importance of poverty and pollution is not clear. It appears that in poor countries the greatest environmental impact on death rates and causes of death may be from waterborne diseases and from respiratory diseases not directly related to air pollution. Respiratory deaths, for example, are actually somewhat lower in the heavily industrialized central municipalities of the São Paulo Metropolitan Area than on the periphery (Hogan, 1992c). Proportions of deaths from respiratory diseases in the SPMA (1986) and in Ecuador (1987) are similar to those of the United States in 1900 (15.8%). Among all 37 municipalities of the SPMA, the proportion of all deaths due to respiratory disease ranges as high as nine times the 1987 rates for the United States. In the United States in 1987, pneumonia caused 3.3% of all deaths, while other respiratory diseases together caused fewer than 1%. But these are diseases of poverty, and the combination of higher incomes and better environmental infrastructure offer greater protection to residents of central municipalities.

Such poverty-related factors such as poor nutrition, inadequate housing and deficient medical care leave the poor more susceptible to respiratory illness. Whether air pollution is cause or aggravating factor, however, there is no doubt of its importance. Whether the poor suffer more than others or not, there is no doubt that air pollution affects all social classes. As in the case of water pollution, industrial sources of air pollution are identifiable and technically controllable. While this challenge faces developed

countries as well (unlike urban sanitation, which is under control), even the most elementary control measures are not widespread in Latin American cities. Changing industrial processes, substituting high-sulphur fuels, recycling wastes and other measures will be required. But the most serious contributor to urban air pollution is the automobile, and São Paulo and Mexico City —among many others— suffer serious problems. In general, the most urbanized countries have more automobiles per capita, intensifying the problem (Graph 10 presents the inverse of this index). Control is more difficult since the pollution sources are dispersed and individualized, but a number of basic measures have not yet been taken. Emission-control devices such as catalytic converters have not been required; polluting fuels have not been substituted; and, most significantly, public transportation has not kept up with population growth. Thus, the private automobile has become a major means of urban transportation and a major polluter (See Box 3).

The Brazilian experience with alcohol fuel is worth mentioning in this context. Alcohol content of "gasohol" has also become a political issue in Brazilian cities. Local officials struggle to maintain a less-polluting mix of gasoline and alcohol, especially in winter when thermal inversions aggravate air pollution. Pollution effects of alcohol are not well-studied, however, and its production on the basis of a vast monoculture generates its own environmental problems. Efficient and non-polluting public transportation looms as the most rational response to air pollution problems of the region's cities. This solution brings us back to settlement patterns as a major obstacle. Far-flung residential suburbs were established on the basis of individualized urban land costs and the post hoc provision of mass transport represents a serious financial strain on local government.

In summary, population distribution patterns have been both cause and consequence as aggravating factors of air pollution. Health problems which result affect all segments of the population but most especially the poor. Solutions include technical control measures and population distribution policies capable of minimizing this problem. Immediate attention is required to deal with respiratory illness.

Box 3

**URBAN TRANSPORTATION AND ITS ENVIRONMENTAL EFFECTS IN
MEXICO CITY: THE ROLE OF GOVERNMENT ACTION**

City growth, land speculation and urban sprawl have generated complex intrametropolitan transport systems to meet the need of the daily commute from residence to workplace. Motor vehicles are the major means of movement and represent a major source of air pollution in Latin American cities. In recent decades the spectacular growth of private automobiles has aggravated this problem to the extreme. Public transportation, identified as an important environmental solution, however, produces its own contribution to the contamination of a city's atmosphere. In Mexico City, data register the predominance of public over private transport, with automobiles representing 90% of private vehicles but only 19% of daily trips in 1983 and 14.2% in 1989. Non-polluting transportation accounts for only 31% of daily trips. Estimates of air pollution levels by the Institute of Geophysics of UNAM in 1975 and by JICA in 1989 indicate a dramatic increase of vehicular emission levels: carbon monoxide levels have increased by 392% and sulphur dioxide by 954%. The principal cause of carbon monoxide is the automobile; one automobile user provokes 176 times as much carbon monoxide as a bus user, and nitrogen oxides follow the same pattern. On the other hand, buses are responsible for more sulphur dioxide, and each user accounts for 1.8 times the quantity as the automobile user.

Measures required to ameliorate this situation include pollution control by automobiles; increased efficiency in the maintenance of public transport, including collective taxis; and greater coordination among the different agencies responsible for pollution control and urban transportation policy. Public transport must be expanded, substituting private automobiles by buses and collective taxis, but this must be accompanied by more efficient service; by technological changes and substitution of components; by programmed maintenance procedures; and by changes in organizational patterns of the city and the activities of its inhabitants. Specific recommendations include: 1) establishment of a deadline of two or three years for all public transport vehicles to adopt antipollution equipment; 2) the development of a national program for the manufacture of components and parts for diesel motors; and 3) urgent regulation of collective taxis, which in the majority of cases do not have maintenance programs to avoid pollution. Public authorities must accept responsibility for planning and implementing transportation policies which concentrate on measures aimed at avoiding traffic congestion and coordinating means of transportation.

Source: Riviera, Víctor Islas. "El transporte urbano y sus efectos ambientales". In Martha Schteingart and Luciano d'Andrea (comp.), *Servicios Urbanos, Gestión local y medio ambiente*. México, El Colegio de México, 1991.

Energy

Latin America's abundant water resources have permitted hydroelectric power a major share in meeting energy needs. In 1984, hydroelectric and geothermal power accounted for 61 % of electric energy production in the region, nearly three times the world average. This lesser dependence on fossil fuels has unquestionable environmental dividends: less air pollution, less acid rain and a lower contribution to the greenhouse effect. Per capita carbon dioxide emissions from industrial processes in 1989, for example, were much lower than in developed countries. Brazil's vigorous substitution program of automobile fuel with methanol is a step in the same direction.

Population growth and development lead to greater energy demands. Graph 11 shows clearly that the most urbanized countries have greater proportions of the population served by electricity. Although there are variations within groups, per capita commercial energy consumption follows the same pattern (Graph 12). Local hydroelectric potential, however, may not keep pace. In densely settled areas solutions will be sought in importing electricity from more distant regions, increasing costs; in greater reliance on thermoelectric and nuclear power, both of which represent serious environmental costs; and in smaller hydroelectric plants designed for smaller streams and serving local communities. The last alternative has met with political resistance from large energy producers and its total potential is still under debate. It promises, however, to have a lower environmental impact and to permit local control, independent from the giant electric corporations. Finally, firewood as cooking fuel is not as widespread as in other less-developed regions, though in some areas continues to produce deforestation and consequent erosion. Traditional fuels as a proportion of total energy requirements in 1989 declined with increasing urbanization (Graph 13).

Energy specialists have pointed to greater energy efficiency as one answer to demand increases generated by population growth. Available technology can already make a serious contribution to energy savings, and research in this area is very active. Alternative sources of energy (solar, wind, aeolic) may all make sizable contributions to the region's energy needs. Solar power for residential use, whose technical development is further advanced, reduces the strain on traditional sources and dispenses with large construction projects and with their attendant environmental problems.

The most direct population and energy relationships are those concerning health and population distribution. Dependence on the private automobile as a major means of transportation places greater demands on fossil fuels, and the consequent health problems have been mentioned in the section on air pollution. Of particular importance are the population dislocations related to the construction of large power projects. Immense tracts of land, often with rich, fertile soils, are flooded for the reservoirs needed for hydroelectricity and entire communities are uprooted. Together with other large development projects such as roadbuilding and irrigation systems, hydroelectric plants have had notable impacts. Significant numbers have been relocated and these "environmental refugees" are rarely absorbed by the labor demands of constructing and maintaining the finished plant. A large, floating population of construction workers is attracted to the construction site. Their needs and consumption patterns disrupt community systems of housing, commerce, family relations and cultural values. The largely unskilled workers suffer the consequences of poor housing, inadequate health services and rootlessness. These population movements, together with other forms of temporary migrations, tend to grow in absolute terms in the face of a prolonged economic crisis which does not favor job creation and in relative terms as secular rural-urban and interregional moves reach their limits (Vainer, 1990).

Land

Within the framework of the four classical natural elements —air, water, fire and earth— land represents both soil and sub-soil minerals. Land availability is perhaps the most frequently cited obstacle to population growth and man/land ratios are the most common measures of overpopulation or exceeded carrying capacity. The image of the pressure of numbers on resources which comes most readily to mind is the impoverished farmer eking out a living on minuscule plots of worn-out, eroded and deforested soils.

