STABILITY IN RURAL COMMUNITIES: MYTH OR REALITY?

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Nothing endures but change.

Plato, 402 A.D.

Introduction

Throughout the world there is ample evidence of the truth of Plato's immortal words. Whether looking at the urban greening, economic growth or the contribution of automobiles to global warming, it is clear that change--frequently rapid change--is the norm. Consequently, the study of change--through a variety of basic theories including systems, chaos, and complexity theories--has made its way into nearly every scientific discipline.

The USDA Forest Service was created in response to rapid change in the condition of forest lands throughout the United States. The rapid deterioration of the these lands from logging activities led to the call for government protection of forests and watersheds. From its inception, the Agency has had the dual mission of caring for the land and serving the people. Caring for the land has traditionally been interpreted as providing for a sustainable yield of goods and services from the forests. Serving the people has traditionally included both managing the land for the goods and services it provides (ranging from timber to recreation) as well as concerns about the economic well-being of rural communities in and around the boundaries of national forests. Like the policies geared toward the forested ecosystems it is concerned with, the Forest Service's rural development policies have worked toward stability in the belief that a stable stream of commodities produced from the forests would contribute to socioeconomic stability of communities.

The idea of stability in rural communities is the focus of this paper. It may seem profoundly obvious that rural communities have not, should not, and cannot be stable entities. It is not likely that anyone would argue that urban communities have been stable over the last century or even recent decades. Rural communities are subject to changing social, political, economic, and demographic forces, just as other communities (the nature of the impacts of these forces may vary across rural and urban areas, but their presence is felt regardless of location).

This analysis consists of six sections. The first two sections provide a broad overview of issues related to rural communities as well as the Forest Service's history with rural development. The third section of the paper focuses on transition theory and what it has to offer to the understanding of rural communities. Sections four and five focus on rural communities in the three Lake States of Michigan, Minnesota, and Wisconsin. It will become apparent that rural communities have been anything but stable through a presentation of the data (section four) and subsequent discussion (section five). The final section of the paper focuses on policy implications as well as suggested future research directions that may be fruitful for exploring change in rural communities.

Pressing Issues in Rural America

It is difficult to make sweeping generalizations about rural communities in the United States. They are as varied as the country they spread across. As I write this paper I look out my window at land dotted by family farms, many are registered centennial farms (owned and operated by the same family for at least 100 years). I am a urban-flight homeowner--I came to this rural village of 2,000 residents for peace and safety. Our township meetings are indicative of the concerns of farming communities across America where farmlands meet the urban fringe--how to keep family farms from being engulfed by the urbanization occurring around them. Our issues and concerns would seem familiar, yet quite different to those in the Pacific Northwest where national attention has focused on the conflict over old growth forests. As they struggle to maintain their way of life, many loggers feel they are being portrayed as the villains in the destruction of the nation's forested heritage--a national policy debate about the appropriate uses of the natural environment surrounds these small towns. Contrast my small village and the situation in the Pacific Northwest with the issues surrounding rural communities blessed with rich and abundant scenic and recreation resources such as Jackson Hole, Wyoming or Mono Lake, California where rapid growth and escalating property costs related to tourism development are pushing rural residents out of their communities. These examples of the diversity of conditions and issues in rural America may lead one to think it isn't possible to talk about rural communities as a whole. The one issue that unites these communities is change. Understanding the patterns and driving forces of change in rural communities is perhaps the paramount issue for those studying and seeking to serve rural communities (Flora, et al., 1992).

Four key issues are involved in change in rural America: demographic, geographic, social/cultural, and economic changes. Seemingly regardless of the nature of change occurring in a rural community, each of these issues comes to bear in one form or another.

Demographic change is perhaps one of the best documented phenomena related to change in rural areas (c.f. Flora, et al., 1992). Census data abound that illustrate the dual phenomena of declining populations in some areas and rapid influxes of population in other areas. For example, the phenomena of naturally decreasing populations (death rates being higher than birth rates) occurs nearly exclusively in rural areas (Johnson and Beale, 1993). Even where natural decline is not occurring, many rural areas are experiencing substantial outmigration of their young people in search of education and employment (Brown and Glasgow, 1991). At the opposite end of the spectrum, rapidly increasing populations in urban fringe, resort, and retirement areas are having dramatic impacts on the social and natural environments in rural America (Platt and Macinko, 1983).

Geography plays a critical role in rural community's evolution. Proximity to large metropolitan areas or regional centers is one of the major influences on change in rural areas. Close proximity brings a variety of resources ranging from access to education and employment opportunities (with a subsequent lessening of population declines) to availability of diverse products and services not available to more remote rural communities (Walzer and Stablein, 1981). Close proximity may also bring rapid land use change (e.g. farmlands being developed into residential areas), a loss of locally-based businesses, and large influxes of "outsiders" (Flora, et al., 1992; Platt and Macinko, 1981).

Social, cultural, and economic changes have been alluded to in the previous two paragraphs. Influxes of new people, losses of native people and businesses, local people commuting out of their community for work and to obtain goods and services all have substantial impacts on the social, cultural, and economic fabric of rural communities. Economic changes are far better documented than the social or cultural impacts and changes. Loss of economic diversity, high unemployment and poverty rates, and lower incomes are well documented conditions in rural America (e.g. Bernat, 1993; Tolbert and Lyson, 1992). Social change in rural areas is less well documented, but is discussed widely in the literature as being critically important (e.g. Machlis and Force, 1988). Issues of institutional breakdown, community solidarity and personal identity, and attachment to place are of central importance to understanding change in rural America. The very concept of community is itself a social institution undergoing change.

The cumulative effect of these changes in rural communities is well summarized by the GAO Report on Rural Development (1992). The background statement for the report is brief, but provides an poignant picture of change in rural America. It reads:

> Since the early part of the century, population movement has been away from rural America to metropolitan areas, encouraged in part by greater economic opportunities--higher-skill, higher-paying jobs--and easier access to services in urban centers. This movement has contributed to a cycle of increasing difficulties for rural America. As businesses fail or leave and new businesses do not replace them, the local tax base shrinks. In turn, the amenities that would attract and retain businesses and people--good medical services, roads and bridges, quality education, and housing--are neglected or not developed. In addition, rural communities are unable to fund programs to meet federal and state mandates, such as environmental requirements for clean water. With fewer or low-paying jobs available to them, those rural residents who remain have less incentive to improve their skills and qualify for higher-paying jobs

and/or lack educational opportunities to do so. Leadership and community cohesion are impaired, leading to further business failure or flight."

Discussing the idea of stability in rural communities given the abundance of changes occurring in rural areas may seem to be a ridiculous topic, but the concept of stability is as prevalent in the literature on rural communities as is the concept of change.

Rural community stability is most widely discussed in the context of natural resource based areas. Definitions of stability are laced throughout the literature on rural development and vary based on the specific discipline being employed. Classic definitions of community stability incorporate three factors: (1) having a diversity of functions within the community; (2) having well-defined personal roles; and (3) changes occurring slowly enough to allow for adaptation--"social conditions are stable if the changes which are taking place do not frighten the affected" (Dessauer, 1949). Many contemporary treatments of stability have seemed to focus on maintaining the status quo, constancy, or modulated and ordered change (Machlis and Force, 1988). The concept of community stability has been prevalent in the Forest Service's rural development policies and is the central concern of this paper.

Rural Development in the Forest Service

The Forest Service has a long history of concern and involvement with rural communities. As early as the turn of the century, agency personnel have linked the sustained yield of forest commodities to stable, prosperous communities (Drielsma, et al., 1990). The dual concepts of sustained yield and stable communities came to the United States from Europe, primarily Germany where they had been practiced since the late 1700s (Behan, 1975). The conditions of forests and communities in the United States have been argued to be much different than those of Germany and questions of whether these concepts can be appropriately applied to the United States given that they were developed under radically different social, economic, political, and ecological conditions have recently been raised (see Lee, 1990 for a more detailed discussion of this point). From the perspective of transition theory used in this paper, the appropriateness of prolonged stability is questioned on a deeper level--is stability, with only slow, orderly change a realistic or beneficial goal for rural development policy--regardless of the European versus United States distinction?

Much of the traditional thinking related to land management and other issues of concern to the Forest Service, including rural development has itself been in transition. As early as 1990 and clearly with the implementation of the Ecosystem Management policy in 1992 there has been a clear shift in the Agency's thinking about its mission of caring for the land and serving the people. Ecosystem Management has been defined as "the use of an ecological approach that blends social, physical, economic, and biological needs and values to assure productive, healthy ecosystems" (USDA

Forest Service, 1994). Ecosystem Management offers a significantly different view of the goals of land management, moving away from single value commodity production to a more holistic sustaining of natural and social systems (Mrowka, 1993).

Ecosystem Management has had two important impacts on how the Forest Service thinks about rural communities. First, there is explicit recognition of the idea that people are part of ecosystems, rather than external to them. This has led to a whole new way of thinking about rural communities as integrated parts of the landscape. Efforts to facilitate the integrated understanding of the human, physical, and biological dimensions of ecosystems are numerous and growing rapidly throughout the Agency (USDA Forest Service, 1993). The second impact Ecosystem Management has had is related to the dynamic nature of ecosystems. Under this new policy, change is given significant attention as a driving force in ecosystems (including the human dimension of ecosystems). With reference to rural communities and rural development new language and policy goals have emerged emphasizing enhancement, enrichment, improvement, vitality, and health of communities where once stability was the focus (USDA Forest Service, 1990).

These shifts in thinking make an examination of change in rural communities particularly timely. As the Agency looks to embrace ideas of change in its policy and decision making, its understanding of the dynamics of resource, economic, social, and technological change in rural America is limited (USDA Forest Service, 1991).

Transition Theory

Transition theory as developed by Drake (1993) is an effort to strike a "balance between the complexity required to portray intricate relationships [in population/environment dynamics] adequately and the simplicity required for analytic manageability" (Drake, 1993 p. 301). Most social scientists are familiar with the demographic transition in which a (developing) society experiencing high birth and death rates undergoes some change or combination of changes that lowers the death rate, soon followed by a lowering of the birth rate. This transition is often the focus of organizations attempting to assist developing countries.

Drake extends this well documented phenomena to explore a much wider array of population/environment relationships with the concept of a family of transitions across human and physical/biological sectors. A transition is defined as "a specific period of time which spans the shift from slow to rapid change in the sector and then usually a return again to relative stability." Transitions discussed by Drake include changes related to deforestation, toxicity, agricultural, energy, urbanization, technology, and education.

