Population - Environment Dynamics: Sectors in Transition

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PREFACE

This monograph is the product of an experimental course held in the School of Natural Resources and Environment during the fall of 1992. The focus of the seminar was captured in its name "*Population-Environment Dynamics: Toward Building a Theory*". The effort draws upon recent work carried out as part of the University of Michigan's Population-Environment Dynamics Project sponsored by the MacArthur Foundation and the Project for the Integrated Study of Global Change sponsored by the Office of Vice President for Research here at Michigan. Ten graduate students and two faculty participated formally, and several other students and faculty sat in from time-to-time, with one visitor attending every session. Seminar participants came from many disciplinary backgrounds ranging from population planning, economics, engineering, biology, remote sensing, geography, natural resources, sociology, international health, business administration to mathematics. In addition to U.S. students, the course was enriched by colleagues from Mexico, Nepal, Taiwan, and Nigeria.

The seminar began with dialogue about alternative conceptual models for studying the population-environment dynamic. Several frameworks were discussed including 1) dynamic simulation as first developed by Jay Forrester at MIT and then extended by Meadows et al., 2) the application of simultaneous equations to population and environment interactions by William Clark, and 3) transition theory as discussed by Drake in his paper "*Towards Building a Theory of Population-Environment Dynamics: A Family of Transitions*".

Dr. Sandra Lach Arlinghaus, one of the faculty participants, provided training on nonlinear curve fitting, both bounded and unbounded. We are particularly appreciative of Dr. Arlinghaus' active involvement as she volunteered all of her time to this endeavor. Course participants also were exposed to representative state-of-the-art PC-based Geographic Information Systems: ATLAS GIS, version 2 and MAPInfo for Windows. Although there was broad exposure to these GIS packages, the software was used in this course primarily as a tool for organizing and displaying population-environment data. Another element of this course was the examination of newly available longitudinal data useful in measuring the status of human population and the environment. Most notable among these data sets was the World Resources Data System, but other sources such as the Digital Chart of the World and the data sets contained in ATLAS GIS and MAPInfo also were utilized.

As true for most courses, a major reason for the success of the seminar was very enthusiastic student participation. Students presented their topics of concentration twice, once at the early stages of development and then in complete form near the end of the course. Feedback was provided by all participants at different points of development.

In addition to specific feedback, each participant's broader area of expertise ***and perspective*** was utilized by the other members of the seminar.

This volume consists of eleven 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 chapter. 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.

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CHAPTER 1: INTRODUCTION

This volume is a study of the relationship between human populations and the environment. The effort consists of nine separate 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 outlines the analytic tools for curve fitting especially useful in applying transition theory. Next, the nine studies undertaken by individual investigators are presented, utilizing 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 developing this approach to analysis.

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 unbalanced. 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

[1]This material has been condensed from the original paper by W. D. Drake, "Towards Building a Theory of Population-Environment Dynamics: A Family of Transitions" in *Population-Environment Dynamics*, Ann Arbor, University of Michigan Press, forthcoming in 1993.

small amounts so total population rises only very 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 by-products 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 help 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 area 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 discussed earlier that the notion of transitions apply across all sectors of investigation. The classes of transition, from demographic, to toxicity, to forestry, to agriculture, to urbanization, to energy or to epidemiologic exhibit 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. These are clearly nonlinear systems but ones which have properties that lend themselves to well-understood mathematics.

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 geographical 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 the 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 if 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 setting 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 composed 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 happen. 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 transition, 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 is 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. TRANSITIONS AND MATHEMATICS: FITTING CURVES TO EMPIRICAL DATA

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. The array of topics provided to seminar participants is outlined in the next section.

I. Continuous Mathematics

A. Curve fitting

i. Bounded--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. Cubic spline interpolation. Derivation, requiring partial derivatives and linear algebra, provided.

ii. Unbounded

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 b.

d. Gompertz--this tool of the actuary, used in the preparation of life expectancy tables, was also presented as one S-shaped curve that appears in considering population dynamics. Computer software was used to make curve fit to data.

e. Logistic. Full discussion of theory. Also instruction on using computer.

f. Alternative ways of thinking about fitting--problem noted that least squares emphasizes role of outliers. Illustrated how to fit a line to a set of data using absolute value of vertical distance of observed value from line and how to fit a line to a set of data using the Euclidean metric.

B. Geometric Feedback and Chaos

i. Feedback--role of the line y=x in Feigenbaum's graphical analysis.

ii. Fixed points and their interpretation--repelling points serve to push process away; attractive points serve to pull it.

iii. Geometric dynamics--cycles in chaotic orbits--emphasis on the role of the horizontal asymptote as a "limit to growth." The mathematical possibility of curves crossing the horizontal asymptote mirrored the notion of going "beyond the limits" with alternative futures forecast by various mathematical models.

II. Discrete Mathematics

A. Systematic partitioning into mutually exclusive classes--a standardizing measure for transitions based on diagrams similar to those used for soil samples--transition profiles. Application to forestry transition graphs from Drake chapter.

B. Difference equations--used to illustrate one way to fit a polynomial to a data set. Useful for interpolation of real data sets.

