The Dynamics of Transition: Population - Environment Interaction

Authors:

Tatiana Bailey
Sanjay S. Baliga
Brent C. Blair
Tamara Carnovsky
John Castanon
Juan Carlos Cervantes
Bruce Frayne
Ilia E. Hartasanchez H.
Roy Rojas Montero
Kameshwari Pothukuchi
Rhonda Ryznar
Suzy Salib
Caroline Stem
Kim Stone
Amy D. Sullivan
Noreen White

Editors:

Sandra Lach Arlinghaus
William D. Drake

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Bill Arlinghaus, President/CEO

PREFACE

This monograph is one of the outcomes of a new course offered jointly between the School of Natural Resources and Environment and the School of Public Health during the fall of 1993. Like its predecessor, an experimental course offered during the fall of 1992, the focus of the seminar is captured in its name "*Population-Environment Dynamics: Toward Building a Theory*". Much of the theoretical developments used in the course were begun as part of the University of Michigan's Population-Environment Dynamics Project sponsored by the MacArthur Foundation. Since 1992, further development of the theory and it application has continued without sponsorship here at Michigan.

This fall sixteen students and two faculty participated formally in the course. There were two undergraduates, seven masters and seven doctoral students. Other students sat in from time to time. Seminar participants had a wonderful variety of backgrounds and interests. Disciplines represented included biology, natural resources, history, economics, geography, population planning, international health, urban planning, remote sensing and architecture. The course was further enriched by colleagues from Mexico, Nicaragua, South Africa and Costa Rica. In addition, several U. S. students had spent considerable time living and working in countries including the Czech and Slovak Republics, Egypt, Ecuador, Bolivia, Taiwan, Malawi and Spain.

During the course of the seminar several different conceptual models for considering the population-environment dynamic were considered. Transition theory as discussed in the recent book, *Population - Environment Dynamics: Ideas and Observations*, University of Michigan Press, 1993, was compared against other models. These alternative approaches included dynamic simulations first proposed by Jay Forrester and later extended by Meadows et al in *The Limits to Growth* and *Beyond the Limits* and the **IPAT** model of Paul Erhlich.

Perhaps most important, the seminar participants were urged to examine their chosen topic of inquiry using data sources which have recently become available in machine readable form. This permitted the students to quickly gain exposure to handling longitudinal datasets, especially those which were not amenable to modeling with linear functions. In turn, an integral part of the course required mastery of non-linear curve fitting techniques. Datasets made available to participants included The World Resources Institute Data System, World Bank STARS and Digital Chart of the World. Another tool used in the course was state-of-the-art PC-based Geographic Information Systems. The GIS package selected as most helpful, was ATLAS GIS version 2.1. Dr. Sandra Lach Arlinghaus, newly appointed as adjunct professor in The School of Natural Resources and Environment, provided instruction in curve fitting and ongoing individualized support to all participants.

The success of this course was based in large part on the enthusiasm of the participants. Near the end of the term, extra seminar sessions were held, often going well beyond the scheduled meeting times. Feedback from fellow participants was provided in these sessions featuring vigorous discussion that became an important highlight in the course. The breadth of participant background and their enthusiasm ensured a successful learning experience and was great fun as well.

This volume consists of sixteen chapters with each student's final paper representing a separate chapter. The instructors, Arlinghaus and Drake, assumed the task of preparing an introductory and concluding remarks. However, the students also participated in this editorial process by providing an abstract of their paper and paragraphs relating their work to the others in the seminar which were then drawn upon to write these sections. Because it was deemed especially useful to provide timely feedback, a severe time constraint was placed on completing the effort. The volume was published on the last day of the fall term.

William D. Drake
University of Michigan
Ann Arbor, Michigan
December 1993

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INTRODUCTION

This volume is a collection of separate but related studies focusing on the relationship between human populations and the environment. The effort consists of sixteen chapters, each investigating a different aspect and geographic setting of the population-environment dynamic. In addition to this *general* theme, a particular framework for investigation is put forth. Namely, the notion that there are some specific attributes which help describe the dynamic and that these attributes exist across many sectors of society.

The organization of the document is as follows: first, we present the common framework, which we call a **family** of transitions. In addition to the common framework, this introductory chapter presents some analytic tools for curve fitting especially useful in applying the notion of transitions. Next, the sixteen studies undertaken by individual investigators are presented, drawing upon the transitions framework and curve fitting tools. Finally, a concluding chapter is provided which relates the individual studies to each other, presents conclusions and suggests next steps in development.

Readers of the monograph reporting last year's work should note that the material in the following section on a family of transitions is repeated here for background and therefore can be skipped.

1. A FAMILY OF TRANSITIONS[1]

One way of viewing the complex dynamic relationships between population and the environment is to visualize them as a **family** of transitions. That is, not only is there a demographic and epidemiologic transition but also a deforestation, toxicity, agricultural, energy and urbanization transition as well as many others. In this chapter it is argued that for each transition there is a critical period when society is especially vulnerable. During that period, rates of change are high, societal adaptive capacity is limited, in part, due to this rapid change, and there is a greater likelihood that key relationships in the dynamic become severely imbalanced. The trajectory society takes through a transition varies, depending upon many factors operating at local and national levels. Transitions not only are occurring in many different sectors but also at different scales, both temporal and spatial. At times, a society experiences several transitions simultaneously, which can raise social vulnerability because of how they amplify each other.