This image, while a reality in Latin America, more often reflects poverty generated by land concentration than overpopulation. International comparisons have for decades identified land tenure patterns as a major regional problem. This phenomenon means that much potential productive land lies idle, and much more is dedicated to export crops. The poor farmer is left with the most undesirable land, often steep slopes whose exploitation promotes deforestation and erosion. Soil loss is a serious concern in most of the countries of the region. Large-scale monoculture also promotes soil loss, as well as compacted soils and leaching of both nutrients and toxic substances into rivers and streams. In the Cordillera de la Costa in Chile, for example, long term land degradation has led to rural exodus:

"Human population density tends to decline consistently. Age structure is modified with the emigration of age and sex groups which have greater job opportunities in other zones. Resource degradation which ranges from light in some reduced sectors, to moderate or intense in the greater part of the zone, has led to a situation of decline, in place of earlier prosperity or of what could exist if the sector were adequately managed" (Gastó and Saenz, 1985:199).

In addition to producing over-exploitation of lands by the poor, concentrated land ownership serves to depress the production of food crops, affecting prices and nutritional levels in both rural and urban populations. At least in one case (the Mexican state of Tabasco) the decline of large-scale cattle raising and the resurgence of subsistence agriculture led to the recuperation of nutritional levels which had suffered declines with the earlier decline of traditional agriculture (Tudela, 1989).

Unless one ignores the social inequality inherent in patterns of land tenure, land scarcity in Latin America can only be attributed to population pressure in limited areas. With land reform, bank credit for small farmers, modernized marketing mechanisms and effective extension services, small-scale agriculture is capable of absorbing significant numbers of farmers and their families, without land degradation. Most proposals for sustainable agriculture have emphasized the importance of the small farmer and a mix of organic and mechanical/chemical production.

When we turn our attention to land and the *components* of population growth, several features stand out. To begin with, the destabilization of traditional economic organization based on family-centered subsistence agriculture has been pointed out as a major factor in *increasing* fertility rates. When marriage is no longer delayed until the son's access to land is guaranteed —because the guarantees can no longer be given— earlier age at marriage leads to higher fertility. With no incentive to delay marriage, earlier marriages and earlier childbearing result (Levine, 1977; Paiva, 1984). On the other hand, in agricultural frontier regions, land availability has been held to account for high fertility rates. Both hypotheses may be true, as frontier regions are a special case, and the issue requires further research.

Box 4

DEFORESTATION, URBANIZATION AND THE NEED FOR INSTITUTIONAL REQUIREMENTS FOR SUSTAINABLE DEVELOPMENT IN THE PANAMA CANAL BASIN

The Chagres River Basin is the most important of Panama. The Canal —principal economic resource of the country— and the water supply of Panama City and Colon, with half the national population, depend directly on the reservoir of Gatún and Alajuela Lakes. These two lakes occupy 10% of the area of the basin, and the greater part of the remaining protective forests are found in the headwaters of the Chagres.

The last forty years have seen rapid and uncontrolled economic growth, destructive of natural resources. Today, the ecosystem is in crisis and deforestation threatens sedimentation of the lakes and contamination of their waters. Given the high annual rainfall and the poor, clayey soils, the optimum use of this region would be permanent crops and protective forests to guarantee water regulation. At an annual deforestation rate between 3,000 and 10,000 hectares, the basin's forests will be destroyed by the year 2000 when Canal ownership passes to Panamanian hands. Four major factors, spurred by population growth, have been responsible for this environmental deterioration: mining, industrialization, urbanization and road construction.

Both rural-urban and rural-rural migration have produced serious environmental impacts in the metropolitan regions of Panama City and Colon. Migration of small farmers has brought different production systems to the region, leading to deforestation. During the sixties and seventies, when natural growth rates were at their highest (over 2.5% per year), this colonization intensified and the Lake Gatún region and the Western part of the Alajuela were deforested. Public and private investments stimulated extensive cattle-raising as the principal agricultural activity, supplemented by subsistence crops, fishing and wage labor. Cattle-raising, the worst alternative from an ecological perspective, today occupies 90% of the deforested land.

While farm families have been the principal agents of deforestation, they may also be an integral part of the solution. Protecting the forests to guarantee water for the Canal and for the metropolitan region will require measures for the survival of small farmers. Public policies which provide access to agricultural credit, reasonable prices for fertilizers, effective technical assistance, roads and fair prices for agricultural products will permit these farmers to modernize their production methods, minimizing environmental damage.

The growth of mechanized mining in the region has had visible environmental costs. Considering the construction jobs created, which depend on these raw materials, mining cannot be simply eliminated but requires more rational and modernized techniques. This is also true for the region's industrialization, which has developed without environmental controls; today it is necessary to determine the types of factories which the area can support, where they may be established and how and who should control pollution standards. Urban growth has not been accompanied by adequate garbage or sewage services, resulting in contamination of the lake. The settling of the region has also led to extensive road construction, contributing to erosion/sedimentation problems. This construction requires the definition of criteria for where and by whom roads will be built.

Solution for the consequences of rapid growth and occupation of these lands is hampered by administrative fragmentation and the increase of the number of public and private institutions which operate with little coordination. The region does not have a single plan or management strategy acceptable to the various institutions. Environmental protection legislation is marked by the multiplication of laws and decrees, many of which are obsolete in relation to the magnitude of the degradation observed. The application of this legislation also faces a cultural obstacle, in that natural resources are considered unlimited and renewable. In this sense, it is also necessary to invest in formal and informal environmental education for the transformation of these values.

Finally, financial resources for the projects needed for environmental protection would be available if the Panama Canal Commission —which uses 96% of the basin's water which the 1977 Torrijos-Carter Treaty provided without cost— were to contribute their share. An increase of a few cents per ton for the ships using the canal would produce between 3 and 6 million dollars per year, and would go far to saving the Panama Canal Basin.

Source: Heckadon-Moreno, Stanley. "El costo ambiental del desarrollo en la Cuenca del Canal de Panamá", in Carlos Reboratti (org.), *Población y Ambiente en América Latina*. Grupo Editor Latinoamericano, Buenos Aires, 1989.

Frontier regions represent a significant problem in many countries of the region, and Amazonia is an especially clear example of the questions involved. On the one hand, large numbers of migrants whose access to land at place of origin is limited have sought in the Amazon forests opportunities for the reproduction of family-centered agriculture. Both government-sponsored and commercial colonization programs, as well as spontaneous movements, have resulted in the occupation of virgin forest. The resulting problems are well known: deforestation, soil loss from improper cultivation techniques, depletion of soil fertility in lands unsuited for agriculture, conflicts with indigenous groups, mercury poisoning of rivers from gold mining which has gone hand in hand with the opening up of these new lands and serious health problems, especially malaria. Some estimate forest loss of Latin America in the period 1978-2000 as an alarming 40% (Council on Environmental Quality, 1980:2,134).

It is questionable, however, to what extent the migration of small farmers is the root cause of such problems. In the first place, land and income concentration in areas of earlier settlement are the driving forces behind such movements and it is this social inequality which must be addressed. But many have questioned the environmental impact of pioneer migrants. Fearnside (1986) in his attempts to understand the dynamics of the settlement/deforestation syndrome in the Brazilian Amazon, distinguished two stages in the process. The first colonists clear the forest quickly to begin planting. But unable to continue investing, these pioneers quickly abandon their lots, which are taken over by others in a process of land concentration. "The greater financial resources and different cultural backgrounds of second owners mean that they clear a larger area per year than do the original colonists" (Fearnside, 1986:76). Agricultural credit and adequate extension services have been notoriously absent. If they were able to survive on the lot, the first colonists would not have given way to investors with a different logic of exploitation (Sawyer, 1987). Large-scale cattle-ranching and lumbering activities have also been responsible for an important share of deforestation.

Once again, environmental degradation cannot be attributed to the simple pressure of numbers nor—in the case of frontier areas—to population distribution patterns. Poverty and the lack of institutional mechanisms for its alleviation—bank credit, agricultural extension services, health and education facilities—have interfered with more harmonious forms of land occupation and have led to more environmentally aggressive exploitation.

Other consequences which require the attention of population specialists are tropical disease and urbanization. Populations unaccustomed to life in the tropics are easy prey to endemic diseases. The most serious of these is malaria, which both debilitates migrants and their families and gains momentum from the presence of large, new, non-resistant populations. Construction of access roads, leaving craters where still water accumulates, creating new breeding grounds for the anopheles mosquito, is one of the activities which serves to increase malaria prevalence. The constant movements back and forth between frontier and more developed regions have reintroduced malaria in the latter areas. Health conditions are also weakened by nutritional deficiencies, since these migrants are not culturally prepared to exploit local food sources. Difficulties in adapting to new dietary patterns and in reproducing the conditions for maintaining old ones combine to produce malnutrition.

Box 5

EL SALVADOR: RURAL POVERTY, WAR AND ENVIRONMENTAL STRESS

El Salvador (5,250,000 population in 1990) is a microcosm of current environmental woes. Its indigenous name, *Cuscatlan*, The Land of Richness, is being put to the test as both traditional and modern environmental problems grow. Rapid demographic growth has led to the second-highest population density (after Barbados) in the Americas. The shift from subsistence farming to export agriculture of non-food crops has brought rural unemployment and pushed small farmers onto marginal land. Cotton and coffee booms in the 1960s and 1970s meant world records in the use of agricultural chemicals per unit of land.