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

D. Atlas GIS and MapInfo software. Digital mapping is an application of discrete mathematics. There were several computer demonstrations of how to use each of these PC-based Geographic Information Systems. Topics focused on were the suitability of map projections and display strategies for different types of data. Students were also shown how to get these two GISs to interact with Lotus 1-2-3 so that data other than that provided could be mapped.

3. AN OVERVIEW OF THE INDIVIDUAL INVESTIGATIONS

As part of their work, each seminar participant prepared an abstract of their work. These abstracts are presented below.

Chapter 2. Dawn M. Anderson.

The Historical Transition of Forest Stock Depletion in Costa Rica.

This paper addresses the issue of deforestation in Costa Rica and its position in the realm of population-environment dynamics. It does this by exploring the historical transition that has occurred from the time when most of Costa Rica was forested through the periods of timber exploitation, agricultural expansion, cattle ranching and the effects of the demographic transition to the point where reforestation is occurring and there is a tremendous effort to protect the last of the forested lands through the formation of parks, reserves, and biospheres. The analyses is based upon these efforts to protect the last of the forested lands and, through the use of a model, to explore possible projections of future limits to deforestation.

Chapter 3. Katharine A. Duderstadt.

The Energy Sector of Population-Environment Dynamics in China.

China currently holds one-fifth of the world's population. As population growth increases, the country will require more energy to provide subsistence for its people. Because of massive deforestation in recent decades, traditional fuels are being replaced by other energy alternatives. As the country boasts the third largest coal reserve in the world, coal will no doubt remain the primary energy source in the near future. The burning of coal, however, contributes heavily to air pollution. This paper discusses the history and problems of energy production in China and presents predictions based on current trends. The approach focuses on transition theory and dynamic systems modeling. The goal is to present an analysis of energy use in China and stress the necessity of policy implementation toward higher energy efficiency and alternative energy use.

Chapter 4. Eugene A. Fosnight.

Population Transition and Changing Land Cover and Land Use in Senegal.

Population growth is limited by the ability of the land to support increased food production, and food production is limited by the soil potential and the availability of precipitation. The limit to population growth is defined by the human carrying capacity of the land. In Senegal population growth was compared to the human carrying capacity for the entire nation and for seven administrative units. The urban administrative units can no longer support their population growth and even the rural units are quickly approaching their human carrying capacity. Several steps must be taken to limit the food deficit. The population growth must be limited, agricultural yields must be improved, and sustainable agricultural practices must be introduced.

Chapter 5. Katharine Hornbarger.

The Energy Crisis in India: Options for a Sound Environment.

Energy is often considered to be the fuel of economic growth and development. A direct correlation exists between aggregate economic growth and aggregate consumption of energy, as well as between per capita GNP and per capita consumption of energy. Thus, it is not surprising that the differences in the levels of per capita energy consumption among developing and industrialized nations are dramatic. However, a review of the *growth rates* of energy consumption in both developing and industrialized countries reveals that these differences will become less significant in the future. The growth rate of energy consumption in developing countries during 1980-85 was 5.7%, as compared to 0.1% on average in industrialized countries. Given such a high growth rate, certain questions necessarily arise. What forms of energy currently are being employed in developing countries, and what are the trends in terms of future energy exploitation and consumption? What impact will these trends have upon existing energy reserves and resources? More importantly, what impact will these trends have upon the global environment? This paper examines these questions in the context of India, a developing country which, up to this point, has relied heavily on fossil fuels to respond to domestic energy demand. India currently is facing an energy crisis, as total energy requirements consistently have exceeded available energy supply for over two decades. The policies that India could pursue to respond to this crisis will have a definitive impact on the global environment. India *could* choose to increase its reliance on fossil fuels: the impacts of this strategy on the global environment, in terms of increased CO_2 emission, are well-known. On the other hand, India could focus not only on improving the energy efficiency of its products, but also on developing the mechanisms necessary to exploit alternative energy sources. India's ultimate choice, and the choice of many other developing nations, depends upon the actions of citizens and policy-makers throughout both the developing and the industrialized world.

Chapter 6. Deepak Khatry.

An Analysis of the Major Sectorial Transitions in Nepal's Middle Hills and their Relationship with Forest Degradation.

Major sectorial trends in the middle hills physiographic zone of Nepal were examined from a review of literature and government documents. Available data were projected under different assumptions in order to assess future scenarios. Variations in data caused projections to vary widely. Nevertheless, broad patterns and trends were discerned. Tentative conclusions were drawn and policy recommendations made based upon observed trends and patterns. The population in the hills is expected to continue growing as Nepal begins a demographic transition. The need for agricultural intensification to meet the increased food demand of a growing population is expected to contribute to forest degradation, as the subsistence hill farming is dependent upon forest biomass. The energy needs of the growing population is expected to exert further pressure on the forests. In is argued that the population growth has already triggered a negative feedback loop between agricultural intensification, forest degradation, and soil erosion and that the loop will get tighter unless urgent and prudent action is taken by the policymakers and administrators.

Chapter 7. Catherine MacFarlane.

The Interrelationship Between the Forestry Sector and Population/Environment Dynamics in Haiti.