1.1 TYPES OF TRANSITIONS

The Demographic Transition

Let us begin with a review of the ideas behind the widely accepted demographic transition. At the onset of this transition, births and deaths are both high and are in relative equilibrium with each other. Historically, births exceed deaths by small amounts so total population rises only very

[1] This material was condensed from the original paper "Towards Building a Theory of Population-Environment Dynamics: A Family of Transitions." in *Population-Environment Dynamics: Ideas and Observations*, Ann Arbor: University of Michigan Press, 1993.

gradually. Occasionally, famine or an epidemic causes a downturn in total population but in general, changes in rates are low. During the transition, however, death rates drop dramatically, usually due to a change in the health condition of the population. This change in health is caused by many, often interrelating factors. After some time lag, the birth rate begins to drop and generally declines until it is in approximate balance with the death rate again.

The Epidemiological Transition

The term epidemiologic transition was coined to describe the changing source of mortality and morbidity from infectious diseases occurring primarily in the younger age groups to degenerative diseases in older age groups. As with the demographic transition, there is considerable volatility during the transition. At the onset, infectious diseases begin their decline usually due to extensions of health care and sanitation by the national or local government. Single vector programs such as malaria control and immunization programs are often the first implemented because they are capable of ready extension and do not require as heavy a commitment to education and other sustained infrastructure - especially in rural areas. These single vector programs are then followed by broader-based health care which demand heavier investment in infrastructure. But an entirely successful move through this transition does not always happen. At times, other sectors in transition overpower the health care delivery system.

The Agricultural Transition

For several hundred years, worldwide agricultural production has been rising in relative harmony with population. Overall, increases in production have kept up with and even outpaced growth in population. The two factors that have been responsible for these increases are 1) extensions of land under cultivation and 2) improvements in productivity. At times changes have been dramatic. Formulating an agricultural transition reflects the condition that, in general, sources of increase in production shift from extending land to intensifying production on land already under cultivation.

The Forestry Transition

At the onset of the forestry transition generally a large percentage of a region is under forest cover. Rapid deforestation occurs during the transition and finally forest cover stabilizes at a lower level determined by many factors such as the local region's needs, the state of the local and national economy, climate and soil characteristics. In most settings this transition will end in a steady state equilibrium balancing growth and harvest. Again, how society handles the vulnerable transition period often determines in a profound way the quality of life for the region.

The Toxicity Transition

The toxicity transition can be considered a composite of many transitions: global atmospheric, local air pollution, surface water, ground water and solid waste to name a few. Again,

there are at least two sets of factors operating in tandem. The transition begins with low levels of industrial or agricultural production and correspondingly low levels of toxins. As production and population increase, toxic byproducts increase to levels which eventually become unacceptable to the general public. This in turn, causes a public demand for pollution abatement. After an environmentally costly time lag, remediation steps are taken which helps to bring pollution under control.

The Urbanization Transition

The urbanization transition is driven by the dual forces of rural to urban migration and central city population growth. The early stages of the transition are characterized by rapid growth of urban population; however, in later stages, growth declines and may reverse. Rural to urban migration is a product of many forces - both "pull" and "push". In terms of the population-environment dynamic, the urbanization transition often acts as an amplifier as it interacts with other transitions.

The Fossil Fuel Transition

The fossil fuel transition is a special case of the energy transition. Historically, many energy transitions have already occurred in different regions and time periods. Significant transformations began in the sixteenth century brought about by sail and later, by steam power. Today, we are now in the most universal and perhaps critical energy transition: fossil fuels. Studying this transition is especially instructive because the record on different societies' passage through the vulnerable period is varied and appears to be heavily influenced by public policy.

1.2 General Characteristics of Transitions

Similarity of Trajectory Across Sectors

We have attempted to show in the seven example sectors discussed earlier that the notion of transitions apply across all sectors of investigation. Each class of transition, whether it be demographic, toxicity, forestry, agriculture, urbanization, energy or epidemiological have similar patterns. It is this perception that has caused us to posit the existence of a **family** of transitions possessing some common attributes useful in analysis. The first common attribute of all transitions is their trajectory. They all begin in reasonable stability, then move to the volatile transition period where change is rapid, and finally return again to relative balance. Analytically, these are clearly nonlinear systems but ones which have properties that lend themselves to well-understood mathematical functions.

Applicability of Transitions Across Scales

The second attribute has to do with scale. One of the most interesting and at the same time vexing aspects of studying population-environment dynamics is that many phenomena manifest

themselves at all levels of geographic and temporal scale. For example, data depict one demographic transition for an entire continent, a different one for a country within that continent and still other different transitions at the regional level. Local conditions may delay or advance the onset and or completion of the transition in relation to the larger body. Thus, moving through the demographic transition can take more or less time as the scale changes.

This same variation seems to exist in all other population-environment transitions that have been investigated. True, national or regional-level determinants often set the stage for the local dynamic, but in the end it is these local conditions which determine the timing, magnitude and specific trajectory of the overall transition.

One can think of our world, seeming to be chaotic, but instead consisting of a multitude of well defined transitions in many sectors, each with its own local characteristic. Different transitions begin at different times and places, but ebb and flow in an overlapping way, sometimes reinforcing one another and at other times dampening their dynamic. As adjustment occurs, occasionally useful niches are created which are then exploited by stressed elements of the ecosystem. Unfortunately, at other times, different sectors interact with each other in a harmful way to broaden and extend the susceptible period.

Societal Vulnerability

During transitions there seems to be a special vulnerability borne by society. Ample evidence indicates that key relationships are most likely to become out of balance during the transition. A primary cause of this vulnerability is the rapidity of change during the high velocity portion of the transition. Adaptive capacity is impeded because there is little time for systems to adjust and often there are limited feedback mechanisms operating which otherwise could help this process. Another contribution to social vulnerability during a transition is the amplifying effects created by transitions occurring simultaneously in several sectors. Rapid rates of change in several sectors could more easily overpower the available infrastructure which leads us to the next source of vulnerability during transitions: capital availability.