There have been serious consequences for nutritional levels. High rates of deforestation (only 2% of the original forest remains), soil erosion from the rocky and denuded hillsides to which poor farmers have been driven (more than three-quarters of agricultural land suffers serious erosion) and river pollution (90% of rivers are contaminated from erosion and the chemical runoff of commercial agriculture) have also resulted from a combination of high-tech monocultures and farming practices of the impoverished.

Urban problems are no less serious. With only 76% of the urban population having access to safe drinking water in 1988, gastrointestinal infections are a major cause of high infant mortality rates. But the severe air pollution in San Salvador is an even more serious killer, and respiratory infections are the major cause of death for children under 5.

The concentration of land and wealth behind these problems is also the root of the prolonged civil war which killed 75,000 people and caused additional ecological havoc. Forest clearing with chemical substances, for "strategic" purposes, added to deforestation rates and increased the flow of toxic substances to natural systems.

Secular patterns of concentrated land holdings have produced and continue to maintain the social inequalities related to today's ecological deterioration. Deforestation, erosion, air and water pollution, monoculture and war have joined the traditional and the modern in a complex web of environmental stress. Demographic pressure is a fact of life in El Salvador, but operates through such institutional and regionally specific features as land concentration and export-oriented agriculture (Durham, 1979).

Box 6

URBAN LAND USE AND ENVIRONMENT: THE CASE OF GUAYAQUIL

Deforestation and land degradation are not privileges of the region's rural areas. Guayaquil, with a 1990 population of more than 1.5 million inhabitants, multiplied six times over the last four decades. The city today occupies 14,000 hectares and urban sprawl proceeds at a pace of 4.4% per year. Social and residential segregation has led to poorer social groups—70% of the urban population—occupying 40% of the built up area. These areas are the least favored ecologically and where basic infrastructure is most lacking. Paradoxically, low income developments are very dispersed, principally along major roads leading out of the city. These developments are separated by immense empty spaces, waiting for land speculation to increase their value, a process which increases the cost of extending urban services.

The environmental degradation resulting from this type of urban growth has accelerated over three distinct periods defined by the scale of land use. These periods are 1) large public work projects in the fifties; 2) industrialization and contamination of the Salado Estuary in the sixties; and 3) recent real estate investments by the private and public sectors, most notably the Via Perimetral. The fifties define the metropolitan characteristics of Guayaquil through a combination of population growth and expansion of the built-up area, specialization and definition of the centrality of the urban complex, and above all the large investments of state resources in major infrastructural works—the airport to the North, construction of access roads to the city, the beginning of port facilities to the South and the building of the bridge over the Guayas River. These processes, complemented in the sixties by industrialization and public housing projects meant the transformation of agricultural soil use and the complete deforestation of some of these areas. In the South Zone, ever since the end of the fifties, when port construction began, ecological alteration of the banks of the Salado Estuary has increased. At the same time access roads permitted construction of public housing projects, the IESS Hospital, the naval base and other works, leaving an empty space of over 1,200 hectares. This area is characterized by empty, flood-prone lands, with low and compact vegetation.

The industrialization of the sixties and seventies was concentrated in the Daule road area, and by the eighties accounted for 89% of the city's industrial park. With the saturation of traditional suburban areas, land occupation between 1976 and 1982 had advanced more than 700 hectares in the Guasmo zone, passing 1,000 hectares in 1986, eliminating plant cover from the area. Real estate projects, which have "swept" hills and "cleaned" lots since the end of the fifties, were extended to the North, including areas of the last branch of the Salado Estuary, which in spite of being protected by municipal law, is being reduced by landfilling and development projects.

More recently, the Via Perimetral has accentuated the degradation which these factors have produced. This road, 41 kilometers long, crosses virgin land and has encouraged residential use in the North, intensifying the "cleaning" process; more than 3,000 hectares close to the road are expected to be developed.

Considering these various factors in an evaluation of the urban environment, the major elements degrading the quality of life in the city are: 1) rapidly increasing air pollution; 2) pollution of the Guayas River by residential discharges, both urban and rural; 3) residential sewage and untreated residues from more than 3,000 industries, which will soon outpace the river's self-purifying capacity. The contamination of the Salado Estuary is particularly affected and since it is an arm of the sea, does not receive river flows which would permit the constant renovation of its waters. In Guayaquil, it is seriously contaminated, receiving both liquid and solid non-biodegradable effluents, which remain active for several years. This contamination threatens not only the Guayaquil area, but progressively advances to the sea, endangering aquatic flora and fauna; 4) deficient garbage collection, covering only 40% of the territory, is a serious health hazard; 5) urban noise levels increase constantly, beyond levels considered permissible by international standards; 6) urban green space is declining rapidly, and calculations indicate that only 0.54% of the land area is dedicated to this use.

Source: Villavicencio, Gaitán and Rojas, Milton. "Medio Ambiente, Urbanización y Localización de las Inversiones: el caso de Guayaquil, Ecuador", in Carlos Reboratti (org.), *Población y Ambiente en América Latina*. Buenos Aires, Grupo Editor Latinoamericano, 1989.

A second unanticipated consequence of frontier settlement is its rapid urbanization. Spontaneous migrants who were unable to gain access to land and colonists who were unable to survive on their lots have contributed to the misery of urban peripheries familiar in older urban centers. These migrants are the new itinerants, excluded from the mainstream of national economic life. For better or worse, earlier patterns of internal migration led to forms of integration with the modern economy. Rural-urban shifts brought 100,000,000 people to Latin American cities between 1930 and 1990 (Lattes, 1989), a process which cannot be repeated: a country can only urbanize once. Interregional migration, on the other hand, has also transferred populations to more dynamic areas. The new itinerancy, however, represents the unsuccessful search for integration of landless migrants who occupy the most environmentally vulnerable spaces in rural and urban areas, unable to establish roots in lasting economic activity.

The population/land relationship, then, must be seen in the light of land availability and population distribution patterns. In the region with the world's lowest population density (excluding Oceania), land scarcity is not an absolute but a relative concept (Graph 14, Table 14). With few exceptions, overexploited land is attributable to social and institutional constraints. Impoverished soils and low productivity which result are environmental burdens born by the poor. As Robert Repetto has affirmed:

"It is misleading to describe the resource degradation that results when marginal farmers misuse marginal lands as a consequence of population pressure, when, in reality, it is a consequence of the gross inequality in access to resources between the rich and the poor" (Repetto, 1985:145).

To the foregoing list of environmental problems, the 1992 World Development Report adds two major global concerns: biodiversity loss and atmospheric changes. The first is related to the possible loss of new medicines, while the latter has several potential effects: possible transfers of vector transmitted diseases, risks from natural climatic factors, illnesses attributable to the depletion of the ozone layer (perhaps 300,000 additional cases of skin cancer and 1.7 million cases of cataracts in the world) (World Bank, 1992a).

POLICY IMPLICATIONS FOR POPULATION/RESOURCE PLANNING

These considerations on the interrelations of population growth and distribution with environment and sustainable development direct our attention to three principal needs: 1) more and better *information* on population and, especially, environmental factors; 2) *research* of both conceptual and empirical character; and 3) *government intervention* in specific problem areas. Population specialists in academic and governmental institutions must increasingly turn their attention to these concerns. The environmental questions must not remain an area of specialization within demography, but permeate the analysis of the whole range of population dynamics. An environmental demography is not an end in itself, but a strategic first step toward the environmentalization of demography as a scientific discipline. Our capacity to deal with these interrelationships will only be more adequate when environmental factors enter into demographic analysis with the same frequency and force as social or economic factors. This will require a much more interdisciplinary perspective for demography— already an interdisciplinary science. This tradition may contribute to building a scientific culture in which openness to other disciplines and an ability to absorb their contributions prevail. Serious investments in the study of basic ecological concepts and in the specific aspects of determined environmental problems will be necessary. Systematic retraining of mid-career professionals and the reformulation of the curricula of demography courses are important steps. Even such initial moves, however, will require intensive international efforts to rethink the teaching of demography.

As to the specific needs mentioned above, environmental data represent a *sine qua non* for progress in this area. With the exception of a few developed countries (see, for example, Canada, 1986 and Italy, 1984), environmental statistics are not systematically collected or published. Available data range from specific local environmental evaluations to the reorganization of data collected for other purposes in large compendia (e.g. World Bank, 1992a or World Resources Institute 1992). These compendia are extremely useful and are evidence of the all-encompassing character of environmental concerns. But indicators are often indirect and incomplete, and efforts to design systems of environmental statistics are urgently needed. An important first step would be to consolidate in a single publication environmentally relevant information already collected by dispersed government departments. More refined work and the development of synthetic indicators would build on the experience of data currently available but difficult to access by population specialists.