Because of its fertile and forested land, Haiti was once known as the "Pearl of the Antilles." Over the past century, an increasing population has forced the peasant farmers, the majority of the population, to clear steeper and steeper hillsides to convert to farmland. Up until the French and Spanish colonialists arrived in the 16th through the 18th centuries, the Caribbean island of Hispaniola, which consists of Haiti and its neighbor to the east, the Dominican Republic, was nearly 100% forested. In the Dominican Republic, that figure now stands at about 12%; in Haiti, a mere 2% of the original forest cover remains. A once productive country has converted into a barren, inhospitable land.

The demographic transition of Haiti is reviewed and population figures concerning Haiti are compared to those of the Dominican Republic. An analysis of the forestry transition shows how a slowly burgeoning population has caused the ruin of Haiti's forests, and consequently, its farmland. Final consideration is given to some potential and vitally needed reforms to slow population growth, to lessen the soil erosion from the hillsides, and to ease the burdens that the Haitian people are facing on a day-to-day basis.

Chapter 8. Gary Stahl.

Transition to Peace: Environmental Impacts of Downsizing the United States Nuclear Weapons Complex.

The end of the Cold War has brought with it hope for a rapid reduction in the United States military industrial complex. The environmental degradation resulting from decades of arms manufacture has been severe. Nowhere is the damage more severe or more lasting than in the area of nuclear weapons manufacture. During the Cold War national security concerns outweighed environmental and even public health concerns. Secrecy limited public awareness of the extent of the problems. This paper examines the environmental legacy of the United States nuclear weapons complex and the potential for change.

Chapter 9. Stephen Uche.

Population and Forestry Dynamics: At the Crossroads in Nigeria.

The fate of Nigeria's environment hangs in the balance. Ethiopia and Somalia, which are today plagued with droughts and famines, were as recently as the 1930s, known for the richness of their genetic diversity. Drought-stricken Mali was once known as the breadbasket of Africa. Niger, Chad and Sudan to the north and east of Nigeria, are suffering from environmental crises which were non-existent in the past few decades.

Keeping a unified vision of the contribution of each of a variety of efforts is essential in any scheme of rebalancing the Nigerian environment. Discerning and working on the primary causes of environmental deterioration will yield the greatest returns and help avoid cosmetic or superficial action-plans or the wasting of valuable resources that should be directed at the underlying causes of the problem. Causes rather than symptoms should be cured. There is now hope that the full dimensions of the crisis, and the potential, irreversible nature of the damages are being fully articulated. There is a need to focus research, policy, and all action plans on the long-range solutions, keeping national commitment and priorities on the responsibility to protect Nigeria's environment for future generations.

Chapter 10. Hurng-jyuhn Wang.

The Cultivated Land--Rural Industrialization--Urbanization--Population Dynamics in Taiwan.

For decades, Taiwan has been successful in economic development. A series of policies in agriculture, demography, and industrial development are keys to successes. This paper examines the major sectorial trends that affect the cultivated land area in Taiwan. The agriculture transition in Taiwan is approaching diminishing returns. The rural industrialization and urbanization are two driving forces that cause the transition of cultivated land. The demographic force that drives most other socio-environmental processes is also close to its final stage. As a result, aging population and comprehensive family planning programs need to cope with this force in the 1990s.

4. EVIDENCE FROM MAPS

There are two sets of maps that accompany the text in this volume. First, there is a set of global maps showing the distribution of the earth's countries according to eight different variables. Each of these variables is one that arises in examining sectors of transitions in population-environment dynamics. Some of these maps are simple dot maps; others are thematic maps in which the values of the displayed variable have been split into four classes of roughly equal size shaded according to class. All are drawn using data from MapInfo; "equality" apparently means some sort of balance between equality of number of entries in each class and range of interval covered. Further description follows. These world maps are all drawn on an Eckert VI projection which is an equal area projection; a unit square on the map represents the same amount of land regardless where that unit square is placed on the map (not the case, for example with a Mercator projection, in which Greenland is obviously disproportionately large). Data from MapInfo was used in generating these maps; countries for which there is no data are crossed by parallels and meridians (if they are large enough). In many cases, the quality of the data is highly questionable. For example, estimates of the Nigerian population range from 88 million to 122 million in various sources. Unemployment figures are also extremely unreliable; again, the figure of 0.7% for Nigeria is quite questionable. Sources for the data are apparently from standard, recent (1990) sources, such as censuses, but documentation giving full citations is not evident on-line.

World: Distribution of Capitals of Countries.

This map shows the capitals of countries in their correct location as open circles against a backdrop of shaded land. Capitals are generally seats of decision making where policy is concerned and so they are displayed, here, first.

World: Percent of Land Arable, by Country.

World: Distribution of Total Population.

In this map, the reader should note that each dot represents 6 million people. The dots are not accurately placed, and dots do NOT represent cities; the MapInfo documentation states that the dots are placed at random within national boundaries. The map just shows, in some very general way, how population is distributed on a country by country basis--thus India and China have heavy concentrations of population, but within the country boundaries, the population is not necessarily located where the dot is located.

World: Population Growth Rate, Percent by Country.