Capital or investment capacity can either amplify or reduce societal vulnerability during a transition. If there are financial resources available to deal with the effects of rapid change, remediation is easier to implement. Africa which is trying to deal with a difficult demographic transition has almost no capital available for its use and will therefore undergo great hardship. The Soviet Union and Eastern Europe are struggling to find financial resources to deal with their flawed toxicity transition. Another dimension of transitions which affects societal vulnerability is the degree of interconnectedness. How closely is the local village connected to the regional and national economy? How much does what happens in one location determine what happens in another? There is no question that interconnectedness is increasing worldwide. We also know that under some circumstances linkage creates dependencies which in turn, increase vulnerability. However, it can work in the opposite direction as well. These very same links to a larger domain can also act as a safety net. If there are connections, resources can be brought to the stressed area more easily to

mitigate the local adversity. The final and perhaps most important dimension of transitions affecting vulnerability is feedback.

Analytic Properties of Transitions

We have seen that many characteristics of transitions are common across all sectors and geographic scales. The question then, is whether there are analytic techniques which might be useful in describing this family of transitions. If so, these techniques may be helpful in portraying transitions in a way that facilitates comparison and thereby increases our understanding. In this quest we are especially interested in techniques and functions which reduce complexity and at the same time provide a reasonably accurate portrayal of reality

Functions which are candidates for consideration include exponential, exponential to the limit L, logistic, Gompertz, and the power function. Bounded functions which fit data more precisely but cannot be used for predictive purposes may also be helpful in uncovering patterns.

1.3 Policy Implications of Transition Theory

But what does it gain us to fit an exponential or logistic or for that matter *any* function to transition data? The answer lies in our ability to gain insights by relating different transitions to each other. First, consider the transitions *within* a given sector and at a given scale. We know there are transitions in a sector which some societies have already experienced while others have yet to endure. If the nature of these experiences can be captured in general form, it is more likely that knowledge can be transferred to other settings where a transition is first starting. Of course, each civilization or local culture has its own unique characteristics but any one emerging transition may be comparable to one or more of those which have occurred before because conditions are similar.

Second, there may be useful comparisons *across* different scales. We already surmise that a national-level transition, perhaps now in process, is actually comprised of a myriad of local transitions also in process or which have recently occurred. But there may be other locales in the region for which the transition has yet to happened. If similar patterns emerge because of similar local conditions, a useful prediction could be made about the nature of the passage through the transitions yet to appear.

Third, there may be insights gained simply by the process of fitting a function to historical data. Different mathematical functions often have very specific underlying characteristics which can provide useful ideas.

The next potential use of transition theory is to facilitate analysis across sectors. There is, of course, no good reason to expect the trajectory of, say, a forestry or agricultural transition to mimic an epidemiologic transition. However, for any society at a given time, there may be similarities in the **rates** of change across sectors. Developed economies have slower rates of change in their agriculture sector than developing economies when conditions are favorable. Rural based

cultures may be expected to have urbanization transitions which are steeper than non-rural cultures. In short, it is worth testing to see if patterns can be empirically determined which would be helpful in predicting the shape of future transitions, given a stated level of intervention.

We have already mentioned the special societal vulnerability associated with several sectors being in rapid transition simultaneously. From a modeling perspective this simultaneity a very difficult condition to describe and analyze, which may be why less progress has been made in this area to date. However, being able to portray these multiple transitions with specific functions could be helpful. There is no question that each transition interacts with the other. And to the analyst this means that a reliable model must be structured as a set of simultaneous relationships. Describing transitions as functions facilitates this manipulation.

Another potential benefit of transition theory lies in the identification of lead indicators. If success is achieved in fitting transition data to an appropriate function, then for a given condition and point in time, the future trajectory can be predicted more accurately. Identifying lead indicators is facilitated because with an orderly function, only one, or at most, two parameters need to be determined to define the trajectory. This advantage is even more evident when several functions are considered simultaneously.

Finally and perhaps most importantly, transition theory may permit more informed public and private intervention. At one level we find ourselves believing that the trajectory of a transition is somehow fixed by an immutable law of nature. But at another level we know that this is not the case. Public and private policy can make a difference as we have seen from some of the cases discussed in this book. Rates of change can be influenced by policy redirection and consequent resource allocation. To the extent that we can link historical rate differentials with historical policy implementation, a better determination can be made about which intervention mix works best in dealing with problems facing society today.

2. AN OVERVIEW OF THE INDIVIDUAL INVESTIGATIONS

National Family Planning and the Demographic Transition: A Case Study of Bolivia

by

Tatiana Bailey

This analysis involved the demographic transition in Bolivia. It was an interesting case study since Bolivia stands out in its region as a nation that has lagged behind others in Latin America in starting the transition and in resolving it. Close analysis revealed that it has not been cultural norms that have slowed the resolution of the transition as much as it has been an implicit pro-natalist national policy. Although the government of Bolivia has not formulated concrete population policies, it has not helped meet the great deal of latent demand in Bolivia and therefore fostered high rates of (illegal) abortions as well as high rates of infant and child mortality. Congruently, the government has not supported the social infrastructure necessary to reduce the poor living standards that exacerbate the high (premature) death rates. Furthermore, the government appears to have favored health investments that aid the middle and upper classes at the cost of health investments for poorer (indigenous) classes.