There are three key aspects to understanding transition theory. First, it orients the phenomena being examined in both time and space. This may seem like an obvious or unimportant point, but it is critical to the advancement of understanding of human/environment relationships to have temporal and geographic context--something frequently overlooked by other social science theory. The second key point is that transitions involve periods of stability and change. In the Forest Service it may be tempting to see stability as a goal to work toward, implying that stability always results in a positive outcome. It is important to note that in the context of transition theory, stability does not necessarily imply a healthy or favorable outcome. The example used by Drake relates to the outcomes of a transition involving increased population pressures in an arid environment. The stable outcome of this transition may be a desert resulting from massive soil erosion; stable--yes--desirable--not likely. From a rural community perspective, a period of rapid changes in employment opportunities can either lead to a vigorous, diversified economy or a veritable ghost town. Both conditions are fairly stable but no one is likely to argue that a collapsed town is a desirable outcome. The third point relates to the relationships among transitions. Transitions can be found across sectors and societies, particularly in recent times where changes in populations and environmental conditions have been rapid. Transitions rarely happen in isolation and tend to have comparable effects on societies. As the study of transitions advances, it is possible to begin to discern patterns of transitions and their subsequent impacts across sectors of societies.

Transition theory has much to offer in the exploration of change in rural communities, particularly within the context of Ecosystem Management. First, by its very nature, it focuses on the integration of the human, physical, and biological dimensions of ecosystems--something the Forest Service is struggling to do in all aspects of its land management activities. Second, transition theory is not based on the premise of finding "one right answer" as much of scientific activity is. As Ecosystem Management has developed it is becoming apparent that there is no such thing as "right answers" and that what the Agency is looking for could be better described as "a range of acceptable solutions" (Carr, 1993). Transition theory supports the quest for acceptable solutions in two ways. First, it is an information rich way of approaching an issue. Just a small amount of social data examined in relation to environmental conditions over time and space generates a large volume of useful information making it easy to envision many possible outcomes. Secondly, transitions can have many outcomes--they are not on a set, unchangeable course and can be altered dramatically by events along the way, again supporting the idea of multiple outcomes. Other reasons transitions theory is a useful tool include its use of existing data and its ability to act as a stepping stone to guide additional research. These points will be discussed in the final section of the paper on research needs.

The paper will turn now to presenting data which attempts to explore the impact federal land management policy has on the socioeconomic conditions of surrounding rural communities.

Rural Communities in the Lake States

Discussion of the impact federal land management policy has on surrounding communities abounds in the literature on rural communities and rural development. Issues of bureaucratic power and control, rational under investment (by rural residents in themselves and their surroundings, rural restructuring (of economies--shifting to urban areas), and moral exclusion (of rural residents from the policy debate by environmentalists) have been put forward to account for persistently bad economic conditions in rural communities located in and around federally-owned lands (Freudenburg and Gramling, 1994). The analysis performed in this paper does not try to account for one of these explanations over the others, rather it takes a step back and asks whether there is a relationship between the amount of federally owned land and socioeconomic conditions in a rural area. It seems to be premature to talk about explanations for a phenomena that has not been particularly well documented to begin with.

The Lake States region (which includes Michigan, Minnesota, and Wisconsin) was chosen for analysis as a way of beginning to get to know the region because of its proximity to where I am assigned as a Forest Service research social scientist. The vast majority of federal lands in the region are owned by the Forest Service. Over the past two years the Lake States Forestry Alliance has been conducting a regional forest resources assessment for the Lake States. While the majority of their findings are not yet available a list of tentative conclusions was released this past summer (Lake States Forestry Alliance, 1994). The region's forests are in generally good and improving health. The trees are moving into large size classes and growth substantially exceeds current harvest levels. Consideration of maintenance of biological diversity in the region is of central importance to the management of the area as is the continued development of the tourism sector. Forest management is good in the region relative to other areas of the country. While timber management is not currently intensive, increased demand for the region's timber is expected due to a combination of technological innovations (related to strandboard and waferboard production) and decreased supply of timber from other regions of the country (primarily the Pacific Northwest). The Alliance's findings relative to the condition of the physical and biological dimensions of the Lake State's ecosystems seem to characterize a healthy and vital region. But what of the human dimension of these ecosystems? Are the people of the Lake States region, particularly the rural people enjoying the same well-being as the forests surrounding them? This paper will attempt to address this question.

The analysis presented here focuses on county-level data from the U.S. Census (U.S. Department of Commerce, 1989) and the Forest Service's Eastwide Forest Inventory Data Base (Hansen, et al., 1992). Census summary levels are used to delineate urban and rural counties. Urban counties are those designated as metropolitan by the Bureau of Census. This combines summary levels 2 and 3--large, single city complexes (the city has at least 250,000 residents) and consolidated metropolitan areas (the county contains at least one city with 50,000 residents). Rural counties are those designated as non-metropolitan by the Bureau of Census (summary level 5). These counties have no cities larger than 50,000 residents.

There is a great deal of discussion in the literature about what constitutes a community and how to approach studying a community (Flora, et al., 1992; Machlis and Force, 1988). Clearly there are limitations to using county-level data to talk about communities--conditions may vary within a given county and communities may cross county boundaries. There are also limitations in using the census designation of "non-metropolitan" as a surrogate for rural areas--there is inevitably tremendous variation among counties with this designation. Getting bogged down in these issues ignores the tremendous need federal agencies like the Forest Service has for information to guide policy decisions and rural communities' tremendous needs to be better incorporated in policy decisions. The information available at the county level is a gold mine and can be quite useful if its limitations are considered, but not allowed to paralyze research.

For the purposes of this paper two approaches to differentiating rural communities will be used to explore the conditions and trends in rural communities. One series of maps differentiates counties based on their census summary level to look at a variety of indicators of community health and vitality. The next group of maps uses the same series of socioeconomic indicators but divides the counties based on the amount of federal lands present in the county. Before presenting these maps, some basic comparisons between rural and urban counties in the Lake States will be useful to provide an overall context.

Resident population trends (see Figure 1) show fairly constant levels of population for both urban and rural counties (as designated by the U.S. Census), particularly for rural counties. Next, it is interesting to note the trends in birth and death rates across rural and urban areas (see Figures 2 and 3). Rural areas have both a lower birth rate and higher death rate than those found in urban areas.

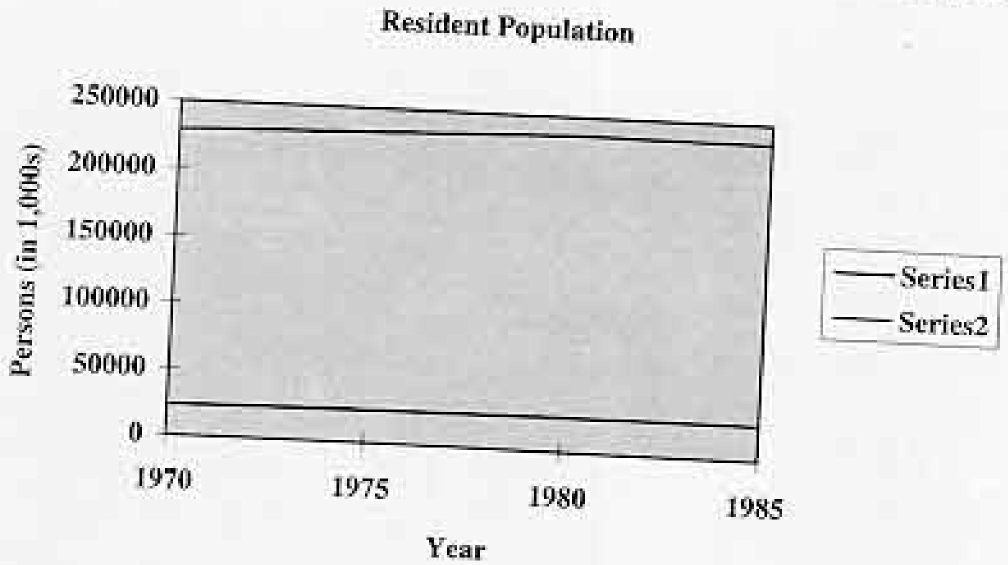

Figure 1. Resident Population Trends. Series 1 is the rural counties; Series 2 is the urban counties.