World: Literacy Rate, Percent by Country.

World: Inflation Rate, Percent by Country.

World: Unemployment Rate, Percent by Country.

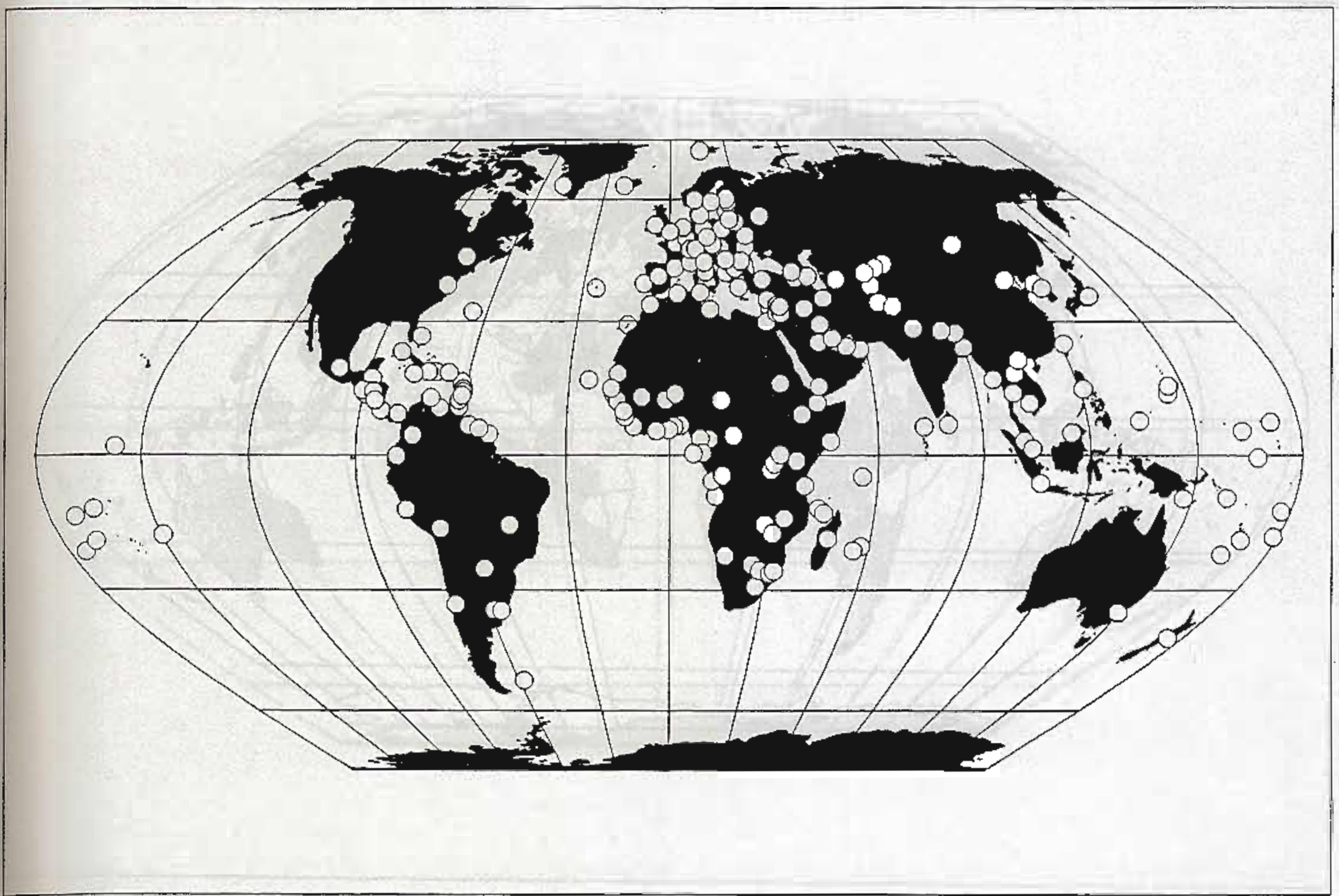
World: Industrial Growth Rate, Percent by Country.

These world maps appear in a group following this chapter.

A second set of maps is used as dividers, on colored paper, between each chapter. On each, a map of the student's study area is given. On this map, the national capital is noted, as are all major cities. The national capital is noted as a filled star and cities are noted as filled dots. In each of these, the filled dots do represent actual locations and offer a locational slant on where the population is located WITHIN national boundaries. Each dot represents a "large" city, according to on-line ATLAS GIS information. Data is from 1990 or later. These maps were drawn using ATLAS GIS on a Robinson projection. This is not an equal area projection but is a "compromise" projection on which both area and shape are reasonably good. Below each country map is a table showing data for each of the eight variables portrayed on the world maps, specified to the student's country. These data were taken from MapInfo and are of highly varying degrees of reliability, as noted above.