The IPAT Model of Cereal Production Impact in India

by

Sanjay S. Baliga

More than one hundred years ago, Thomas Malthus predicted a bleak future where population growth rates would far outpace growth rates of agricultural productivity. Death and disease would certainly follow. However, technologies such as those found in the Green Revolution have allowed agricultural productivity rates to outpace population growth rates. There is, however, another menace for developing countries, particularly those like India, where recent fertility declines have resulted in increasing wealth. This affluence works to increase per capita demand for agricultural products. The mechanism of this increased demand lies in affluence-population dynamics. That is, as people become more wealthy, they tend to reduce fertility rates. Similarly, reductions in fertility rates can lead to increases in wealth. Indeed, reduction in fertility are a main cause of wealth accumulation. Hence, there is a new evil that Malthus never predicted, that of wealth. The relationship between wealth, population, affluence and non-sustainable productivity is given by an equation derived from Paul Erhlich's IPAT model. That is, (Environmental IMPACT)/(TECHNOLOGY) = (POPULATION)(AFFLUENCE). This model is based on the assumption that population and affluence interact to lead to demand for cereal products. Technology and Environmental impact interact to produce a supply of cereal grains. There is an equilibrium between demand and supply such that increases in population or

affluence can be compensated for with increases in technology or environmental degradation. Using affluence, population, and technology variables, one can predict the level of productivity of agricultural systems needed to achieve zero environmental degradation given a certain population number and affluence level in the future.

Deforestation in Legal Amazonia: The Evolution of the Forestry Transition in Brazil

by

Brent C. Blair

There has been a long history of deforestation throughout the world. Many forests are now completely gone or are only a small fragment of their pre-settlement size. Europe, the United States and other countries lost the majority of their forests long ago. Deforestation in Latin America began relatively recently but, in many countries, is destroying forests at an alarming rate. Brazil is one of these countries. Before the early 1960s deforestation was not a threat to the majority of their forested land. This paper examines the transition of deforestation in the Brazilian Amazon region. The transition is broken into two parts. The current cattle ranching stage, dominated by deforestation through pasture degradation, and a logging stage, now in its infancy, dominated by timber extraction. It is concluded that just as most deforestation to date was dependent on governmental subsidies for development of the area, to slow future deforestation will require the Brazilian government to actively protect the rain forest--now!

The Transition from a Predominately Agrarian Society
to an Industrialized Society in Spain

by

Tamara Carnovsky

Historically, Spain enforced isolationist controls over its internal and external economic relations. These controls stifled economic development which influenced the change from traditional economic policies towards more progerssive policies in the early 1950s. These economic policies were the driving force behind Spain's shift from an agrarian society to an industrialized society. This paper examines the preceding transformation by analyzing three transitions: demographic, industrialization, and urbanization. Since these transitions occurred with great magnitude and velocity, there was limited time for sufficient feedback systems to develop. Therefore, today Spain is facing one of the most critical periods in its society in terms of policy implications and changes.

Taiwan: National Development and Land Use

by

John Castanon

During the past forty years, the Republic of China (Taiwan) has been transformed from a relatively underdeveloped, poor nation of primarily agriculturally based workers to a newly developed, moderately wealthy nation more focused on manufacturing and knowledge-based industry. The national government promoted rapid development and provided a strong, guiding hand in the form of policy initiatives, national development planning, financing, and implementation. The lack of natural resource endowment, limited amount of flat land, and a current population of over 20 million relatively affluent people are factors that will influence the future economic development of the island. The government has developed a Six-Year national development plan that is intended to improve the economic, social, educational, and quality of life status for the island's population. This paper evaluates the Six-Year plan with respect to the population-environment transition that confronts future successful development on the island. For perspective, politically significant events, a geographical assessment of the island, and past national development planning are briefly discussed prior to the evaluation of the Six-Year plan. development literature appropriate to cases similar to Taiwan have been included to set a framework from which to base policy recommendations for future national development planning on the island.

Capital and Bureaucratic Transition Dynamic in Mexico

by

Juan Carlos Cervantes

The world is currently undergoing a rapid change in its economy. As the net profit returns on capital diminish, the sectors of production seek ways to maximize profits by internationalizing the financial markets. The internationalization of capital is part of a strategy to make financial resources fluid and unconstrained in a global market. Essentially, it is the freedom to move wherever investments offer the highest returns. Short term speculative investment is the end result; for some countries it means a rendering of state sovereignty to the whims of capital in exchange for short term investments. On a country-specific level, the means is manifested in Mexico. This paper examines the most critical aspects of the transition with regards to its bureaucratic manifestation and its potential impact on the country's future economic and social development.

The Potential Role of Urbanization in Achieving Global Sustainability
Towards Establishing an Urbanization Transition Model

by

Bruce Frayne

It is apparent to the scientific and political worlds that present economic and population growth trends are unsustainable. While the complexity of the global ecosystem, of which humankind is a part, is such that quantitative precision regarding the outcomes of these trends is impossible, it is clear that rapid changes in global resource allocation and consumption must occur if burgeoning populations are to reach levels of socio-economic development that facilitate the implementation of policy designed to retard, and ultimately stabilize, current global growth trends. The demographic and economic changes facilitated by urbanization provide one means by which improvements in this regard are possible. This has particular application in the less developed countries of the world where socio-economic development is low and population growth is high. It is suggested here that public policy in urbanizing countries should seek to raise the socio-economic status of both rural and urban populations with the aim of increasing levels of urbanization and thus capitalizing on the potential benefits offered by a highly urbanized society. If global development policy was to be centered around this concept, and if, as a consequence of a global vision of a highly urbanized society, politicians were able to better implement policies aimed at a more pragmatic use of global resources across socio-economic, political and geographical boundaries, then the goal of achieving a more sustainable future for the world might be more readily within grasp.