In this regard it is important to note that standard units of analysis (countries, states or municipalities) are only approximations —often poor ones— to the ecosystems within which population and resources interact. If political-administrative boundaries have always been an obstacle to more refined demographic analysis, environmental considerations exacerbate this limitation. Progress in understanding the links between population dynamics and environmental change requires that we come to terms with the organization of nature, i.e. looking at these relationships within specific ecosystems. Conceptual work on comparative indicators would contribute to removing the limitations of case studies from such work. A major tool, still to be absorbed by demographers, is geoinformation referencing (Clarke and Rind, 1992). This, and other attempts at looking at population/environment relations at the level of their concrete interactions, will contribute to the design of environmental statistics systems.

Research is required on many issues and on several levels. The very terms of the debate still need refinement. Concepts such as sustainable development, quality of life and environmental quality, while more and more present in discussions of population and development, have variable and often contradictory content. Though theoretical unanimity is not to be expected, differences must be made more

explicit. This process will serve to clarify the different perspectives present in contemporary discussions. Of particular importance for population specialists is the idea of *population carrying capacity*. It is necessary to rescue the term from common sense discourse, refining and specifying its meaning for demographic analysis. It is also necessary, considering the range of differences within Latin America, to relate carrying capacity to the distinct stages of the demographic transition.

A number of specific issues requiring further research have been mentioned in this text. An evaluation of the relationships between environmental factors (as understood in the contemporary environmental debate) and fertility is a prior step for more intensive studies of fecundity, sterility, spontaneous abortion, premature births and birth defects. In large areas of Latin America, where birth rates have fallen or are falling rapidly, such qualitative aspects of human reproduction will require growing attention. Extensive bibliographic reviews, from this perspective, would be helpful to defining specific research objectives.

The study of health consequences of environmental degradation, in both rural and urban settings, is perhaps the most immediate and imperative need. A major obstacle to such work is the poor quality of mortality and morbidity data. Death reporting, especially by cause, is notoriously deficient and evaluation of environmental impacts on health is thus very precarious. Even rarer are standard and universal health indicators which go beyond a few highly contagious diseases. Intestinal and respiratory diseases and cancer (by specific type) are the most direct consequences of environmental stress. Epidemiological studies must be followed by systematic programs to monitor health status. Together with more refined environmental statistics, this would go far to improve the description and understanding of the health/environment link.

For planning purposes, the study of migration (largely internal migration but for some countries international migration as well) and population distribution patterns is essential. A systematic historical review of how environmental constraints directed or limited the territorial occupation of Latin America and on the environmental consequences of settlement patterns would contribute to understanding contemporary problems and the limits involved. Such an analysis would also serve to show that resource degradation began centuries ago and would serve to characterize the question as a long-term issue —not to be solved by short-term corrective measures.

Resource availability, especially water for drinking and irrigation, must be evaluated and used to direct investment decisions. The long-range consequences of large-scale engineering efforts to bring water from other regions must be weighed. Environmental impact assessment is a government responsibility and will require the collaboration of population specialists. But it is also necessary to carry out general assessments of resource distribution and the consequences for population distribution, as the analysis of individual projects cannot be summed to provide a general view.

A number of consequences for governmental intervention are clear:

- 1) All environmental problems are aggravated, when not directly caused, by social injustice; without the alleviation of poverty these problems will not be solved.
- 2) The interaction of social groups with their natural environment stresses the importance of local action; participatory democracy is both a fundamental social value and a necessary mechanism for resolving these local problems.

3) The most important single measure implied by the foregoing analysis is the improvement of urban water supply and sanitation systems. Declines in infant mortality rates and of water-borne diseases depend directly on such measures. The Action Plan of Health for All in the Year 2000 has given first priority to this issue (OPS, 1982:31).

4) Combating degradation of agricultural lands by small farmers requires investments in bank credit, marketing mechanisms and extension services, as well as evaluation of soil quality. The single most important issue continues to be land reform, without which other measures will not solve current problems. Considering the regional capacity to support agricultural populations, these measures would contribute to stemming rapid urbanization rates and to improving nutritional levels.

5) Macro agro-ecological zoning is necessary to define the economic and environmental vocations of a nation's distinct ecosystems. Ad hoc preservation efforts will generate political resistance at the local level if economic alternatives are not provided. Population density and intensity of resource use will vary across a nation's territory and regional planning efforts must account for such differences.

6) Industrial polluters must be identified and controlled. But the control of air pollution also requires changes in fuels, mandatory emission controls for automobiles and major investments in public transportation.

7) Energy requirements will be better attended by smaller power plants, whose environmental impact is less and which allow greater local control. The region's hydroelectric potential must be explored in ways which minimize the disruption of community life. These measures would also contribute to the capacity of small and medium-sized cities to retain population.

8) Institutional mechanisms of all kinds must be put into place at national, sub-regional and municipal levels. Integrating population and environmental considerations in planning processes demands close collaboration among the different segments of government administration. In most cases, specific environmental agencies will contribute to this integration. The authors of *Compact for a New World* add two important suggestions to this list. Trade and investment activities are essential ingredients to development/environment relations and require a specific consultation mechanism:

"We therefore call upon governments to establish a special ongoing hemispheric consultation on trade and the environment to identify impediments to sustainable development, define legitimate trade measures for protecting the environment, and design better mechanisms for handling disputes involving environmental criteria. This consultative body would be the appropriate venue for strengthening hemispheric control over international traffic in hazardous substances, the transnational migration of polluting industries, and the international sale of products, such as DDT, proven to be unsafe and prohibited from use in the exporting country. The removal of such impediments to sustainable development as agrochemical and fossil-fuel subsidies (which encourage overuse) and agricultural export subsidies (which encourage overproduction and depress world prices) would be discussed in such negotiations also" (New World Dialog, 1991:20-21).

Finally, a financial initiative to generate additional funding for sustainable development from new and existing sources is recommended (New World Dialog, 1991:20). The World Bank has defined four objectives in this direction: 1) increasing development aid to reflect the costs of environmental degradation on health and productivity; 2) investments in technology research and development on soil erosion and sustainable use of tropical forests; 3) access to markets of developed countries; and 4) compensation mechanisms to poor countries for conservation of biodiversity and control of greenhouse gases (World Bank, 1992a).

These concerns have been expressed in varying degrees by a long series of international analyses and programs. The earliest calls for action on population/environment issues tended to be generic appeals, based on an intuitive understanding of the importance of the environment (UNFPA-ECLAC-ILPES-CELADE, 1979:6-7; United Nations, 1974, 1979). They have also tended to emphasize abstract categories like population carrying capacity, without arriving at concrete proposals. These appeals, however, have found echoes in the research community and have encouraged more detailed and specific analyses of population/resource problems. This analysis was defined as a major objective of ECLAC as far back as 1979, when the population program sought to encourage in distinct national settings the comprehension of nature and the importance of the reciprocal relations among demographic, socioeconomic and environmental factors in development (ECLAC, 1979).

Some early calls for attention emphasized the importance of environmental education, suggesting secondary school and university courses on population, environment and development (ECLAC, 1975:13-25). The World Action Plan, of the 1974 Bucharest conference, began to emphasize specific issues: uncontrolled urbanization (United Nations, 1979:44), mortality (p. 49) and the long-term consequences of migration (pp. 53-54). In 1984 the Mexico conference continued to emphasize the general importance of environmental factors (United Nations, 1984:2-12). The same specific issues are treated: the integration of public policy (p. 14); health (p. 36); migration (p. 27); as well as a recommendation on the substitution of traditional by renewable energy sources (p. 14).

In ECLAC's analysis of progress on population policy between Bucharest and Mexico, however, environment and sustainable development are not significant topics. A meeting of experts on population, resources, environment and development is noted, but post World War 2 economic/demographic growth is not analyzed in the light of consequent environmental problems (ECLAC, 1983:14-41). Statements on population and resources have become increasingly incisive and emphatic over the last decade, though still somewhat generic. The Amsterdam Declaration stresses the importance of linking population programs with programs in health, education, housing and employment as the path to sustainable development. Countries are urged to adopt integrated policies on population, environment and resources and specific mention is made to migration and population distribution (UNFPA, 1989).

A host of major issues have now come to be seen as related to environmental degradation. Protection of the child is promoted by protection of the environment, since children are the most interested in environmental protection and sustainable development. The UN Action Plan for children defines as means to these goals the struggle against disease and malnutrition and the promotion of education. Both measures will contribute to reducing mortality and fertility, to improving social services, to the better use of natural resources and to breaking the vicious circle of poverty and environmental degradation (United Nations, 1990:15).

Health specialists, in particular, have pointed to a wide range of multiple interactions of health and environmental conditions. The Action Plan for Health for All in the Year 2000 emphasizes the intersectoral nature of these relations in a series of specific areas: water and sanitation services; prevention and control of many bacterial, viral and parasitic illnesses; lowering exposure of populations to specific risks from environmental factors in the workplace; the improvement and extension of services for food protection and control of physical and chemical contamination; efforts to reduce rates of non-contagious diseases; the interaction of rural development and health programs for agricultural workers and their families; and the safe use of pesticides and fertilizers (OPS, 1982:29).