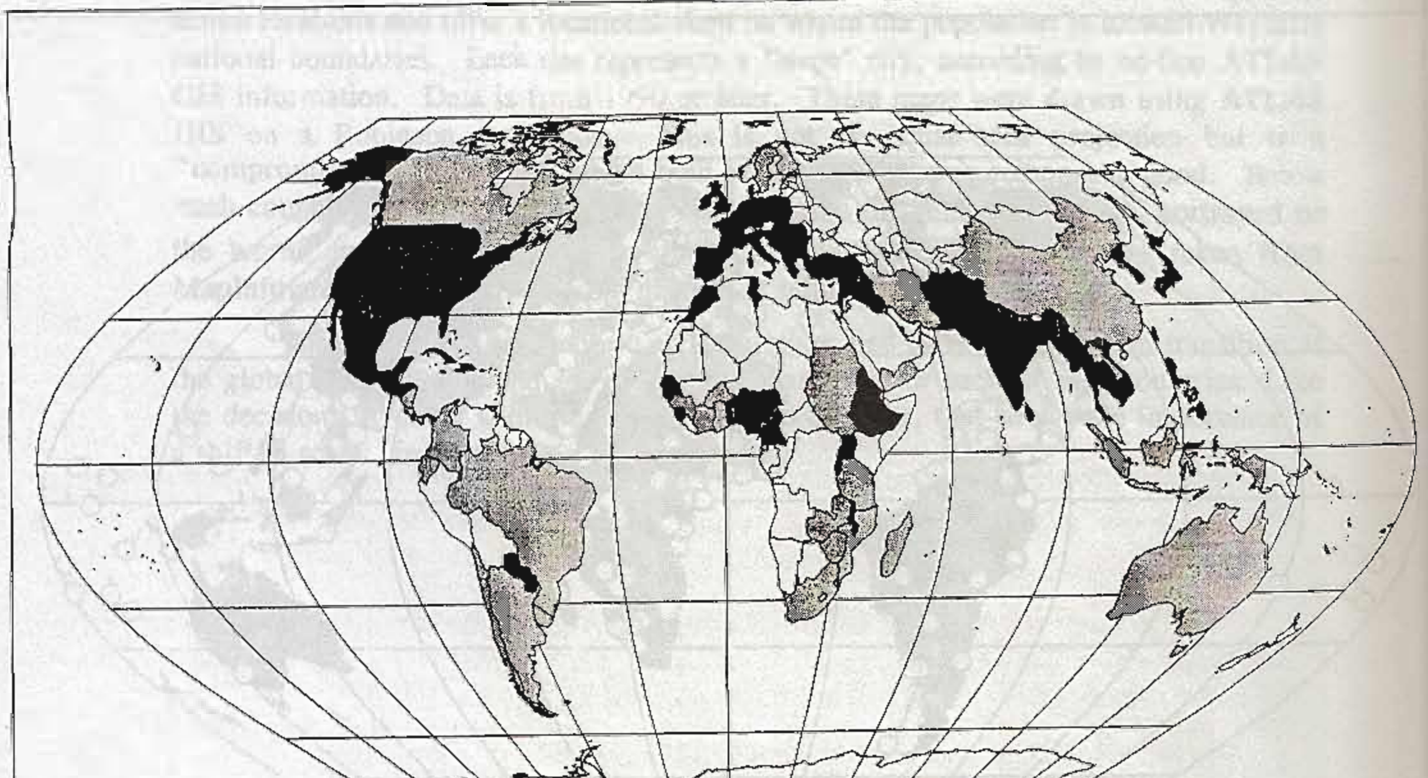
The first set of maps shows eight variables tied to world sectors in transition at the global scale; the second set shows these variables for each of nine countries. Like the decisions involved with the data, the choice of maps, too, shows the importance of a shift in scale: from global to regional.

WORLD: DISTRIBUTION OF CAPITALS OF COUNTRIES



The open circles represent capitals of countries
--centers of policy formation and implementation--
of the World.

WORLD: PERCENT OF LAND ARABLE, BY COUNTRY.