Wetland Losses and Shrimp Fisheries in the Region of
Laguna de Terminos, Campeche, Mexico — A Proposal

by

Ilia E. Hartasanchez H.

A proposal to analyze the trends of the shrimp fisheries in the wetlands of the Laguna de Terminos in relation to wetland conservation is presented. The ecological importance of the Laguna de Terminos wetlands is closely related to the economic development of the region. The interdependence of the economic activities and the biological processes of the area have determined the development of the region. The analysis will be done through the use of the theory of population environment dynamics with shrimp fisheries data, rice production, aquaculture production, wetland area lost, and economic indicators. To demonstrate the methodology to be applied, U.S. data on shrimp production from 1950 to 1990 will be analyzed. Finally, a description of the proposed analysis beyond the submitted research is presented.

A Historical Approach to the Agricultural Transitions in Costa Rica and Its Impact on the Environment: From the Colonial Subsistence Economy to the 1990s Agroexport Development Model

by

Roy Rojas Montero

Agricultural transitions in Costa Rica are addressed from a historical perspective. The pre-capitalist mode of production of the native people was completely disrupted by the arrival of the Europeans to their lands. In a very short time, native population was decimated by warfare, slavery, and the diseases introduced by the conquerors. The lack of slave labor and mineral resources, was a decisive factor which made it impossible for the Spanish to set up a typical colonial plantation-mining economy in the country. This explained the extreme poverty and isolation the country faced during the whole colonial period. After the independence and with the introduction of coffee, Costa Rica moved very rapidly from a basic subsistence economy to an agroexport model. This set Costa Rica into the international trade scene as a peripheral commodity export and highly dependent country. This condition was then reinforced with the introduction of banana plantations at the turn of the XIX century. This model remained unchanged until the introduction of the Import-Substitution Economic Model in the 1950s and 1960s through at last this model only increased the country's dependence and fostered an accelerated process of indebtedness. This eventually led to a general economic crisis which peaked at the beginning of the 1980s. Under the pressure of the IMF and the Creditor Banks who urged the country to pay its enormous debt, Costa Rica adopted a new economic model intended to promote the exports of non-traditional high value crops. As a consequence of the application of this model, this sector of the economy has increased its participation in the market and has even surpassed traditional products as a source of hard currency for the country. Nevertheless, it has also affected the food production for the national market and the small and medium scale farmers depending on it. Despite that, in the short term this model is proving to be economically successful in the long term it might increase the current dependency of the country. Besides, the ever voluble conditions of the international markets and the competition with other countries in the same situation make it extremely difficult to expect that this sector will keep growing at the current rates.

What Has the Urbanization Transition Meant for Women's Lives in India?

by

Kameshwari Pothukuchi

Indian urbanization is a rapidly growing phenomenon; urban population is increasing, both, in absolute numbers as well as in proportion to the national population. This paper looks at some of

the implications of the amount and rate of change for Indian women's lives. Specifically, indicators of welfare and development are compared across dimensions of gender and rural/urban residence. Broadly speaking, urbanization has meant greater gender-equity in access to social welfare inputs such as literacy, education, health, and other infrastructure. While gender inequalities still persist, urban women are better off in many respects than rural women. Enhancing rural women's access (spatial as well as social) to development inputs is a critical need. However, higher disparities in urban sex-ratios and women's work participation rates are some areas of concern that need to be addressed by policy. Policy recommendations are suggested.

The Toxicity Transition in the Czech and Slovak Republics

by

Rhonda Ryznar

The population and environment dynamics of the Czech and Slovak Republics is investigated by examining the demographic transition, energy efficiency and use, toxic emissions, and the agricultural transition that have occurred in these two countries. The demographic transition in the Czech and Slovak Republics is in the late stages, but equilibrium has not been achieved. The low birth rate and increasing death rate indicate a slowly diminishing population. However, the environmental degradation is extreme, and will likely get worse before remedial efforts lower levels. This contrary relationship is explained by the imposition of a centrally planned economy using market technologies with no democratic control mechanisms in place. Projections and future strategies, in view of the new democratic government, are proposed and supported by a toxicity model.

Schistosomiasis in Egypt: Transitions at Work

by

Suzy Salib

Using transition theory as a theoretical framework to assess the population-environment dynamic of schistosomiasis prevalence in Egypt, the conditions which allowed for the country's high endimicity are examined. Emphasis is on the demographic, agricultural, urbanization, and epidemiological transitions within Egyptian society, beginning with trends in the 1800s and continuing to the present. After examining historical as well as ongoing interactions among these sectors, and how those relate to past and current schistosomiasis prevalence, policy implications are discussed for future prevention and control efforts.

Sustainability of Small Scale Farming in the Ecuadorian Andes

by

Caroline Stem

Within the development field, there exists a general assumption that soil erosion and land degradation in many non-industrialized countries is the result of destructive practices implemented by peasant farmers. This assumption holds that small scale producers lack the scientific knowledge necessary to best utilize the land and that their ignorance has resulted in increased land deterioration.

The Ecuadorian sierra is an area characterized by both subsistence agriculture and high rates of soil erosion. While erosion is widespread throughout the country, it is particularly severs in the Andean highlands. Placing blame upon "ignorant" peasants is a simple and attractive explanation for this current state of land degradation. While small scale farmers have often been the direct link to land misuse and deterioration, to attribute ecological degradation solely to their farming systems would be to ignore the underlying causes of unsustainable practices.