Whether environmental quality has improved over the last two decades is difficult to assess. Public *awareness* of the problem has certainly been raised and the question has become politicized throughout the region. These are prerequisites for serious action, which has, however lagged behind greater consciousness of the problem. Population content of these concerns has become more specific, and the number of publications, specialists and academic groups testify to this growth. Earlier concerns, although excessively generic, have been followed by some initial attempts to deal more concretely with the issues. It is now time to act more decisively to promote such studies and to implement solutions to both long-standing and more recently identified problems.

CONCLUSION

The cultural, economic and ecological diversity of Latin America —long a recognized trademark of the region— is the most salient feature of an analysis of population, environment and development. From Antarctica to the tropics and from São Paulo's industrial park to primitive indigenous groups, Latin America encompasses the entire range of contemporary environmental ills. While falling fertility rates and high levels of urbanization differentiate its demographic dynamics from other world regions, internal differences are great. In spite of abundant resources and a favorable population density, at the regional level, sub-regional and national patterns vary considerably.

The discussion of carrying capacity of distinct ecosystems within national territories may contribute to an evaluation of trade-offs implicit in national development policy. The great regional diversity points to the need for such specific local planning. At the same time, an analysis of the environmental determinants and consequences of *components* of population growth is a means of separating the relevant factors of specific problems, offering a more objective base for policy-making.

In spite of the diversity mentioned above, the analysis and examples presented in the text call attention to several universal problems. The most significant of these are related to urban sanitation and land reform. The region's high levels of urbanization have placed great strain on the quantity and quality of water supplies; sanitary infrastructure, which has not kept pace with growth, now requires large-scale investments. Land reform, long recognized as an inescapable social need, if accompanied by agricultural credit and adequate extension activities, is capable of interrupting the degradation of soils through deforestation and erosion and of slowing rural-urban migration.

While the problems are serious and diversified, the large resource base, declining fertility rates and relatively low density in much of region signal the potential for conciliating development and resource preservation in Latin America. Solutions are available but will require financial commitments, institutional change and, above all, a reorientation of development goals.

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ANNEX

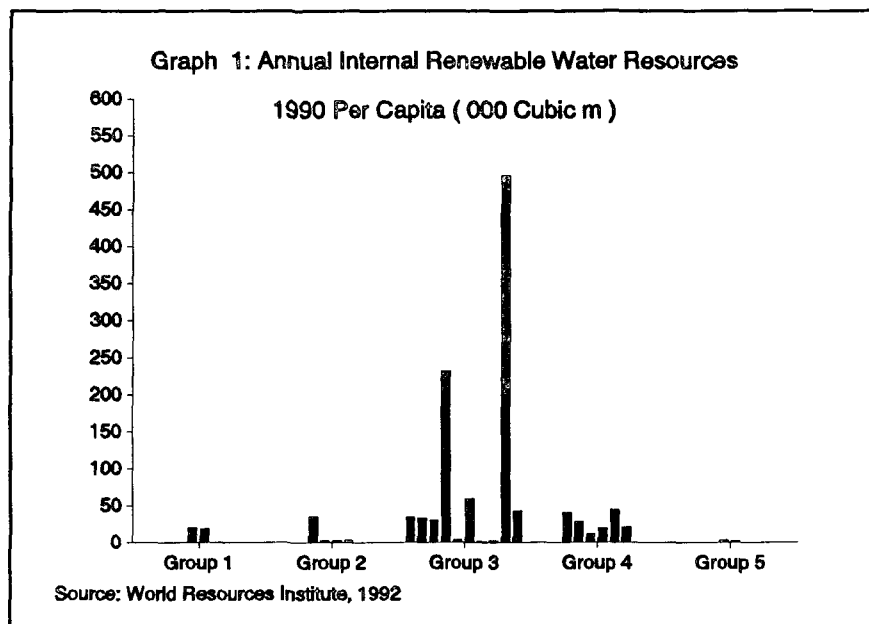


Table 1: Annual Renewable Water
Resources 1990 Per Capita
(000 Cubic m)

Group 1			
Argentina	21.47	Uruguay	18.86
Group 2			
Barbados	0.2	Chile	35.53
Cuba	3.34	Jamaica	3.29
Trinidad and Tobago	3.98		
Group 3			
Brazil	34.52	Colombia	33.63
Costa Rica	31.51	Guyana	231.73
Mexico	4.03	Panama	59.55
Peru	1.79	Dominican Rep.	2.79
Suriname	496.28	Venezuela	43.37
Group 4			
Bolivia	41.02	Ecuador	29.12
Guatemala	12.61	Honduras	19.85
Nicaragua	45.21	Paraguay	21.98
Group 5			
El Salvador	3.61	Haiti	1.69

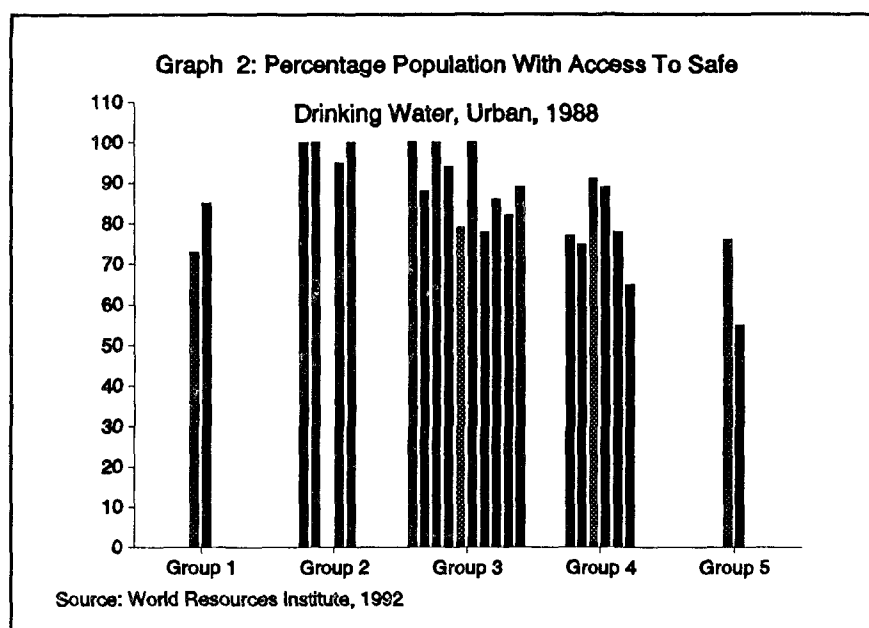
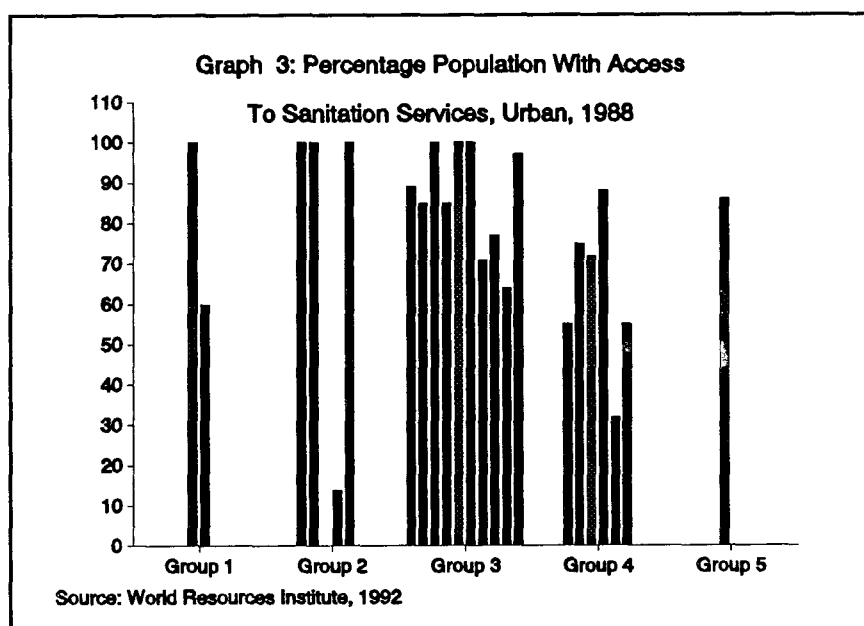


Table 2: Percentage Population With Access To Safe Drinking Water, Urban, 1988

Group 1			
Argentina	73	Uruguay	85
Group 2			
Barbados	100	Chile	100
Cuba	x	Jamaica	95
Trinidad and Tobago	100		
Group 3			
Brazil	100	Colombia	88
Costa Rica	100	Guyana	94
Mexico	79	Panama	100
Peru	78	Dominican Rep.	86
Suriname	82	Venezuela	89
Group 4			
Bolivia	77	Ecuador	75
Guatemala	91	Honduras	89
Nicaragua	78	Paraguay	65
Group 5			
El Salvador	76	Haiti	55