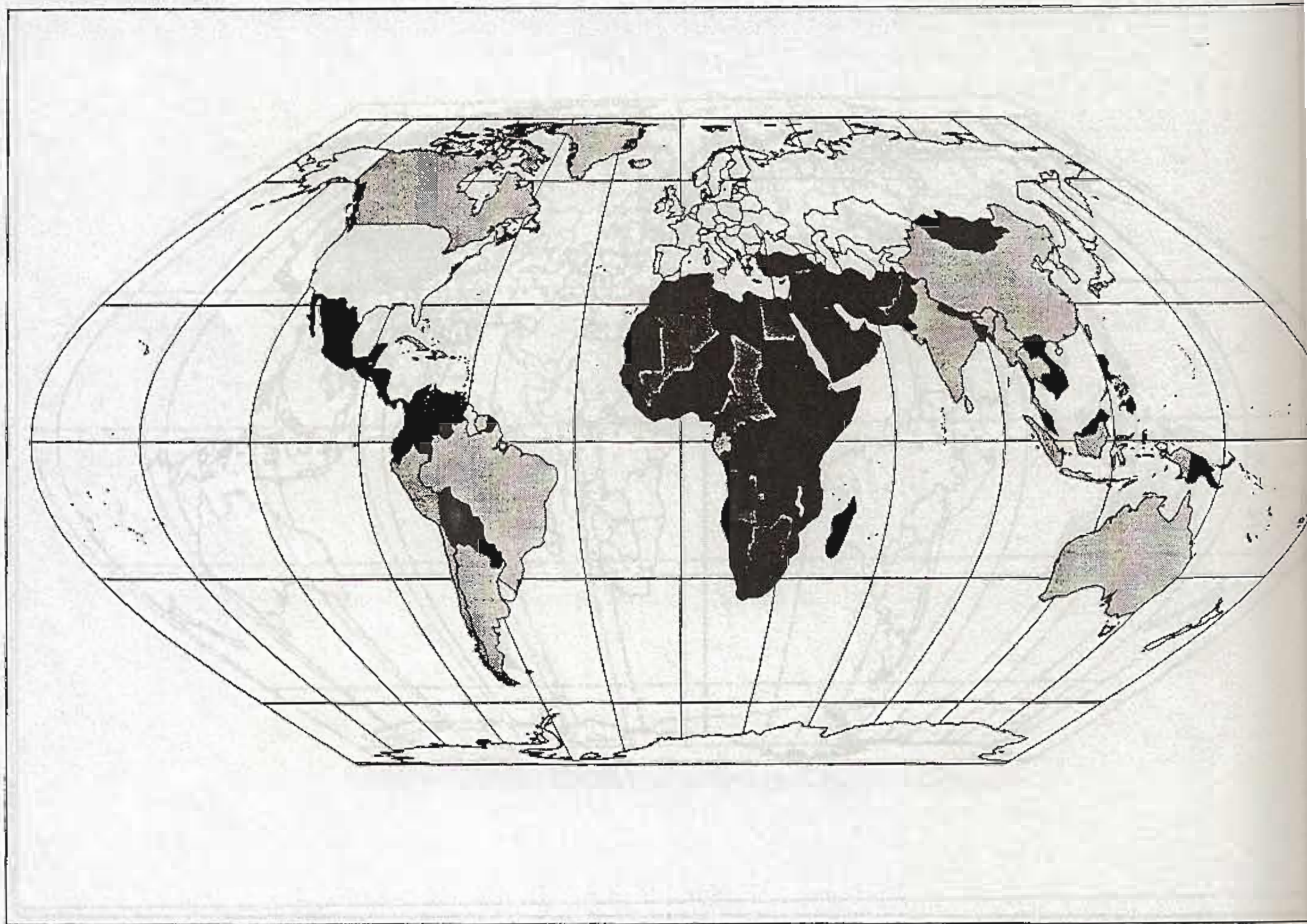
WORLD by Arable_Pct

- 23 to 77 (45)
- 11 to 23 (41)
- 4 to 11 (45)
- 1 to 4 (38)
- all others (51)

WORLD: DISTRIBUTION OF TOTAL POPULATION

One dot represents 6 million individuals.
Within a single country the positions of the dots are not accurate.
This dot map suggests which countries have heavy concentrations of people.

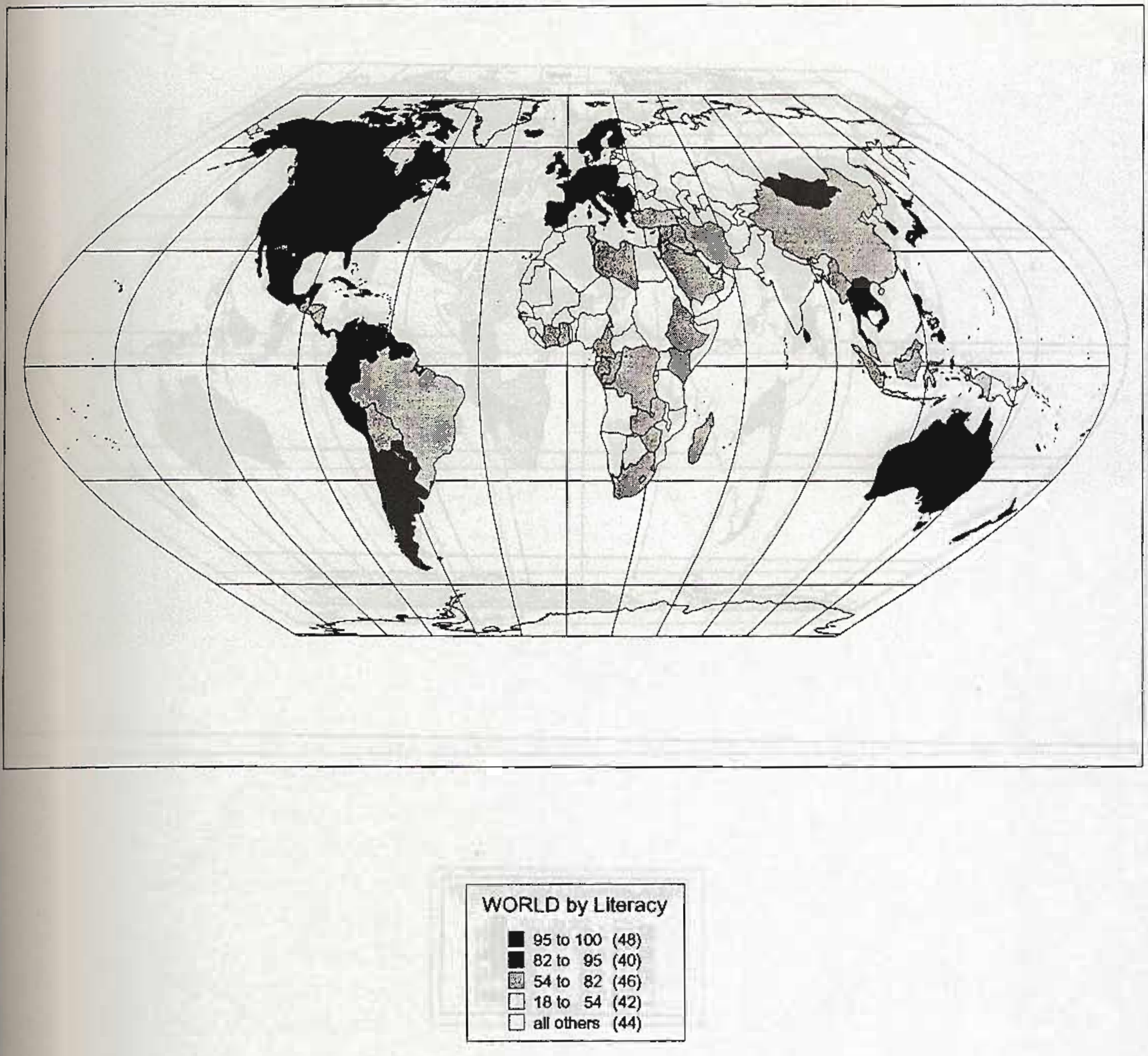
WORLD: POPULATION GROWTH RATE, PERCENT BY COUNTRY.