This paper outlines the various exogenous elements which have shaped the methods small scale farmers in the Ecuadorian Andes have chosen to utilize. It argues that peasant agriculture could be sustainable if it were isolated from these external forces. Agents influencing agricultural practices include social and economic factors such as poverty and national and international market forces. In addition demographic forces such as high population growth, migration, and urbanization play an instrumental role in influencing small scale producers' techniques.

While demographics and socio-economics have substantially impacted natural resources exploitation, policies are conceivably the primary cause of land degradation in the Ecuadorian Andes. Forces initiating and supporting these policies range from government to development agencies to national and international companies. In general, the policies are biased in favor of commercial farming and have successfully managed to keep small scale farmers fixed in poverty.

An in-depth analysis of all of these factors and their relationship to the Andean farmers provides a more comprehensive view of small scale farming and its role in land degradation. This analysis stresses the need to restructure various policies, as well as to alter the way in which Western science views indigenous knowledge and it s role in environmental preservation. This paper specifies various routes which the Ecuadorian government and scientific community could utilize in order to mitigate the precarious state of land degradation in the Andes.

The Role of Women in Population/Environment Dynamics in Costa Rica

by

Kim Stone

Costa Rica has one of the lowest fertility rates in Latin America with a 1989 Total Fertility Rate of 3.3 children per woman. However, its population is still growing at a rate of 2.4%. In the midst of its demographic transition, Costa Rica's fertility seems to have stabilized. Environmental degradation (especially soil degradation and deforestation), the resulting heavy workloads for women, and women's lack of control over resources and land make it unlikely that further reductions in fertility will occur easily or quickly.

For Costa Rica to complete its demographic transition and reach zero population growth, it must actively work to stop environmental degradation and its causes. Although literacy is high (93%) for both men and women, the content of education must be changed to offer women alternatives to their stereotypical roles. Women must be allowed to own and control the land that they farm and must have access to resources, besides the labor of their children, to enable them to work the land sustainably and to make their work easier. Costa Rica must work to stop the rate of land degradation. This will help insure soil fertility and make the work of rural populations easier. Export agriculture and cattle ranching have caused much of the deforestation and soil degradation in Costa Rica. The country must look for other, more environmentally sound sources of income and reduce its external debt. To effectively reduce the demand for large numbers of children, data on women's workloads and their time allocation in urban and rural areas is needed. This data will offer ideas on how women's lives can be improved so that demand for children is reduced and they may voluntarily decide to have fewer children.

Early-Stage Health and Demographic Transitions:
Infectious Disease and Health Services in Malawi

by

Amy D. Sullivan

This paper considers health and demographic transitions in Malawi. General economic, social, and health conditions are reviewed, as is the age structure of the population. The age structure of Malawi is heavily weighted toward the younger ages, with about 19% of the population below the age of five years old. The demographic and health indicators are looked at more closely to assess the human environment in which infectious diseases exist. Explosive population growth driven by divergence of crude birth rates and crude death rates is illustrated. Surprisingly, given global trends, urban growth rates are not dramatically great with respect to rural growth rates. Health indicators reviewed are infant mortality, child mortality, and immunization coverage by the Expanded Programme for Immunization. IMR is high, though

decreasing. Interestingly, child mortality rates are considerably greater than are infant mortality rates. Possible reasons for this phenomenon are discussed. Immunization coverage is high. A possible association between the IMR and the crude birth rate is considered. After the data has been reviewed, other studies are considered with respect to the findings presented, and speculations are made as to the possible overall effect of population growth on the present health situation in Malawi. These speculations specifically address the possible impact regarding malaria. It is seen hypothesized that young age structures and rapid population growth provide a demographic environment wherein malaria thrives, and that pressures on health services infrastructures are increased by rapid population growth. Recommendations are then made. They include,1.) prioritizing delivery of family planning services in the context of a community-based primary health care program, 2.) developing a suitable MIS structure to track the health of the population, 3.) including promotion of permithrin-impregnated bed nets in the primary health care program, and 4.) increasing knowledge of women's health services needs.

Government Policies in a Commerce Transition in the South Atlantic Autonomous Region of Nicaragua

by

Noreen White

The South Atlantic Autonomous Region (RAAS) of Nicaragua has experienced, for the past two centuries, dramatic changes in its socio-economic and political structure. The great differences that are registered between the Pacific and the Atlantic coasts has been accentuated more in the past 30 years than in earlier times. This difference has left the Atlantic coast only weakly interconnected to the socio-economic system of the country, suggesting that the Atlantic coast is a zone that is disregarded by the national government.

The objective of this paper is to expose the most relevant aspects of a commerce transition in the RAAS. They are related to:

1. the warlike conflict in Nicaragua during the early 80s, lasting until the change of government in 1990;
2. hurricane Joan that devastated the Atlantic coast in October 1988, leaving in its wake a variety of economic and social difficulties such as overcrowding, slums, and unemployment; and,
3. the changes of government, the Somozas (1936-1979), Sandinistas (1979-1990), and Chamorro, the current government---each implementing different policies to "integrate" the Atlantic coast to the rest of the country in order to raise the economy of the region.

Since the country is no longer living under war stress, and since powerful hurricanes occur only rarely, the recommendations are directed to governmental policies.