**Table 3: Percentage Population With Access
To Sanitation Services, Urban, 1988**

Group 1			
Argentina	100	Uruguay	60
Group 2			
Barbados	100	Chile	100
Cuba	x	Jamaica	14
Trinidad and Tobago	100		
Group 3			
Brazil	89	Colombia	85
Costa Rica	100	Guyana	85
Mexico	100	Panama	100
Peru	71	Dominican Rep.	77
Suriname	64	Venezuela	97
Group 4			
Bolivia	55	Ecuador	75
Guatemala	72	Honduras	88
Nicaragua	32	Paraguay	55
Group 5			
El Salvador	86	Haiti	x

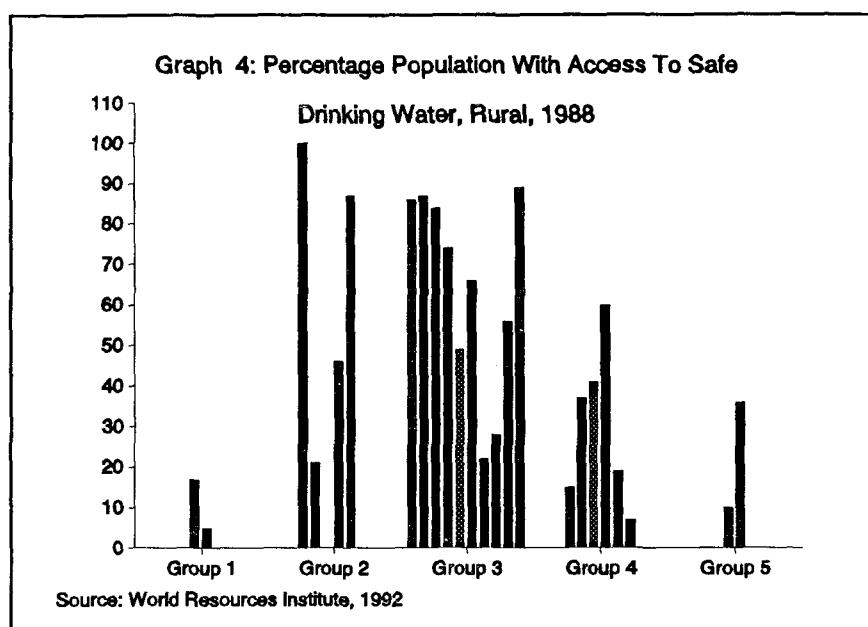


Table 4: Percentage Population With Access
To Safe Drinking Water, Rural, 1988

Group 1			
Argentina	17	Uruguay	5
Group 2			
Barbados	100	Chile	21
Cuba	x	Jamaica	46
Trinidad and Tobago	87		
Group 3			
Brazil	86	Colombia	87
Costa Rica	84	Guyana	74
Mexico	49	Panama	66
Peru	22	Dominican Rep.	28
Suriname	56	Venezuela	89
Group 4			
Bolivia	15	Ecuador	37
Guatemala	41	Honduras	60
Nicaragua	19	Paraguay	7
Group 5			
El Salvador	10	Haiti	36

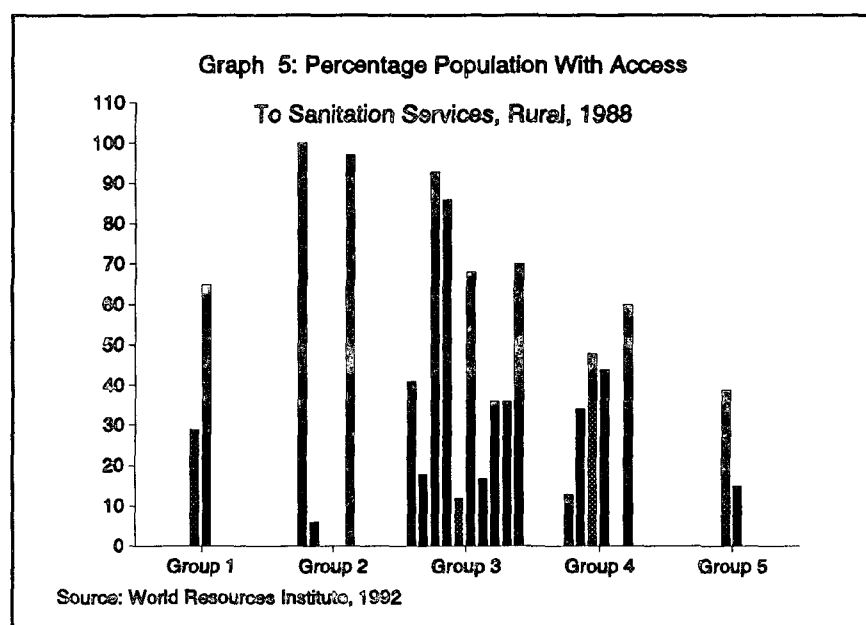


Table 5: Percentage Population With Access
To Sanitation Services, Rural, 1988

Group 1			
Argentina	29	Uruguay	65
Group 2			
Barbados	100	Chile	6
Cuba	x	Jamaica	x
Trinidad and Tobago	97		
Group 3			
Brazil	41	Colombia	18
Costa Rica	93	Guyana	86
Mexico	12	Panama	68
Peru	17	Dominican Rep.	36
Suriname	36	Venezuela	70
Group 4			
Bolivia	13	Ecuador	34
Guatemala	48	Honduras	44
Nicaragua	x	Paraguay	60
Group 5			
El Salvador	39	Haiti	15

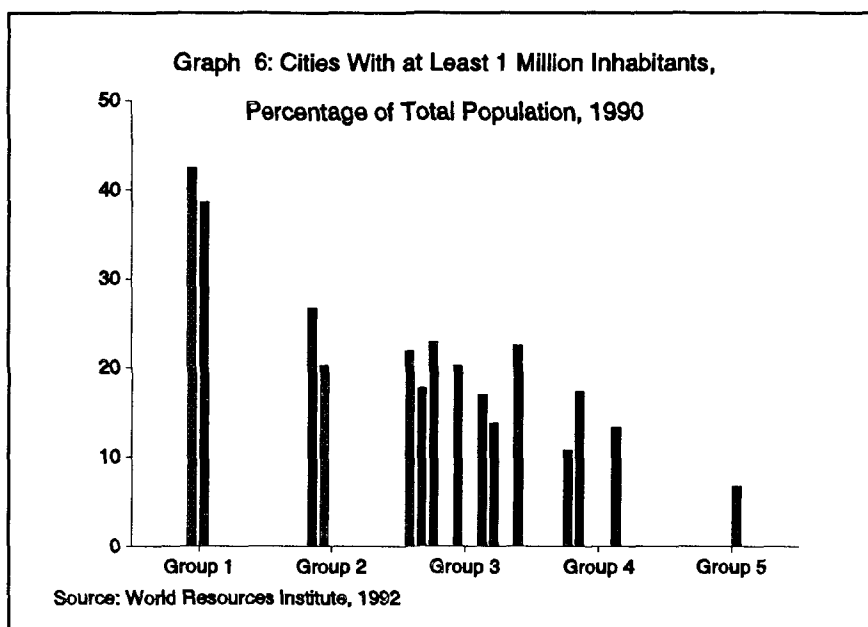


Table 6: Cities With at Least 1 Million
Inhabitants, Percentage of
Total Population, 1990

Group 1			
Argentina	32.7	Uruguay	38.7
Group 2			
Barbados	0	Chile	26.7
Cuba	20.3	Jamaica	0
Trinidad and Tobago	0		
Group 3			
Brazil	21.9	Colombia	17.8
Costa Rica	22.9	Guyana	0
Mexico	20.2	Panama	0
Peru	17	Dominican Rep.	13.8
Suriname	0	Venezuela	22.5
Group 4			
Bolivia	10.8	Ecuador	17.3
Guatemala	0	Honduras	0
Nicaragua	13.3	Paraguay	0
Group 5			
El Salvador	0	Haiti	6.8

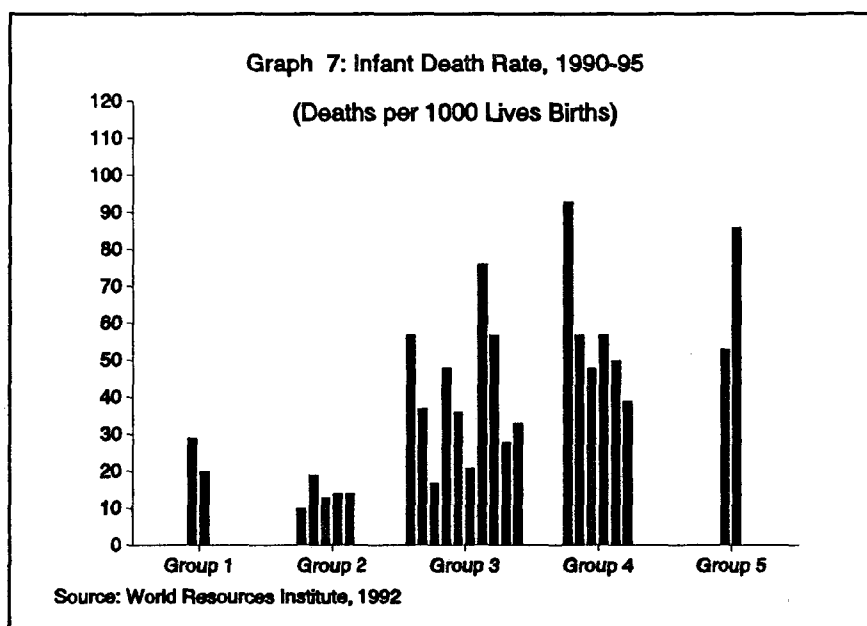


Table 7: Infant Death Rate, 1990-95
(Deaths per 1 000 live births)