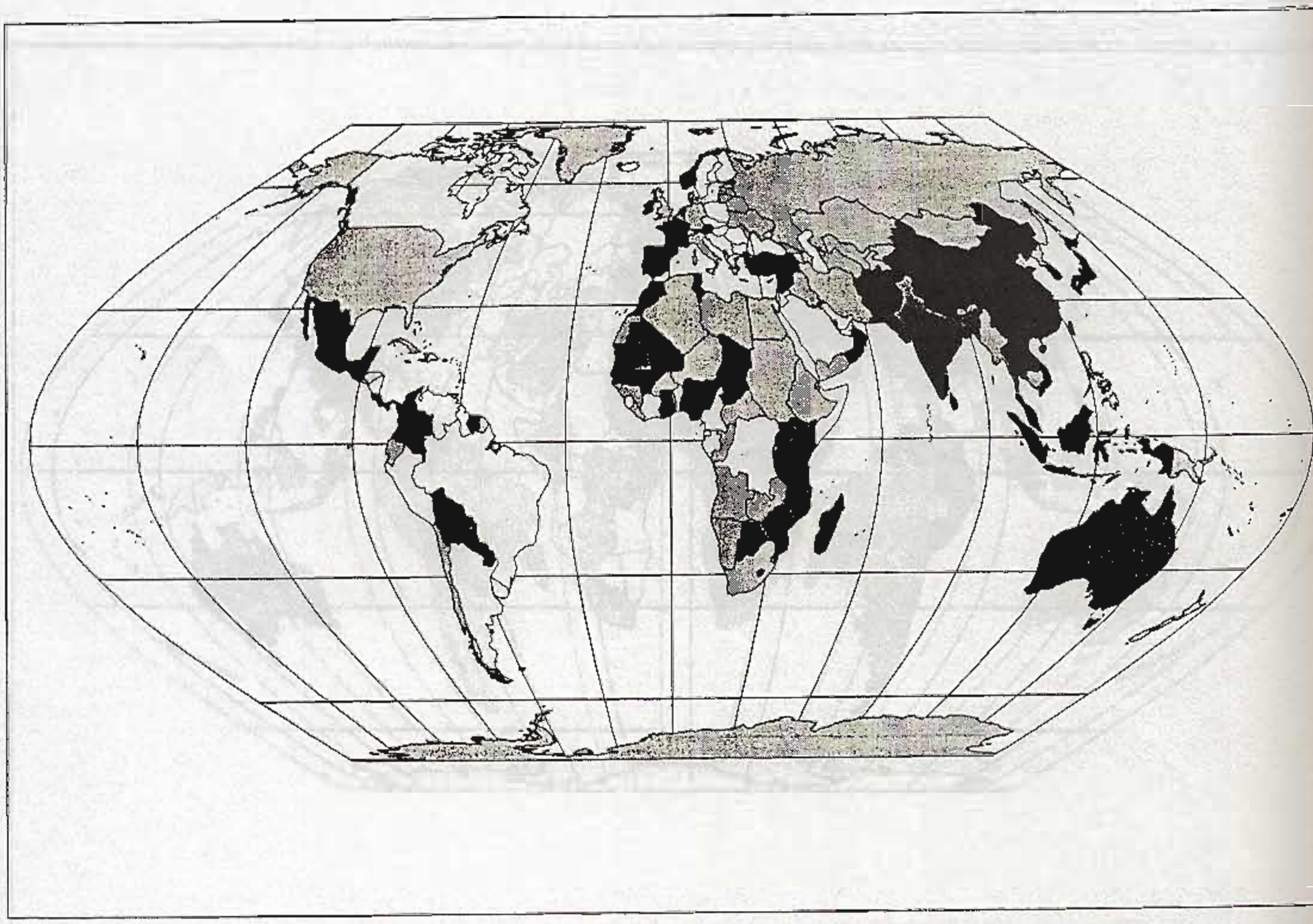
WORLD by Pop_Grw_Rt

- 3 to 6.3 (51)
- 2.1 to 3 (50)
- 0.9 to 2.1 (45)
- -0.4 to 0.9 (74)