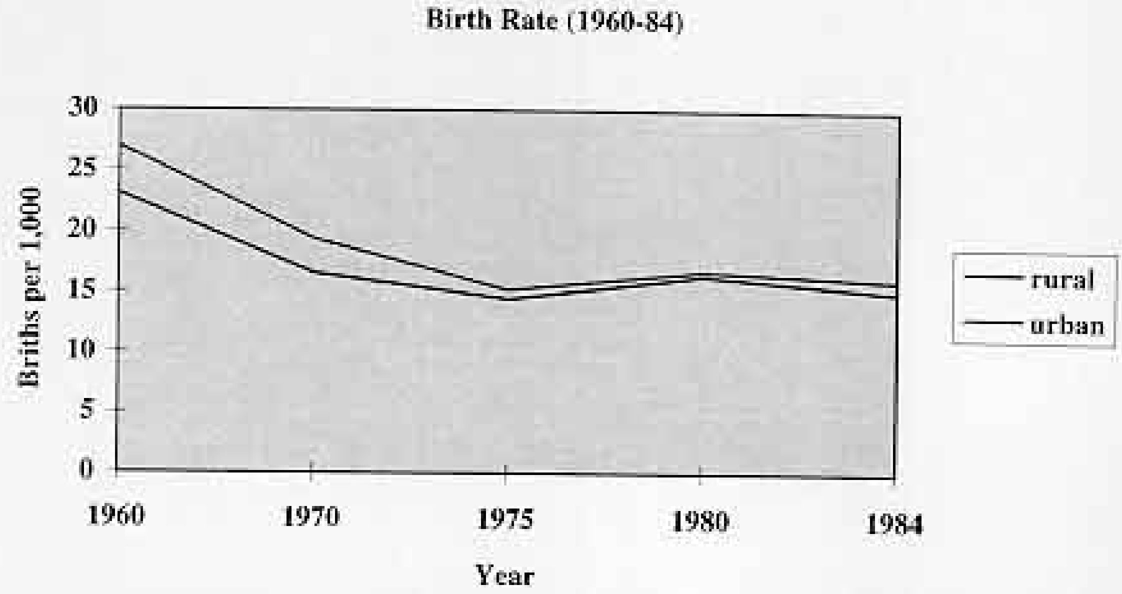

Figure 2. Birth Rate Trends

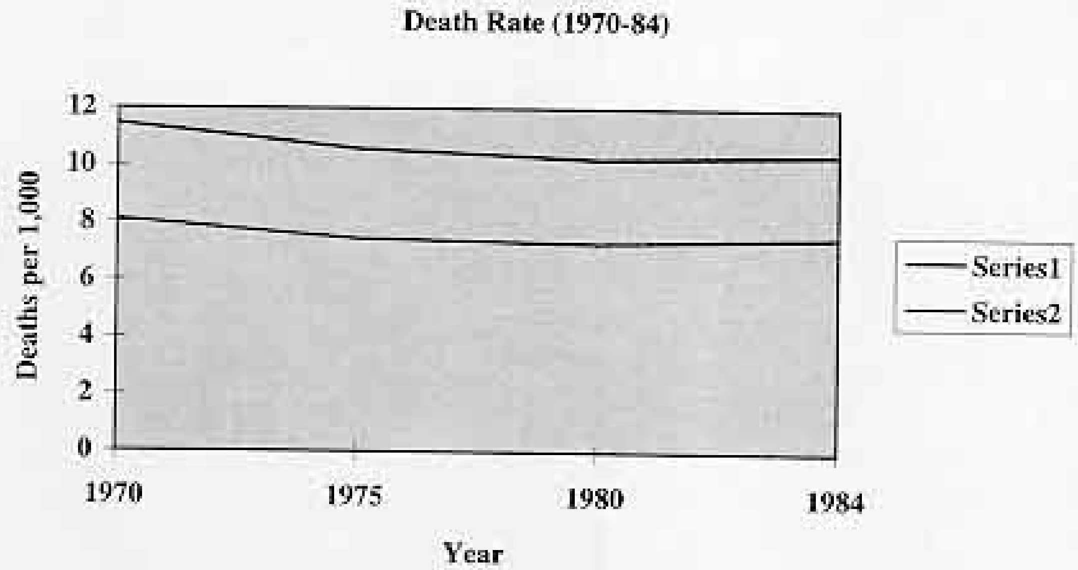

Figure 3. Death Rate Trends. Series 1 is the rural counties; Series 2 is the urban counties.

Figure four shows the net migration rate (standardized for population size). Counties 1 through 186 are rural counties and counties 187 through 243 are urban counties in the Lake States. Net migration varies from a growth of 16% to a decline of 20% in rural counties. A larger proportion of rural counties showed declines in population, and those declines tended to be larger than those found in urban counties.

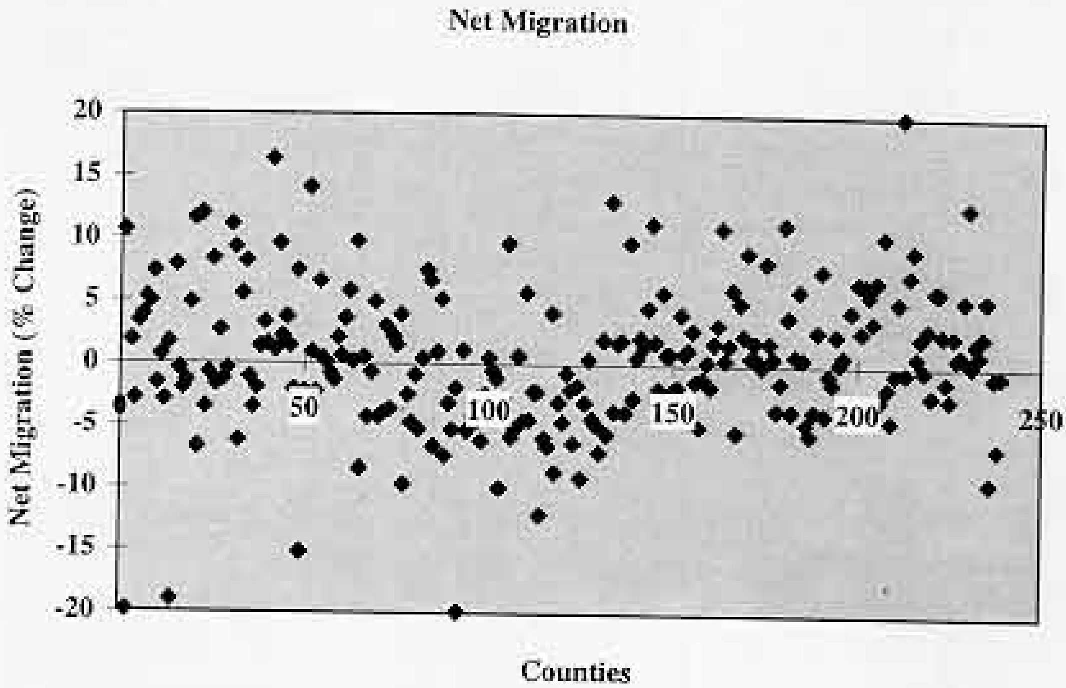

Figure 4. Net Migration (1975-80).

Four indicators of socioeconomic health have been chosen for this study: per capita income (for 1988), poverty rates (for 1979--the only year available in the data base), unemployment rates (for a single year--1988), and changes in unemployment rates over time (1975-89). Each of these measures give a slightly different perspective on socioeconomic conditions of rural residents. The time periods for the data were matched as closely as availability allowed.

The trend between urban and rural per capita income shows an interesting pattern (see Figure 5). The actual dollar amounts are not useful since they are real, rather than standardized amounts. Neither is it particularly surprising that rural incomes are lower than those in urban areas. What is seemingly important in this graph is the widening gap between rural and urban incomes. Figures 6 and 7 show projections for per capita income using linear and exponential assumptions. Year one is 1969 with subsequent five year intervals reported. Each figure reports the actual income amounts in addition to projections. The linear projection seems to fit the data well and shows the continually widening gap between urban and rural per capita incomes. By year 10 (2014) this gap has widened to approximately $8,000--with rural residents earning approximately 26% less than their urban

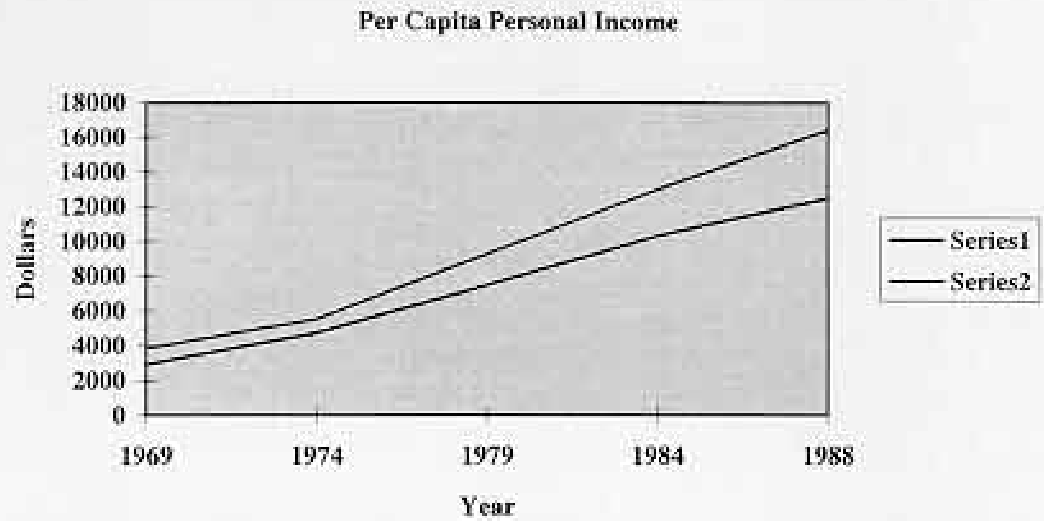

Figure 5. Per Capita Personal Income Trends. Series 1 is the rural counties; Series 2 is the urban counties.

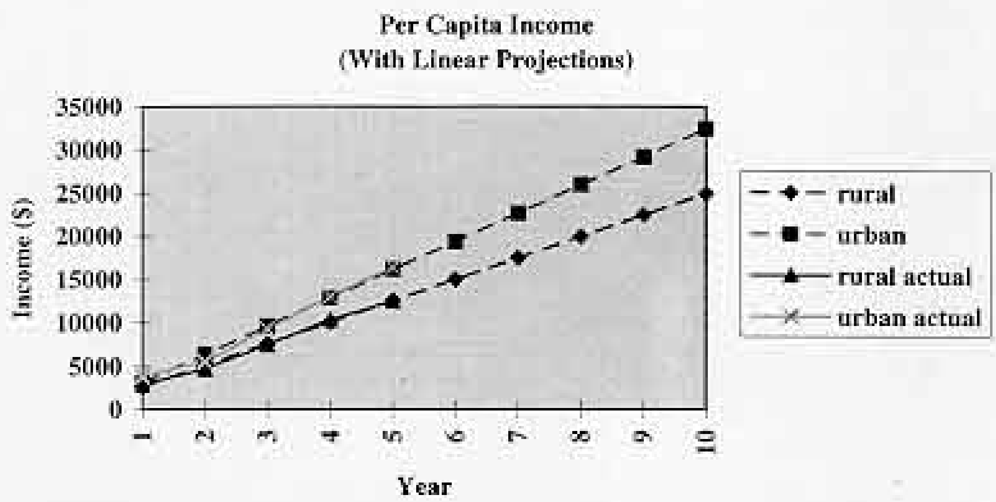

Figure 6. Per Capita Personal Income with Linear Projections

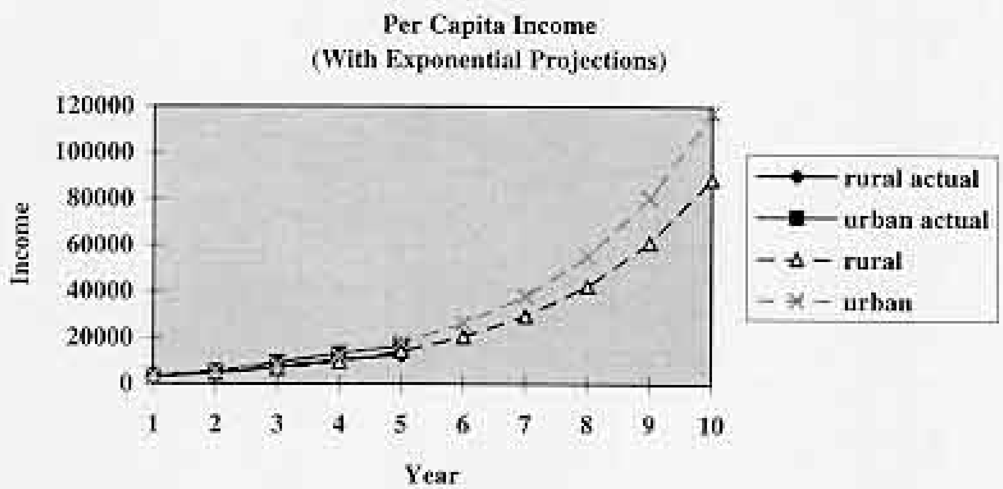

Figure 7. Per Capita Personal Income with Exponential Projections

counterparts. The gap in the exponential projection is proportionately equivalent to that under the linear projections (26% versus a 24% difference) while the actual dollar amount is much higher. Particularly for those rural areas on the urban fringe (where cost of living is likely increasing) this trend does not bode well.