Group 1			
Argentina	29	Uruguay	20
Group 2			
Barbados	10	Chile	19
Cuba	13	Jamaica	14
Trinidad and Tobago	14		
Group 3			
Brazil	57	Colombia	37
Costa Rica	17	Guyana	48
Mexico	36	Panama	21
Peru	76	Dominican Rep.	57
Suriname	28	Venezuela	33
Group 4			
Bolivia	93	Ecuador	57
Guatemala	48	Honduras	57
Nicaragua	50	Paraguay	39
Group 5			
El Salvador	53	Haiti	86

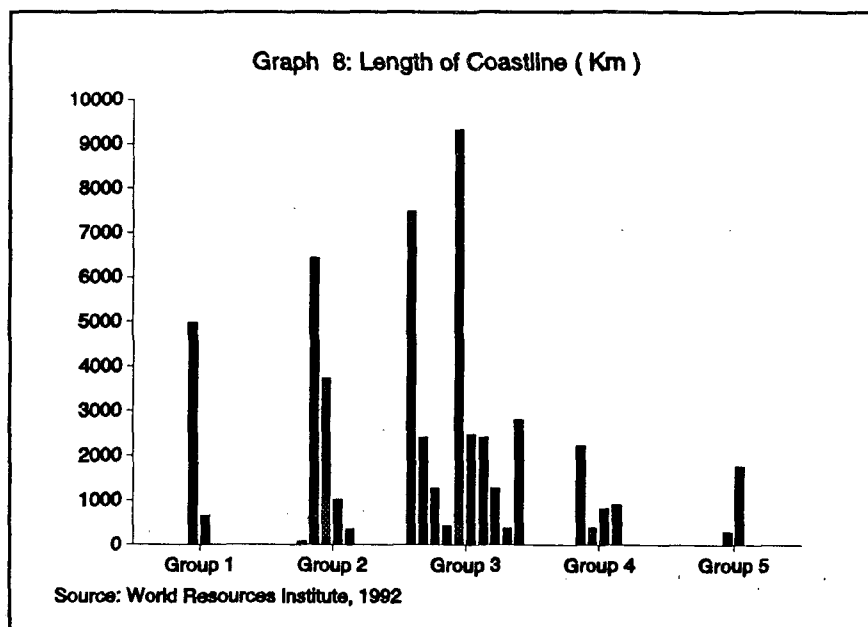


Table 8: Length of Coastline (Km)

Group 1			
Argentina	4989	Uruguay	660
Group 2			
Barbados	97	Chile	6435
Cuba	3735	Jamaica	1022
Trinidad and Tobago	362		
Group 3			
Brazil	7491	Colombia	2414
Costa Rica	1290	Guyana	459
Mexico	9330	Panama	2490
Peru	2414	Dominican Rep.	1288
Suriname	386	Venezuela	2800
Group 4			
Bolivia	-	Ecuador	2237
Guatemala	400	Honduras	820
Nicaragua	910	Paraguay	-
Group 5			
El Salvador	307	Haiti	1771

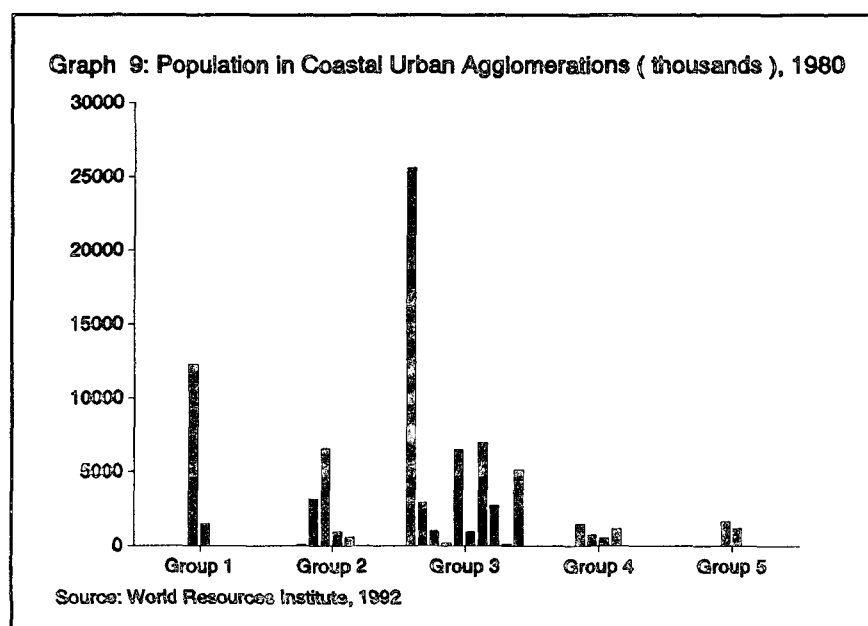


Table 9: Population in Coastal Urban Agglomerations (thousands), 1980

Group 1			
Argentina	12273	Uruguay	1511
Group 2			
Barbados	100	Chile	3212
Cuba	6628	Jamaica	1016
Trinidad and Tobago	623		
Group 3			
Brazil	25616	Colombia	2926
Costa Rica	1050	Guyana	213
Mexico	6529	Panama	989
Peru	6975	Dominican Rep.	2787
Suriname	140	Venezuela	5158
Group 4			
Bolivia	-	Ecuador	1529
Guatemala	780	Honduras	583
Nicaragua	1166	Paraguay	-
Group 5			
El Salvador	1680	Haiti	1216

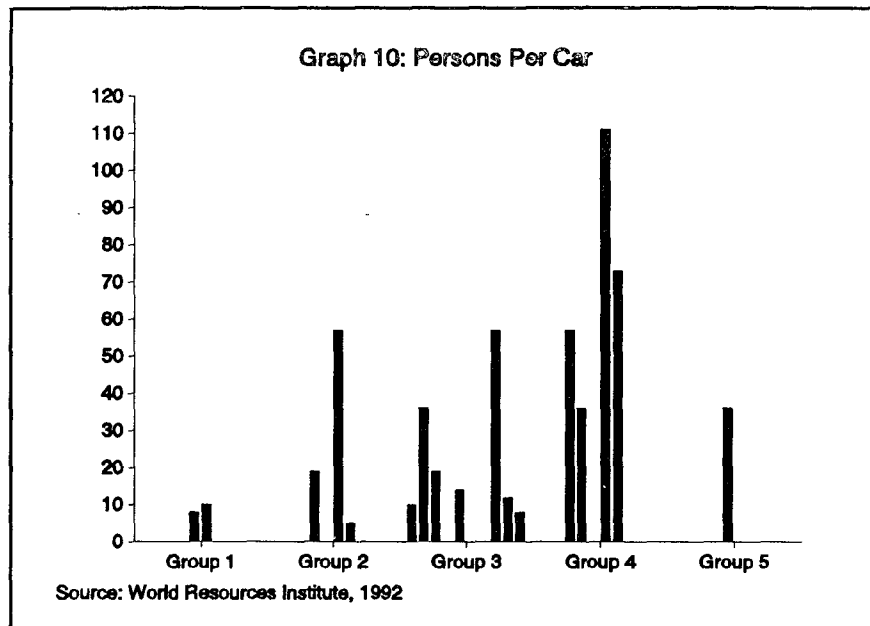


Table 10: Persons Per Car

Group 1			
Argentina	8	Uruguay	10
Group 2			
Barbados	x	Chile	19
Cuba	x	Jamaica	57
Trinidad and Tobago	5		
Group 3			
Brazil	10	Colombia	36
Costa Rica	19	Guyana	x
Mexico	14	Panama	x
Peru	x	Dominican Rep.	57
Suriname	12	Venezuela	8
Group 4			
Bolivia	57	Ecuador	36
Guatemala	x	Honduras	111
Nicaragua	73	Paraguay	x
Group 5			
El Salvador	36	Haiti	x