WORLD: LITERACY RATE, PERCENT BY COUNTRY.



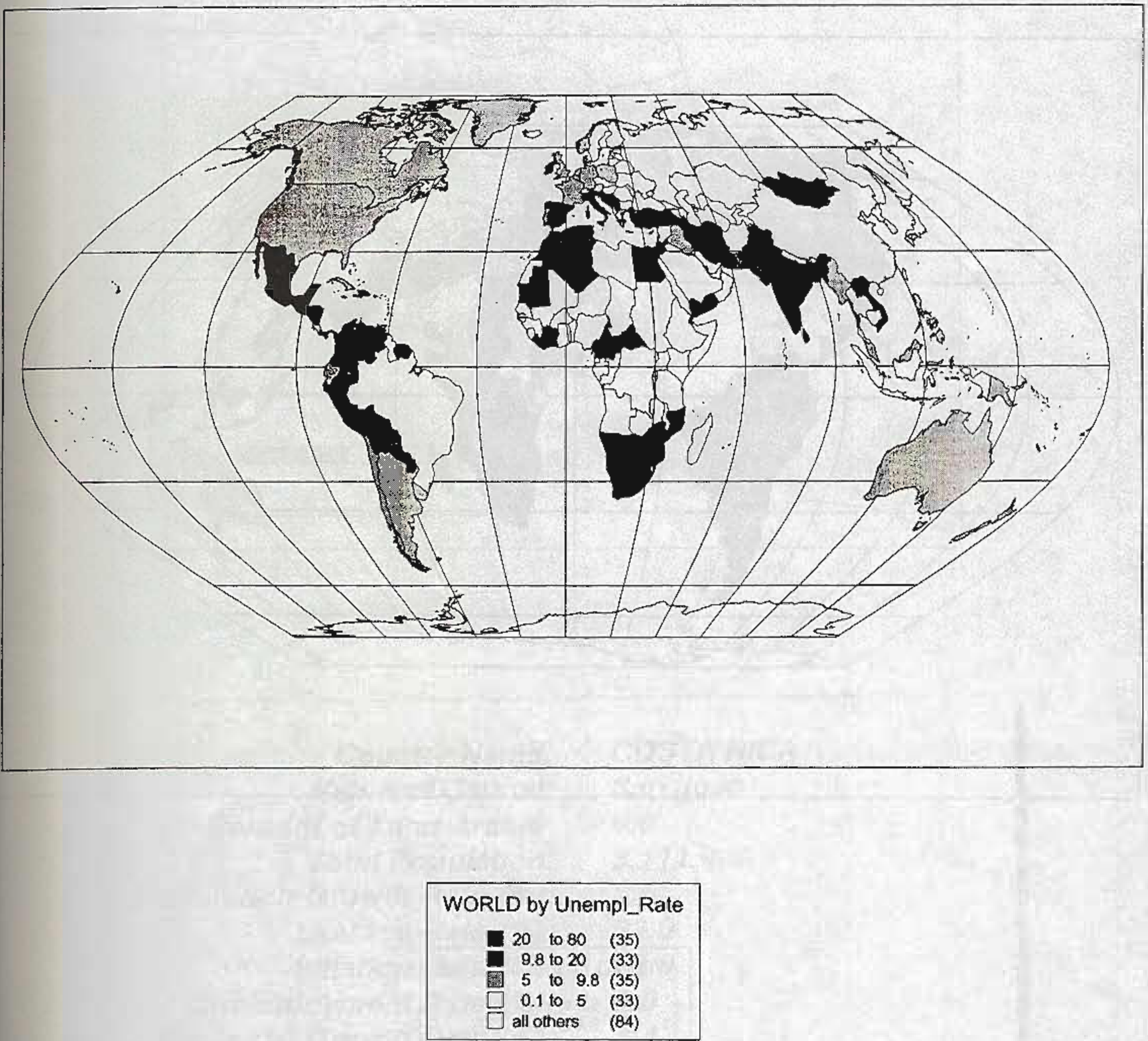
WORLD: INFLATION RATE, PERCENT BY COUNTRY.



WORLD by Inflat_Rate

22.9 to	11800	(45)
8.6 to	22.9	(46)
4.1 to	8.6	(45)
-4.9 to	4.1	(84)

WORLD: UNEMPLOYMENT RATE, PERCENT BY COUNTRY.



WORLD: INDUSTRIAL GROWTH RATE, PERCENT BY COUNTRY.