The remainder of the data will be presented in pairs of maps; one using the census summary level to differentiate rural and urban counties and the second differentiating counties based on the amount of federal land holdings in the county. The major focus of the analysis is variation in socioeconomic conditions across different levels of federal land holdings in a county. The census summary level map is included to allow for comparisons of conditions in federal land-holding counties with those in counties with no federal land holdings.

The first pair of maps show the distribution of counties based on their census summary level and the amount of federal land holdings (Figures 8 and 9). The vast majority of counties in the Lake States area are rural (non-metropolitan, strictly speaking). The two major metropolitan areas involve Detroit (MI) and Milwaukee (WI). Major consolidated metropolitan areas include the Minneapolis/St. Paul (MN) area as well as much of southern Michigan. Federal land holdings are found in rural and to a lesser degree consolidated metropolitan counties and are predominantly in the northern part of the region. The vast majority of these holdings are owned by the USDA Forest Service although the USDI Park Service and USDI Fish and Wildlife Service each have holdings dispersed throughout the region.

The second pair of maps focuses on per capita income (Figures 10 and 11). Comparing the census summary level map to the federal land holdings map it can be seen that nearly all the rural and semi-rural counties with the highest income levels are those with no federal land holdings at all. Further, those that do have high income and federal lands are those in the smallest federal lands category (.01 to .1 percent of lands in federal ownership). There are no counties that include both the highest income and highest federal land categories. Overall, the vast majority of the two highest land holding categories have income levels in the lowest two categories.

The relationship between poverty rates and federal land holdings is less distinct (Figures 12 and 13). There seem to be large regions of high poverty that occur where there are no federal lands as well spanning all levels of federal land holdings. Seemingly the only area that follows a pattern similar to that seen in per capita income is in the upper peninsula of Michigan where poverty rates are low in the central portion where federal land holdings are also low--the pattern reverses at the other end of the spectrum, with high poverty rates and high proportion of federal lands for much of the rest of the U.P. The lowest poverty rates in the region occur near urban areas.

Figure 8. Census Summary Level Distribution in the Lake States Region

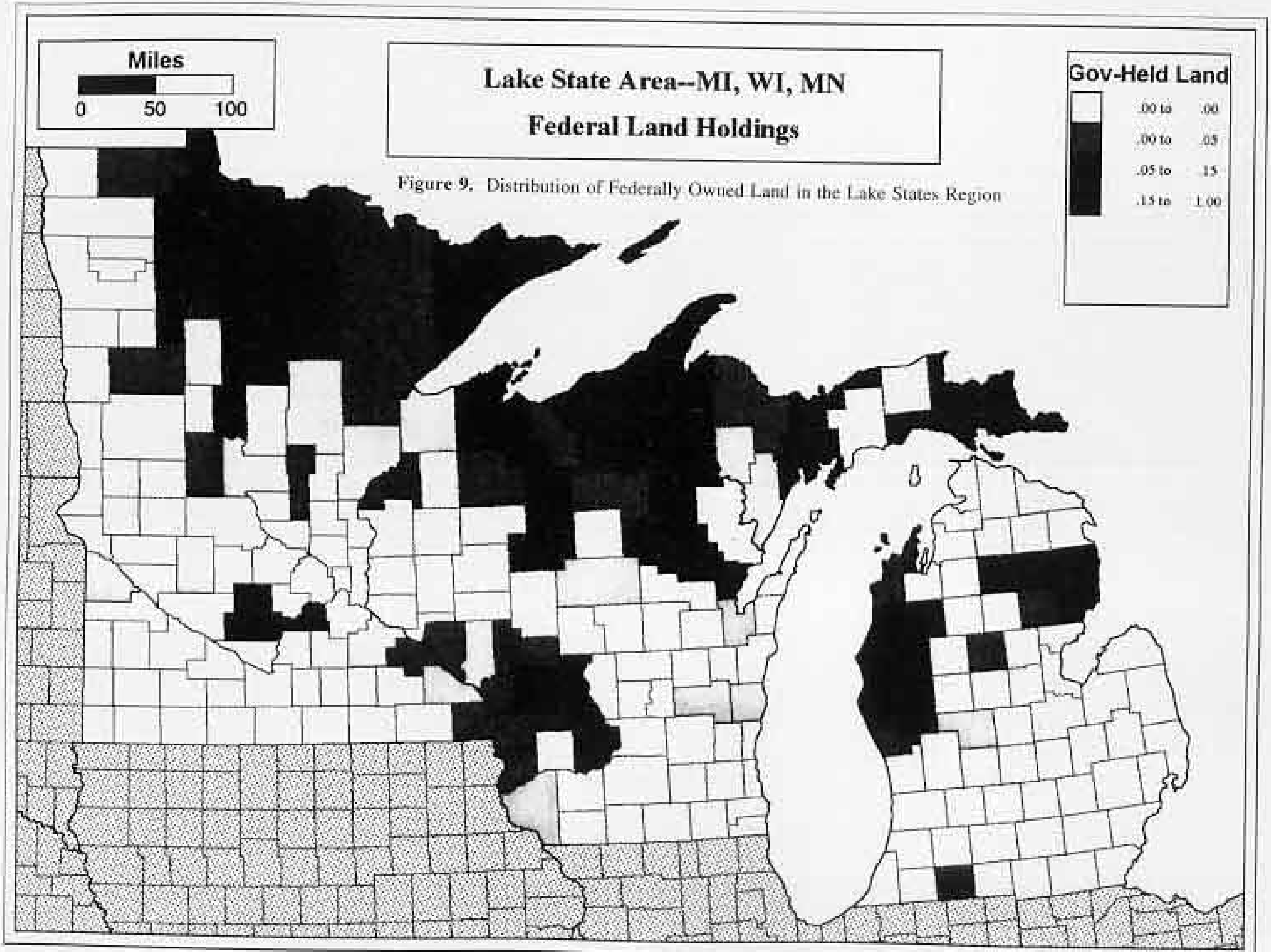

Figure 9. Distribution of Federally Owned Land in the Lake States Region

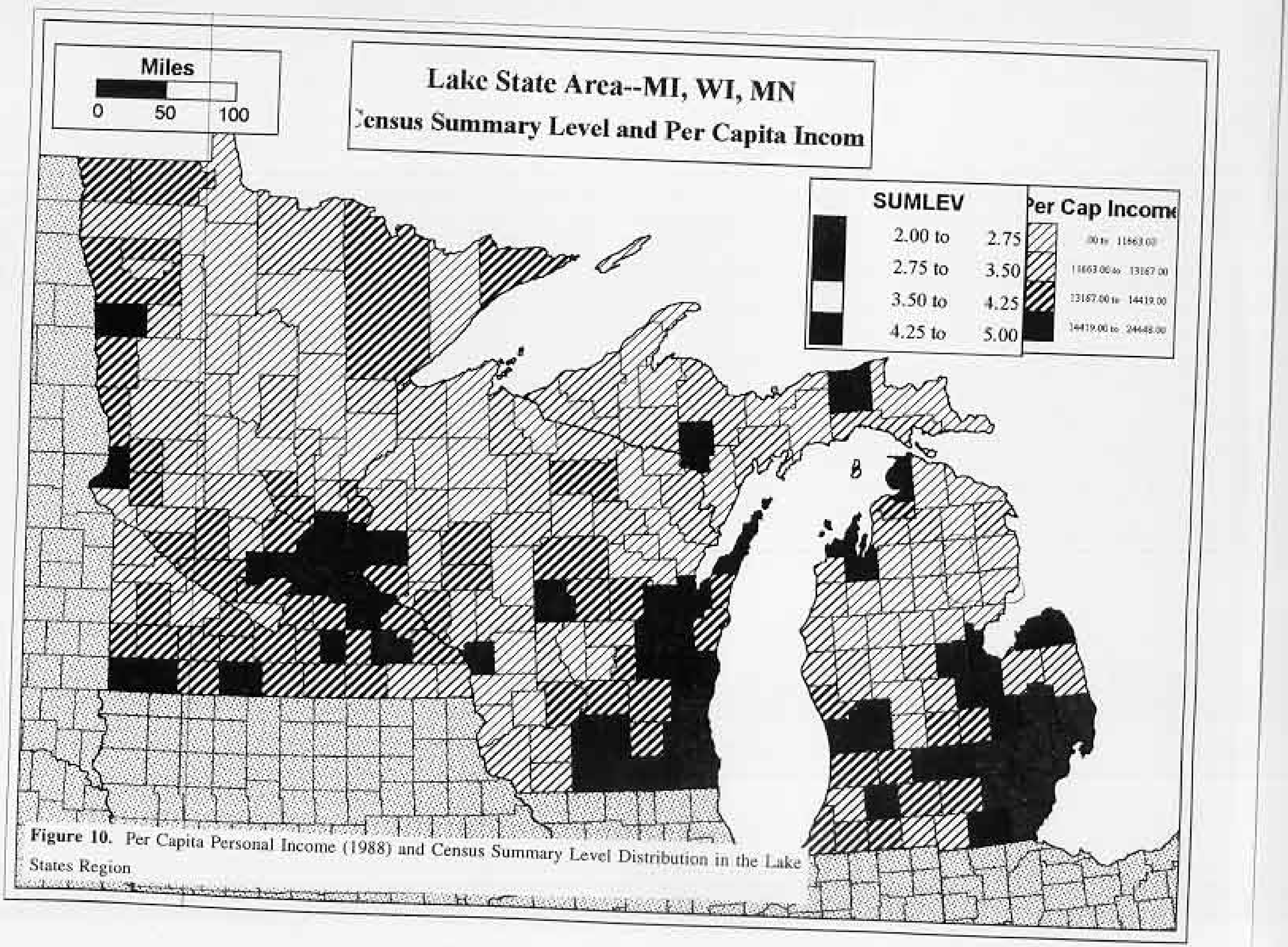

Figure 10. Per Capita Personal Income (1988) and Census Summary Level Distribution in the Lake States Region