3. FITTING CURVES TO EMPIRICAL DATA

Theoretical considerations of curve fitting

We have seen that many characteristics of transitions are common across all sectors and geographic scales. They are all derived from actual numerical data and can therefore be considered logically different from the vast array of theoretical perspectives offered by mathematics. Often, mathematics is used to model real-world data. When it is, typically, the mathematics is used to describe, either exactly or approximately, observed instances for which there is data. Then, the mathematics is used to make some sort of forecast as to the future status of the variables under consideration. A problem arises, however, when the reader passively accepts such forecasts on an equal footing with the part of the model that truly fits real data. When funding and policy decisions include projections as to future likelihoods, it becomes critical to know how forecasts were made and to have the opportunity to assess alternative futures using various mathematical tools. In studying transitions these tools facilitate comparison. In this quest we are especially interested in techniques and functions which reduce complexity and at the same time provide a reasonably accurate portrayal of reality.

Because any given data set can, in theory, be fit by an infinite number of mathematical "objects" (functions, relations, surfaces, and so forth), the participants were exposed to a wide variety of them. Mathematical models were fit to data gathered by seminar participants. Time was also spent discovering what kinds of fits had already been employed in published data sets that included projected data alongside actual data. Indeed, where linear curve fitting had been employed in these published data sets, it was illustrated how the forecasts in the table of data would change if an exponential or logistic curve had instead been fit to the actual data, and then extrapolated.

Because there were no mathematical prerequisites for the seminar, explanations were given using material required for a correct derivation (for those participants with sufficient mathematical background), and explanations were adjusted to give a broad overview and instructions for operating in a black-box mode for those with less exposure to mathematics. This sort of teaching strategy, employed in two consecutive years in the classroom, also serves as the backbone for a handbook, forthcoming from CRC Press in April of 1994 (*Practical Handbook of Curve Fitting*, Editor: Sandra Lach Arlinghaus; Associate Editors: William C. Arlinghaus, William D. Drake, John D. Nystuen). Student participants helped us to learn the sorts of difficulties one might have with curve fitting; we thank all now, and we have thanked all for the past two years, by name, in the Acknowledgment section of this forthcoming handbook. We also

note the presence of this monograph in an electronic journal entitled *Solstice*; each student member of the seminar will receive an electronic copy of this free journal over the e-mail.

Practical considerations of curve fitting

The array of curve-fitting tools and related topics provided to seminar participants is outlined below.

I. Bounded curve fitting--useful for interpolation between observed data points. Forecasting is between data points. Not often used for extrapolation. Should give accurate fit to existing data points.

A. Default computer curve fits, such as those in Lotus 1-2-3, are bounded. Other curve fits can be obtained, but the default obtained simply by using the "graph" feature is line segments linking dots, used to suggest a smooth curve by a crinkled one.

B. Cubic spline interpolation--a handout was provided illustrating a derivation involving partial derivatives and linear algebra.

II. Unbounded curve fitting--useful for forecasting--fit to actual data points is only approximate. Goodness of fit to actual data points becomes an issue; various statistical techniques for looking at goodness of fit, such as R-squared values, and root mean square errors may be employed.

A. Linear regression. Fitting a line to a set of observed data--using software. Derivation of least squares line using partial derivatives.

B. Exponential. Derivation, beginning with laws of exponential growth and decay, and instruction of how to fit an exponential curve, independent of position of horizontal asymptote. The exponential was seen as but one example of a "power" function. The strategy employed was general and a thorough understanding of the derivation requires knowledge of the calculus through solution of differential equations by separating the variables.

C. Logarithmic. Done in conjunction with the exponential.

D. Logistic. Full discussion of theory. Also instruction on using a computer.

III. Discrete mathematics

A. Population doubling formula--derivation of precise formulation of the "rule of 70" and its extension for arbitrary population multiplication.

B. MapInfo GIS software. Digital mapping is an application of discrete mathematics. Students were shown how to get this GIS to interact with Lotus 1-2-3, after a very brief overview of the GIS capability, so that data other than that provided could be mapped.

Actual data, when graphed over time, can produce all manner of curves. There are many techniques for interpolating values between actual data points. There are also many ways of fitting curves to actual data so that curves fit to actual data can be extrapolated into the future to suggest alternative futures.

The dynamic interaction between population and environment cannot be captured by a single, static curve. To have a notion of where to direct the application of policy to guide future development, it is thus important to consider the variety available in looking at alternative futures. When doing so and using a data set that has "future" data in it, it is therefore critical to know how this data has been projected from actual data: along a straight line, along an exponential curve, or along a logistic curve (to name a few)? Good data sets should tell the user how such projections have been made; if data sets do not so inform the user, then the user should feel obliged to determine this information and pass it along to future users. The only opportunity the user of a data set has to know if the projected data represents an extreme or a moderate forecast, is to know how the projection was made. In data as in maps, the method of projection is critical in understanding where distortion in meaning might occur.