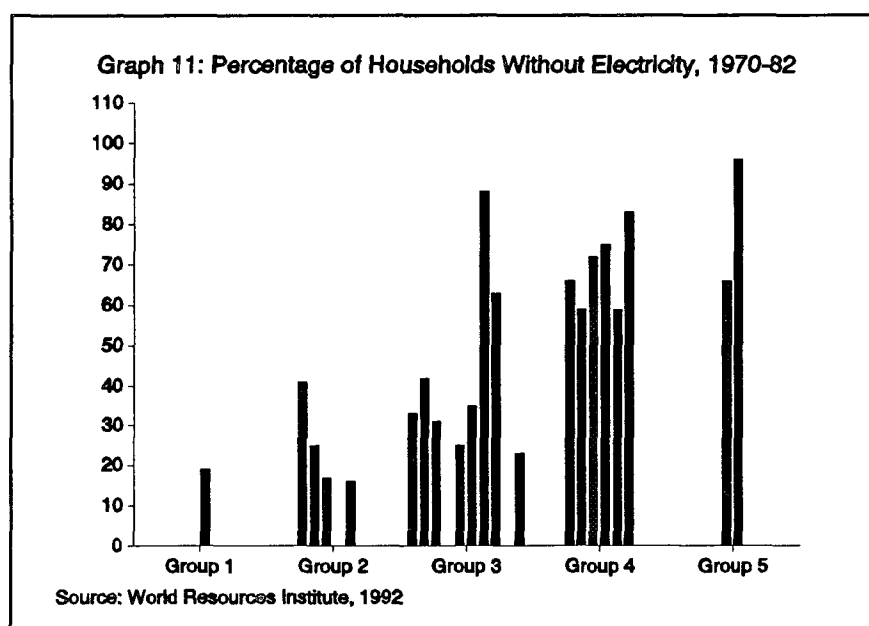
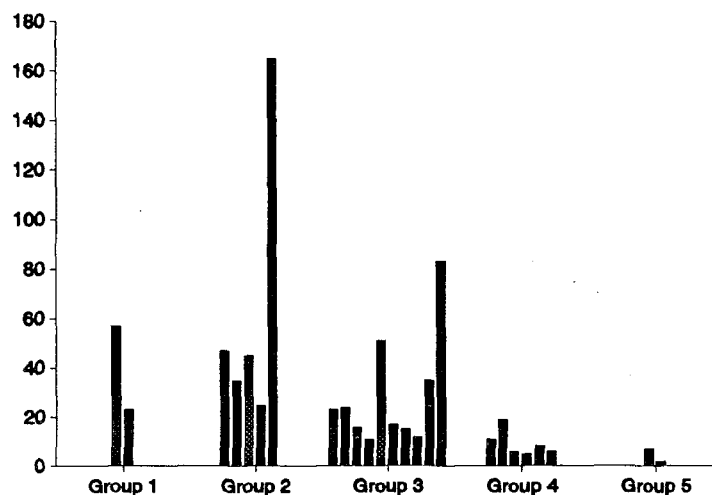


Table 11: Percentage of Households Without Electricity, 1970-82

Group 1			
Argentina	x	Uruguay	19
Group 2			
Barbados	41	Chile	25
Cuba	17	Jamaica	x
Trinidad and Tobago	16		
Group 3			
Brazil	33	Colombia	42
Costa Rica	31	Guyana	x
Mexico	25	Panama	35
Peru	88	Dominican Rep.	63
Suriname	x	Venezuela	23
Group 4			
Bolivia	66	Ecuador	59
Guatemala	72	Honduras	75
Nicaragua	59	Paraguay	83
Group 5			
El Salvador	66	Haiti	96

Graph 12: Commercial Energy Consumption Per Capita, Gigajoules, 1989



Source: World Resources Institute, 1992

Table 12: Commercial Energy Consumption Per Capita, Gigajoules, 1989

Group 1			
Argentina	57	Uruguay	23
Group 2			
Barbados	47	Chile	35
Cuba	45	Jamaica	25
Trinidad and Tobago	165		
Group 3			
Brazil	23	Colombia	24
Costa Rica	16	Guyana	11
Mexico	51	Panama	17
Peru	15	Dominican Rep.	12
Suriname	35	Venezuela	83
Group 4			
Bolivia	11	Ecuador	19
Guatemala	6	Honduras	5
Nicaragua	8	Paraguay	6
Group 5			
El Salvador	7	Haiti	2

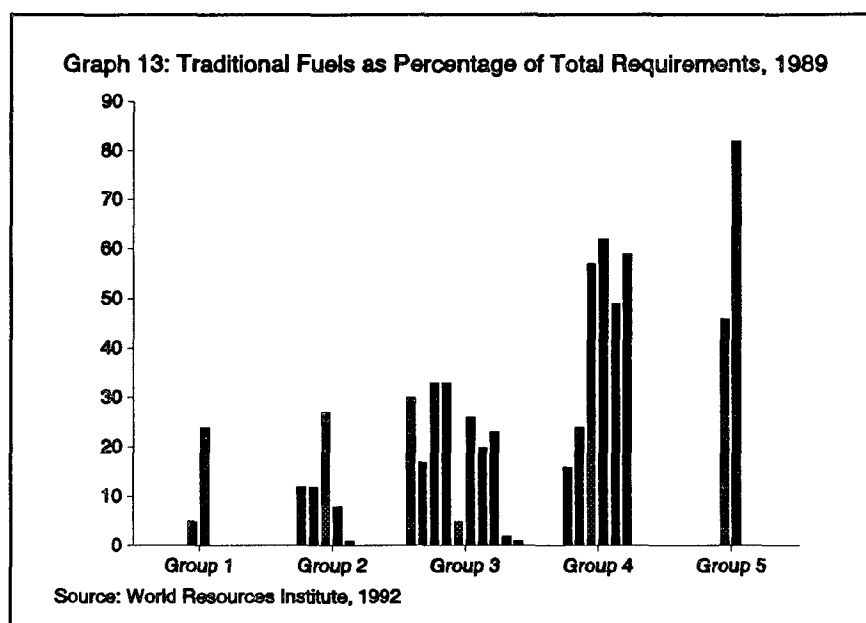


Table 13: Traditional Fuels as Percentage of Total Requirements, 1989

Group 1			
Argentina	5	Uruguay	24
Group 2			
Barbados	12	Chile	12
Cuba	27	Jamaica	8
Trinidad and Tobago	1		
Group 3			
Brazil	30	Colombia	17
Costa Rica	33	Guyana	33
Mexico	5	Panama	26
Peru	20	Dominican Rep.	23
Suriname	2	Venezuela	1
Group 4			
Bolivia	16	Ecuador	24
Guatemala	57	Honduras	62
Nicaragua	49	Paraguay	59
Group 5			
El Salvador	46	Haiti	82

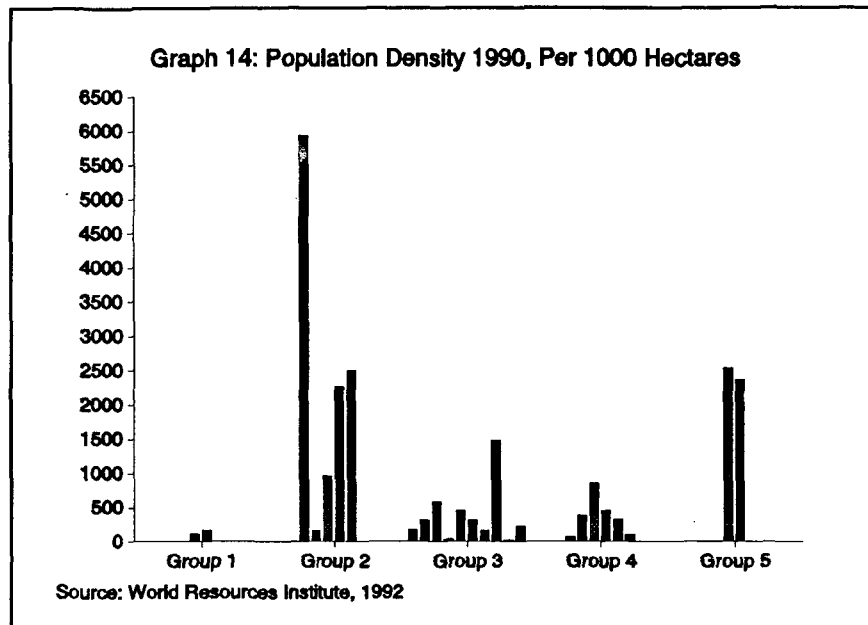


Table 14: Population Density 1990,
Per 1000 Hectares

Group 1			
Argentina	118	Uruguay	177
Group 2			
Barbados	5930	Chile	176
Cuba	966	Jamaica	2268
Trinidad and Tobago	2497		
Group 3			
Brazil	178	Colombia	317
Costa Rica	590	Guyana	40
Mexico	464	Panama	318
Peru	168	Dominican Rep.	1482
Suriname	27	Venezuela	224
Group 4			
Bolivia	67	Ecuador	382
Guatemala	848	Honduras	459
Nicaragua	326	Paraguay	108
Group 5			
El Salvador	2535	Haiti	2363