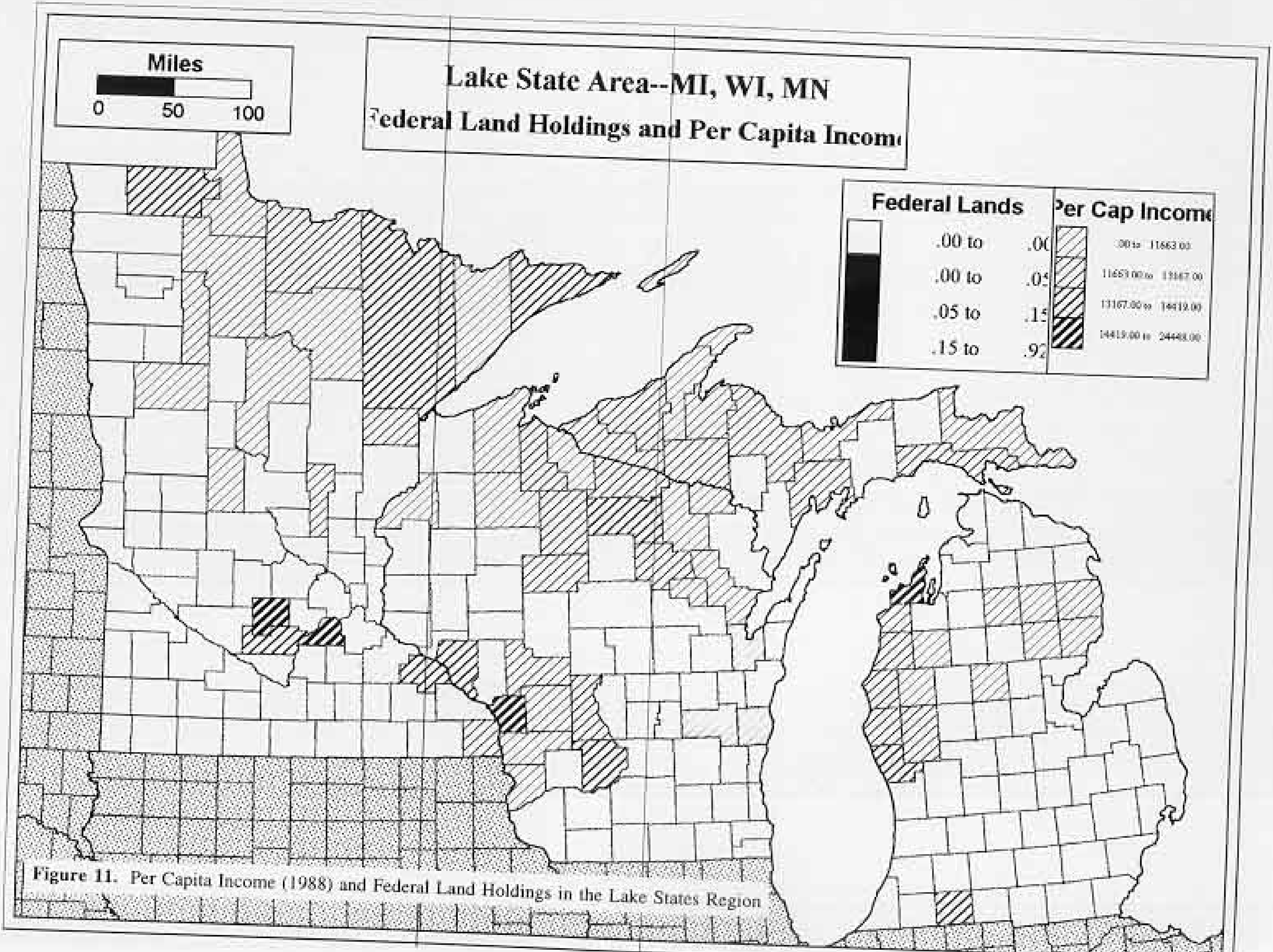

Figure 11. Per Capita Income (1988) and Federal Land Holdings in the Lake States Region

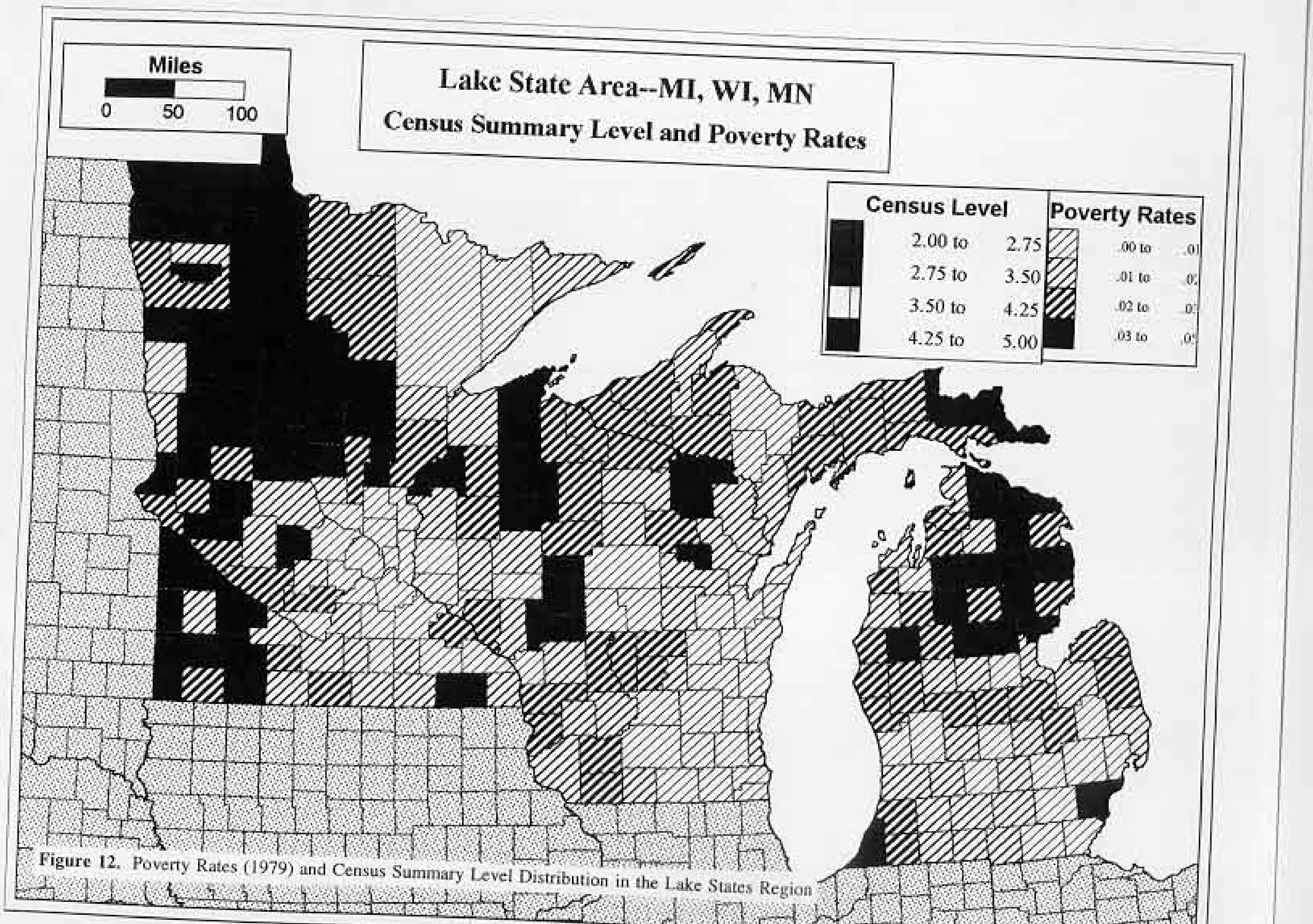

Figure 12. Poverty Rates (1979) and Census Summary Level Distribution in the Lake States Region