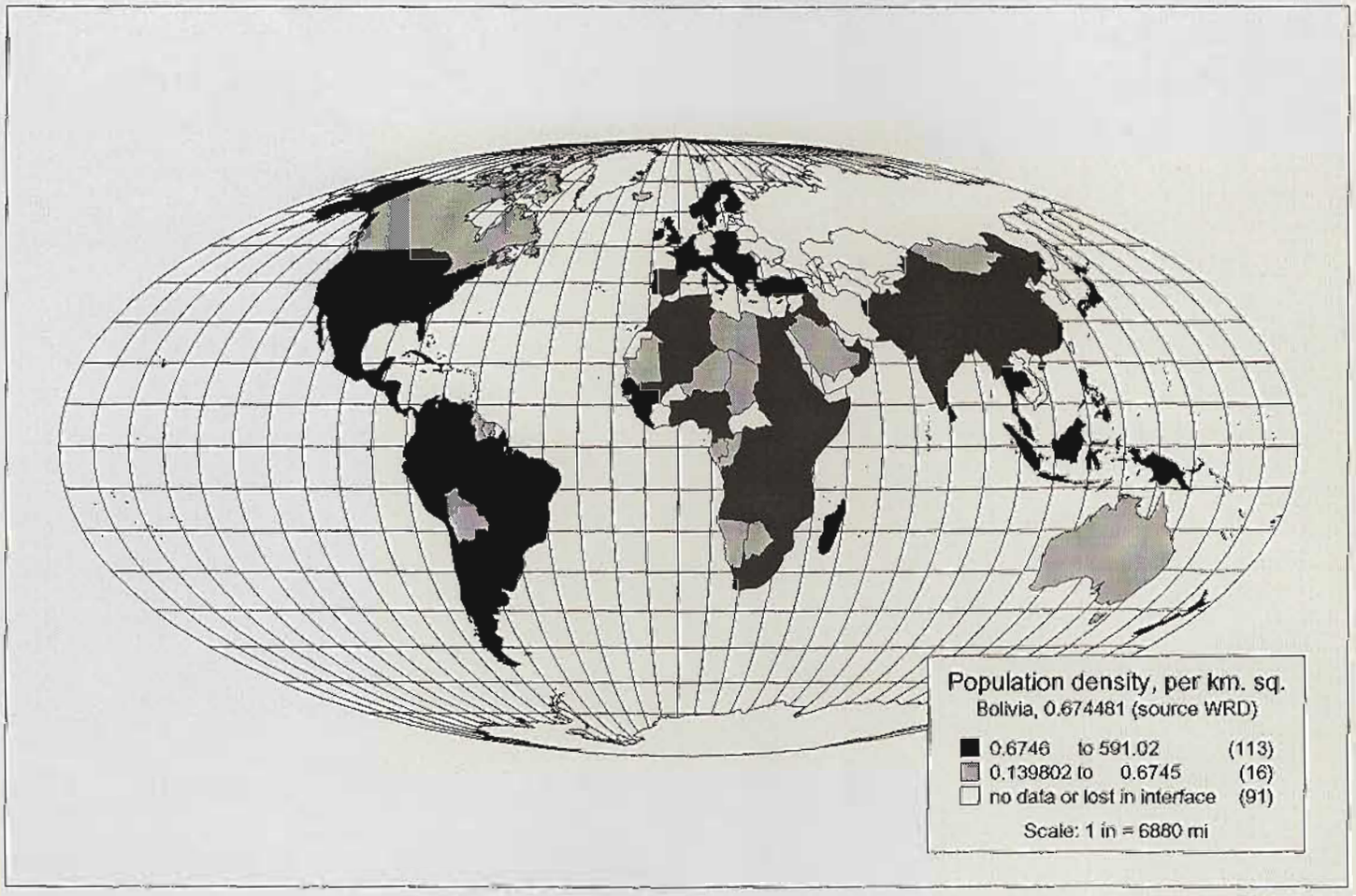
Partitioning data using maps: where to draw the line

As curves may be fit to data, so too may maps be fit to curves, to data, or to both. For this reason, seminar participants were exposed to the presence of Geographic Information Systems, and encouraged to take courses devoted to this single topic, should they wish to learn to do more than make simple maps using this exciting new technology.

The maps separating chapters of this monograph illustrate the idea of partitioning the same data set, in a variety of ways, in order to make visual comparisons. There are 16 papers in this volume, dealing with 13 countries (3 are duplicated). The countries are: Bolivia, Brazil, Costa Rica, Czechoslovakia, Ecuador, Egypt, India, Malawi, Mexico, Namibia, Nicaragua, Spain, and Taiwan. The World Resources Institute Data base (WRD) contains information on population for each of these countries and on land area. Thus, the WRD data could be exported to a Lotus 1-2-3 spreadsheet where density calculations, of people per square kilometer, were easily executed. Then, the spreadsheet density table was imported into MapInfo for Windows and joined to the World table already present in that software to map density values for each of 127 countries. Some data was lost in the interface; for example, one west African nation is called Upper Volta in MapInfo, although its more current name, as it appears in WRD, is Burkina Faso. When names do not match, both are rejected. The base map chosen is a Mollweide projection; this projection is an equal area projection so that comparisons between areas are accurate. A

square one unit on a side represents the same amount of territory in northern Canada as it does in Brazil.

The map preceding each chapter, on colored paper, partitions the population density using the value of the country to be studies; all nations with density greater than the target value are colored black; all nations with density less than or equal to the target value are colored grey; those for which there is no data (or lost data) are colored white. Thus, the target country, in all cases, is the one that is colored grey with the highest population density. Each map shows at a glance, the spatial distribution of all countries with population densities greater than that of the target country (those in black), and the spatial distribution of all countries with population densities less than that of the target country (those in grey). For example, Bolivia has lower population density than almost all of Central and South America; among developing countries, it is in the same grouping as a number of sub-Saharan African countries. The range of countries selected illustrates comprehensive coverage of the logical possibilities available: Namibia has one of the lowest population densities in the world--almost all countries are colored black; India has one of the highest population densities in the world--almost all countries are colored grey. Consider flipping through the colored pages to gain some perspective on how to cut a single data set using different target values; single images coalesce to form a global picture.


Population density, per km. sq.
Bolivia, 0.674481 (source WRD)
0.6746 to 591.02 (113)
0.139802 to 0.6745 (16)
no data or lost in interface (91)
Scale: 1 in = 6880 mi