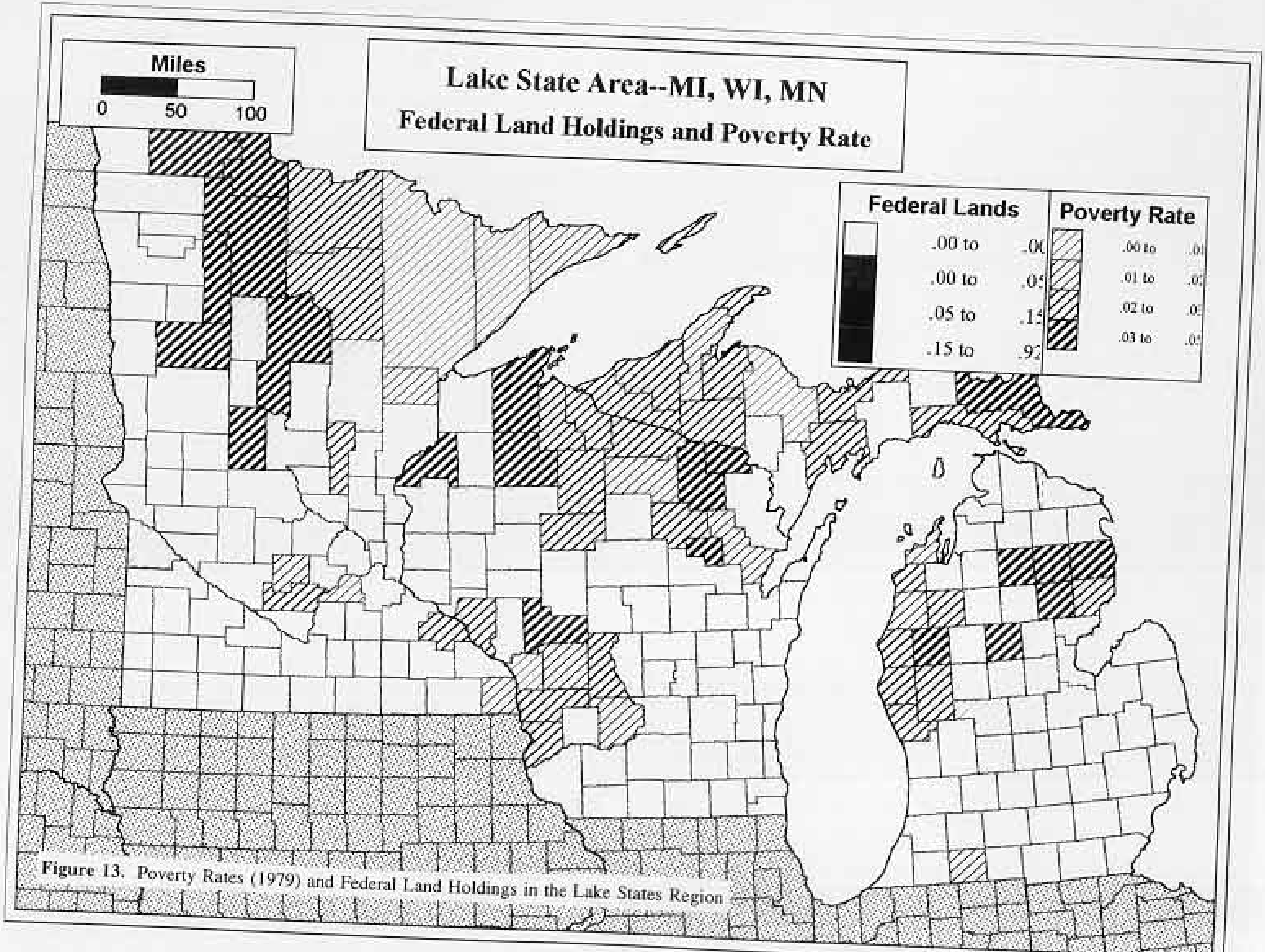

Figure 13. Poverty Rates (1979) and Federal Land Holdings in the Lake States Region

It is also difficult to discern patterns within the next pair of maps looking at unemployment rates for 1988 in the region (Figures 14 and 15). There are large areas of high unemployment throughout northern and upper Michigan, northern Minnesota, and central Wisconsin. This distribution roughly follows the area of federal land holdings (irrespective of proportion of federally owned lands).

The trends in changes in unemployment (1975-89) show a different pattern than that seen for 1988 alone (Figures 16 and 17). Much of Michigan has shown the largest decreases in unemployment (this in spite of having large regions of high unemployment in 1988). The largest region of stagnant or increasing unemployment is in Minnesota while Wisconsin appears to have a mixture of moderately decreased unemployment. None of these changes seem to relate to the amount of federal lands present in the county.

Discussion

The analysis presented in this paper provides seemingly strong support for debunking the idea that rural communities are stable entities. They appear to be changing at rates equal and in some cases greater than their urban counterparts in the Lake States region. One could argue that this is evidence of failed rural development policies--successful conditions would show the stability expected under traditional views of rural communities. It seems more fitting however, to interpret these findings to indicate that the stable relationships found between German forests and rural towns of the 1700's do not apply to the lands and communities of twenty-first century United States. The dynamic nature of rural communities evidenced in this analysis is more in keeping with that expected by transition theory and with the ecological view of the world being fostered by the Agency's Ecosystem Management policy. Some researchers have incorporated ecological concepts into their attempts to understanding the composition, structure, and function of rural communities (c.f. Wilkinson, 1986). This view is in keeping with how the discipline of human ecology would characterize communities.

Demographic trends in rural communities (independent of federal land holdings) of the Lake States are consistent with national trends. Higher death rates, lower birth rates, and higher net losses in resident population than their urban counterparts in the region all point to significant and potentially dire circumstances for these communities. A declining population--particularly if it is young people being lost--spells potential disaster for the social, cultural and economic well-being of these communities.

This analysis provides modest support for the idea that there is a relationship between federal lands in and depressed socioeconomic conditions. There is a fairly clear-cut relationship between per capita income and the proportion of land in a county held by the federal government. This relationship blurs when looking at the other socioeconomic variables, but general patterns can still be

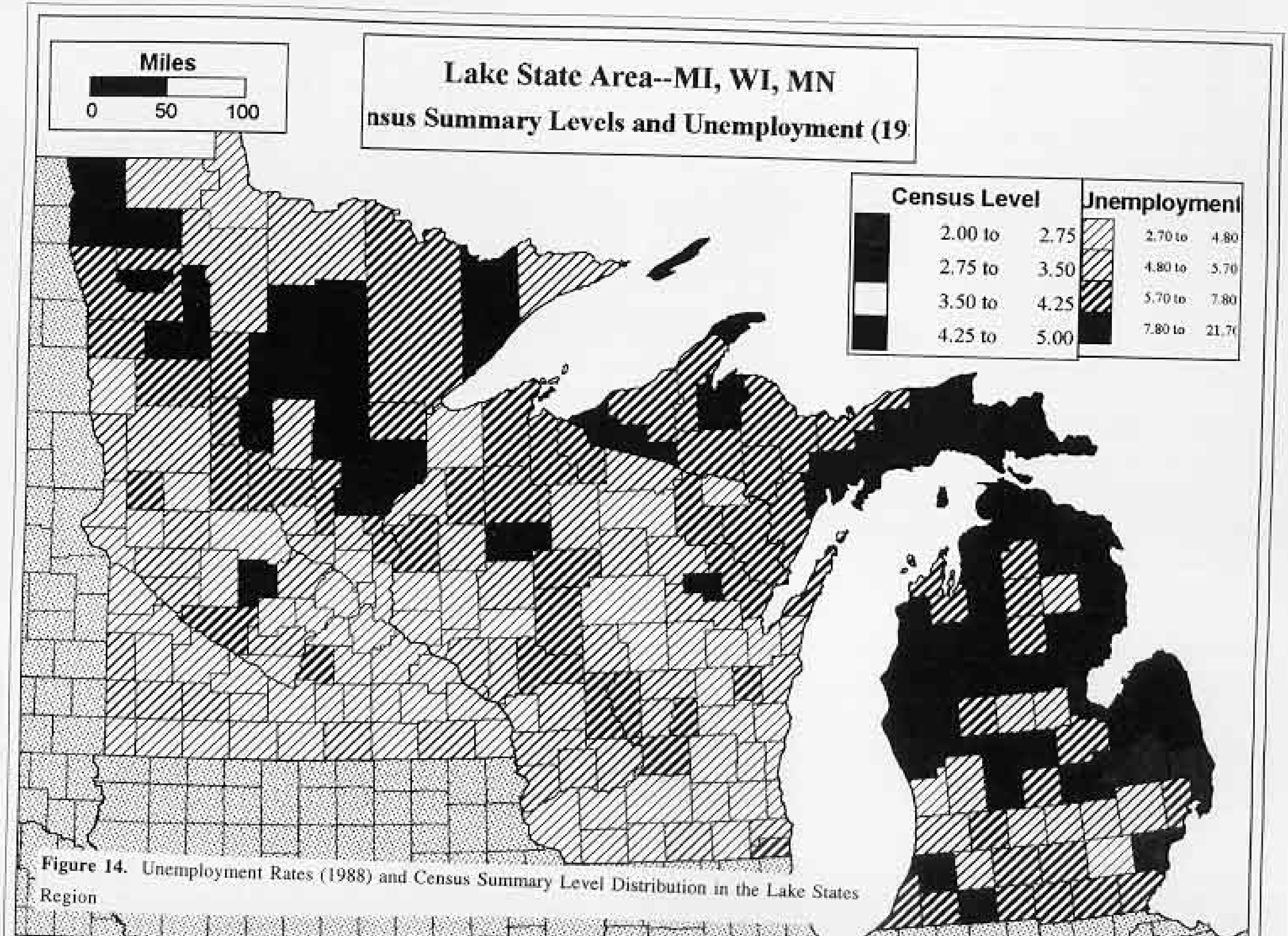

Figure 14. Unemployment Rates (1988) and Census Summary Level Distribution in the Lake States Region

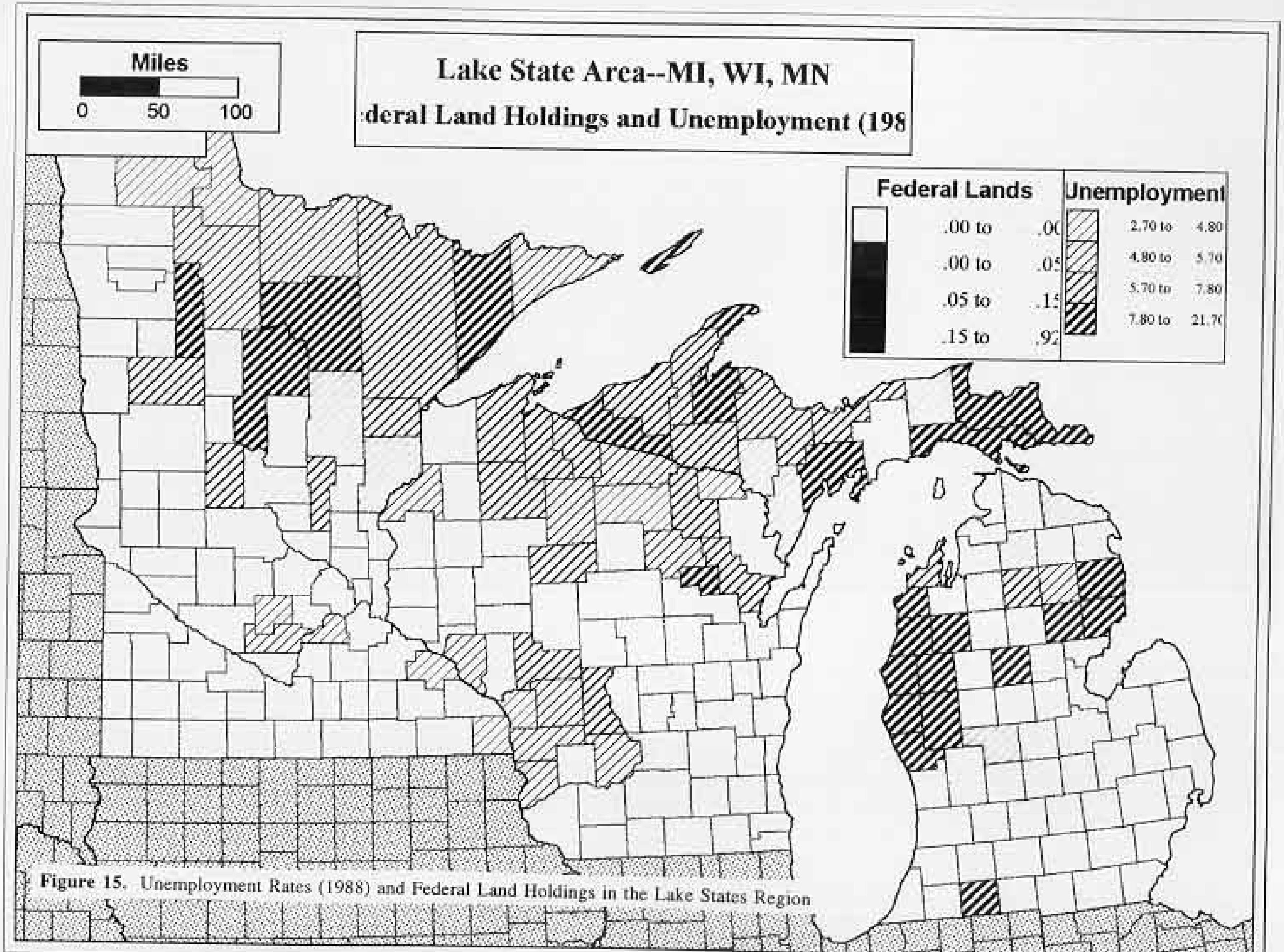

Figure 15. Unemployment Rates (1988) and Federal Land Holdings in the Lake States Region

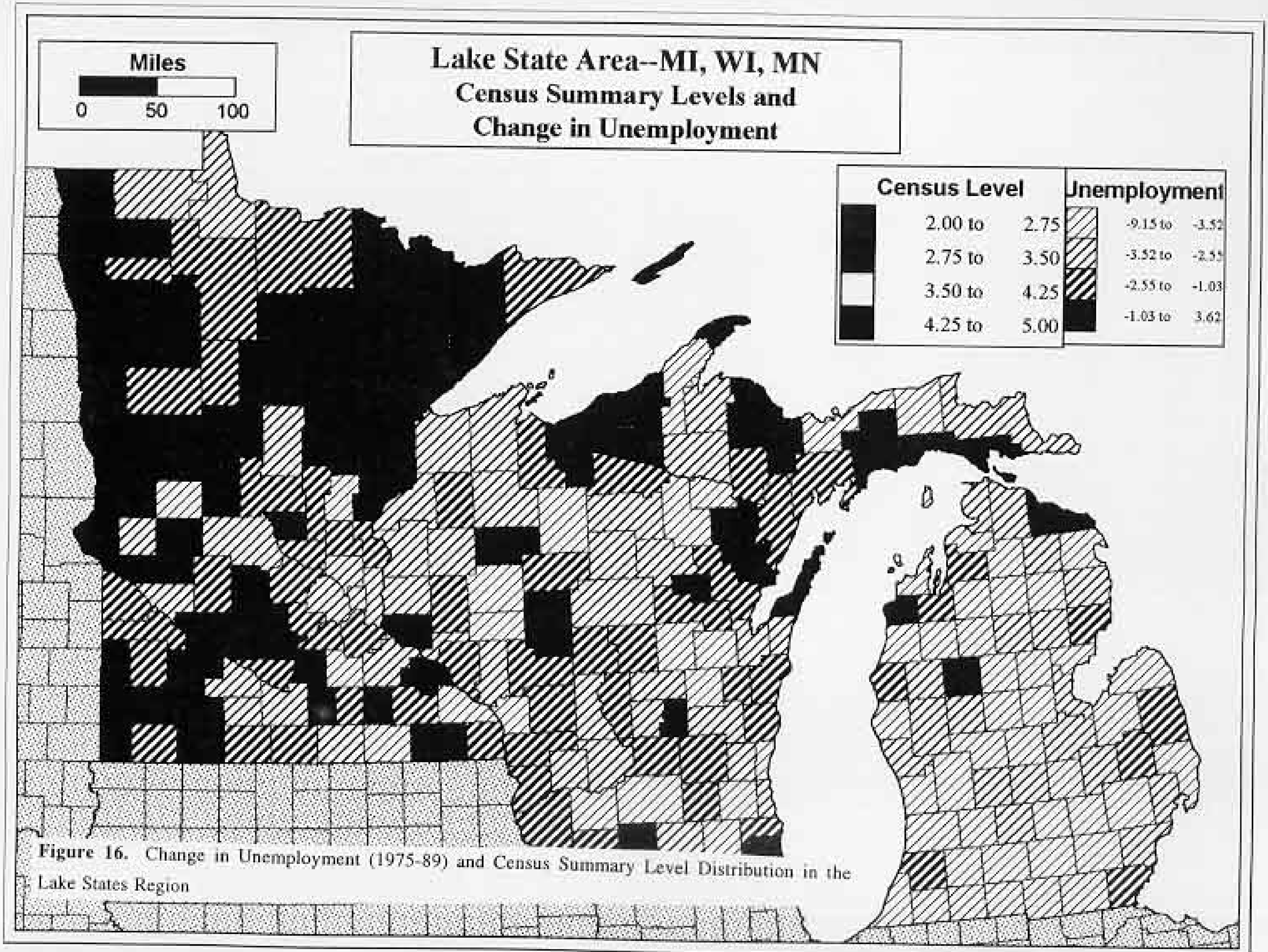

Figure 16. Change in Unemployment (1975-89) and Census Summary Level Distribution in the Lake States Region

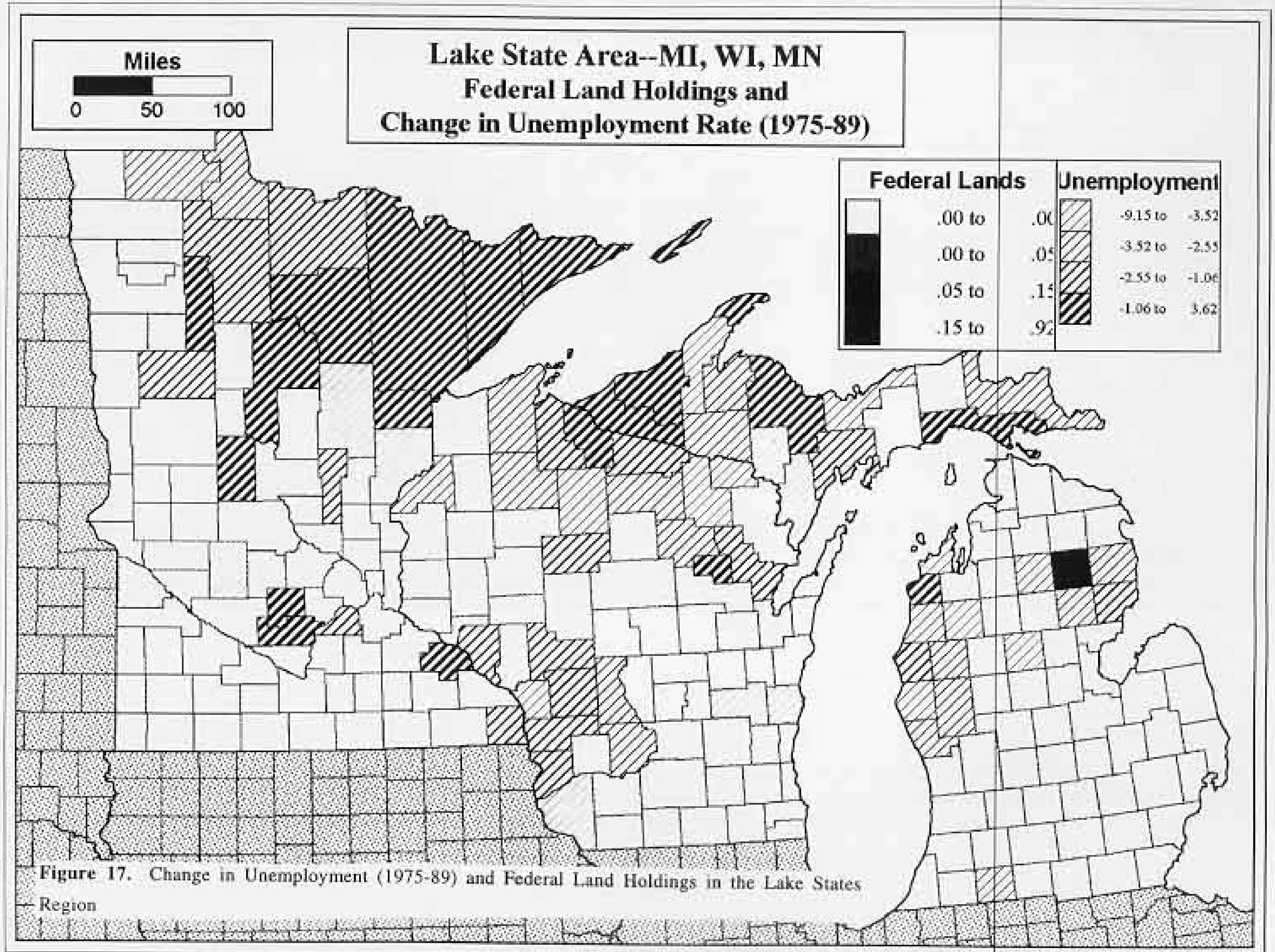

Figure 17. Change in Unemployment (1975-89) and Federal Land Holdings in the Lake States Region

seen. These relationships bear further investigation, particularly in light of the potential serious impacts of the widening gap between urban and rural income levels.

Some indicators (particularly unemployment and poverty rates) seem to be better described by a simple presence/absence of federal lands as indicated by the large regions of high poverty and high unemployment regardless of the amount of federally-held lands. It may be that conditions other than federal land holdings play a larger role in determining levels of poverty and unemployment in a county. The upper peninsula of Michigan seems to be the exception in the region, following the pattern that would be expected in the literature with a direct relationship between amount of federal lands in a county and its poverty and unemployment rates. Because of its isolated nature and distance to large urban centers, the upper peninsula may show a "purer" relationship between these variables, without confounding influences.

The different information yielded from looking at a single unemployment rate (for 1988) versus trends in unemployment illustrates the importance of treating these socioeconomic variables as dynamic indicators of changing conditions in rural America. Michigan in particular illustrates this point with both high unemployment rates for 1988 as well as high decreases in unemployment rates over time. The single measure of unemployment would give incomplete and perhaps misleading information about employment conditions in the state.

Policy Implications and Future Research Needs

The most obvious policy implication from this study is that the traditional view of stable rural communities and rural development goals does not fit the conditions revealed in the Lake State region (nor is it likely to fit conditions in the rest of the nation). The newer thinking related to Ecosystem Management is far more appropriate and seemingly will lead to more relevant policy directions with regard to rural communities.

At a recent meeting focused on finding ways to integrate social sciences into the Forest Service's Ecosystem Management policies, Regional Forester Elizabeth Estill listed several areas where she and her staff needed assistance from social scientists to further their policy development and decision making (Estill, 1994). This cogent listing of social science needs by such a high ranking Agency official is nearly unprecedented in the Forest Service. Three of the four areas she listed are directly related to transition theory and will be used to develop the policy implications of this paper (the fourth, understanding fundamental values, attitudes, and opinions is critical to the job of Ecosystem Management, but perhaps less central to the approach taken here). The three issues she identified as important to policy development and decision making and asked for social science assistance with are:

(1) **A systematic understanding and description of the people and communities affecting and being effected by national forests.** Specific questions Estill listed included who are the people, where are

they relative to the national forests, what social systems are operating and at what scales? She felt that isolated descriptions of individual communities or clusters of communities did not help her do the job of developing policy and making decisions for an entire region (in her case the Rocky Mountain region).

Clearly, analyses done using transition theory such as that presented here provide an excellent starting point for developing this systematic understanding. Seeing an entire region laid out before you facilitates the compilation of profiles for specific areas and the comparison of different areas with each other. Differences in adjacent counties are a jumping off point for understanding conditions in the communities. For instance, as I wrote this paper, three counties in northeast Michigan caught my eye because of what seemed to be unusual pattern. These three counties, Oscoda, Ogemaw, and Iosco are adjacent to one another (see the outlined area on Figure 10). All three are at the lowest per capita income level even though two have the highest and one the second lowest level of federal land holdings. Turning to poverty rates, the low federal land holding county (Ogemaw) and one of the federal land holdings counties (Oscoda) fall into the highest poverty rate category, while the other high federal land holdings county (Iosco) falls into the second lowest poverty level category. Looking at how unemployment rates have changed over time, Oscoda county (high federal lands/low poverty rate) shows less of a decrease in unemployment than the other two (its static unemployment rate is higher than the other high federal land holdings county). This pattern shows that the relationship between these variables is complex and deserves the attention of both policy makers and researchers.

This sort of analysis can act as a tool to assist in decisions about where scarce agency resources should be concentrated in a region as well as how an area may be impacted by proposed agency actions. Transition theory would indicate that those areas where change is occurring most rapidly are most vulnerable and deserve extra attention. Given the health of the physical and biological dimensions of Lake Sates ecosystem, Agency resources may be best targeted at the human dimensions of the area. Widespread regions of high poverty or unemployment as seen in Wisconsin and the upper peninsula of Michigan indicate areas where the Forest Service may do well to join with other federal, state, and local governments rather than attempt to address these issues alone.

(2) **Understanding of social systems and processes across scales.** Discovery, characterization, and explanation of conditions found in communities requires the incorporation of both temporal and geographic scale, as well as an understanding of the nesting or hierarchy across scale levels.

The strengths of transition theory in this area are discussed earlier in the paper. From the perspective of a policy maker it is possible to see areas where scales may be meaningfully aggregated up to subregional levels (e.g. the upper peninsula of Michigan and central Wisconsin)--a critical step to implementing policy since a different policy cannot be developed for each county. Also, proximity to large urban areas can begin to be incorporated into understanding of community conditions and decisions about how to develop policies to enhance and enrich different types of rural communities.

(3) **Describing and understanding social change processes and their relationship to the natural landscape.** Currently Agency policy and decision makers have limited tools available to them for describing social trends and patterns and how they relate to trends and patterns in the physical and biological dimensions of ecosystems. Policy development requires more than descriptive information, it is greatly facilitated any time anticipatory information can be interjected into the process.

The type of analysis coming from the use of transition theory such as this are powerful tools for this purpose. It facilitates an integrated understanding of the interrelationships between the three dimensions of ecosystems and visually describes patterns and trends. As work on transitions progresses it will increasingly be possible to understand and anticipate trends, patterns, and impacts of families of transitions. This integrated information is particularly useful in the Lake States region where the physical and biological dimensions of ecosystems seem healthy and vital, while rural communities seem to be in considerably worse shape.

Having spent many long days and nights working on this analysis I have had ample opportunity to think about potential future research directions for this specific study as well as in using transition theory in general. I will start with transition theory as a whole and conclude this section with a brief listing of the future research directions for this study.

Transition theory provides an excellent use for existing data. The questions that could be approached by combining census data with data about environmental conditions collected by a variety of governmental and private organizations are numerous and of central importance to agencies like the Forest Service. In this way transition theory is an excellent exploratory research tool that can act as a guide for further research. The importance of areas where change is rapid as well as the importance of social context for understanding transitions are excellent criteria for making decisions about where to focus more in-depth field research. Also, because transition theory would seem to work well with a variety of quantitative and qualitative research methods, it may provide an umbrella theory for guiding a research program.

Stepping back to the analysis conducted here, it seems that just these few variables have generated a plethora of research questions. If I were going to pursue this work further I would be interested in addressing several questions. First, I would incorporate additional data including the number of establishments from a variety of sectors (e.g. manufacturing, retail, service, agriculture and forestry, etc.) present in each of the counties. I would also add a measure of urban proximity. An analysis of the number of establishments gained or lost over time relative to the amount of federal lands present as well as how establishments change in relation to proximity to large urban areas would begin to address the economic vitality and sufficiency of communities. Taking a second look at the variables used in this study with proximity to urban areas as the environmental variable (instead of census summary level or proportion of federal lands) would perhaps better illuminate the patterns seen in these variables during the current analysis. Also, if it were possible to further differentiate the character of the federal land holdings to look at how differences between extractive, service, and amenity orientations used to manage lands in each county may show clearer relationships between the socioeconomic variables and federal lands (it is possible to differentiate this data based on Agency ownership, but this would not provide the desired information--particularly for Forest Service lands). Finally, several areas would appear to be excellent candidates for more in-depth analysis. The three county area discussed above is just one example of patterns revealed in this analysis that would likely contribute to understanding the relationship between socioeconomic conditions and federal land ownership.

Conclusion

This analysis was conceptualized as a simple test of the validity of the assumption of change in rural America. As it unfolded, other questions have arisen and have attempted to be answered. This analysis shows the power of combining the ample census data available with that produced by federal agencies like the Forest Service for enhancing our understanding of changing conditions throughout the country.

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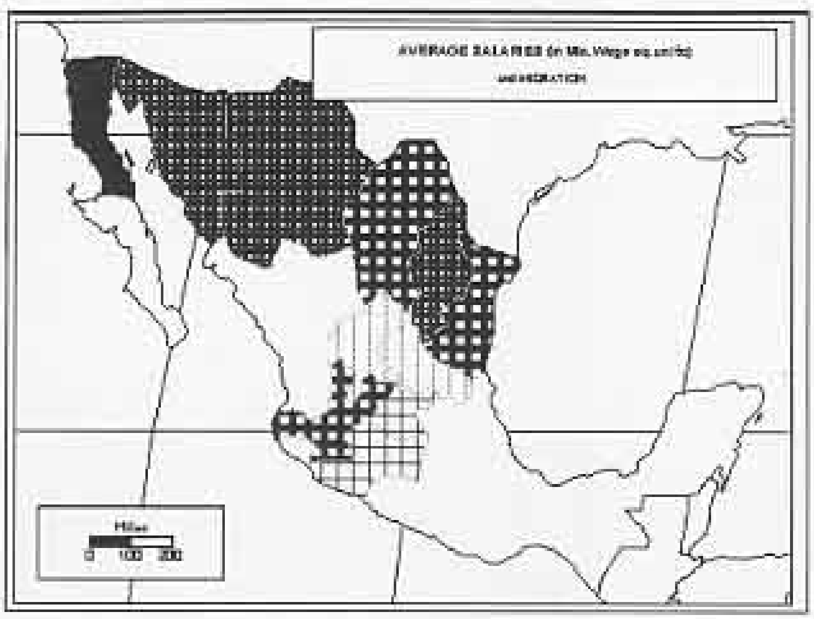
ANALYSIS OF TRANSITIONS IN THE US-MEXICO BORDER

Carlos de la Parra


AVERAGE SALARIES (in Min. Wage eq.units)
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Introduction

The United States-Mexico border is a political boundary unlike any other in the world. Not only is it home to almost 10 million people, of which slightly more than 4 million live on the Mexican side and slightly less than 6 million on the US side[1], but it also unites a highly developed, industrialized economy to an emerging, developing one. The cross-border differences in average income, language, culture, religion and political systems are among the most contrasting anywhere.

During the Nineteenth Century, the United States saw tremendous expansion in its geographical borders and in its economic resource base. Highly navigable waterways, extensive flat ranges and fertile valleys, agriculture in a private-property/free-market system, with solid institutional support were probably the main reasons the US economy prospered throughout the early 1800's. Only the Civil War years interrupted a rapid and continuously growing gross national product.

Mexico arrived at the status of an independent nation almost 50 years after the US. The Mexican republic survived through a series of internal struggles for power, which included the pretentions of a couple of would be emperors, after the independence war: Iturbide, supported by Spanish interest and Maximiliano supported by the French later on. This republic prevailed even after invasions by the United States (1847) and France (Napoleon III in 1862). In the beginning of the 20th Century, the Mexican nation was involved in still another war: a social Revolution that overthrew Porfirio Diaz, a military dictator who maintaned a 30 year stronghold on the country's government, until 1911. The war for political power and land reform that followed the overthrowing of Diaz lasted 11 years, ending in 1921.

Younger and politically less stable, Mexico has historically seen it's northern neighbor as a more prosperous nation, a land of opportunity. Analogous to the north American's "*go west*", for the mexican population, the wise adage has been "***go north***", as a sign of frontiership and the will for exploration. The employment opportunities that have been found in the USA for migrant workers from south of the border have gone from agricultural labor during the war years in the forties, to low skilled work in the oil fields of Texas or the fast growing Southern California cities, to a wider array of job openings in recent years, mostly in urban settings, and scattered throughout the whole United States. Either conquering the employment or investment market of the United States of America (USA) or settling in the marginal urban strips in the outer limits of a city in the arid northern border area within the United Mexican States (Mexico), succeding in the northward journey has been synonymous with progress, a symbol of triumph which to this day remains a revered and respected prowess.

Hence, the northern states of Mexico, *Baja California, Sonora, Chihuahua, Coahuila, Nuevo León and Tamaulipas,* have been forged by migrants who have had the foresight, cunning or desperation to abandon the traditional homebase states of the *meseta central* (central plateau). But the development of each of the northern border states has not been simultaneous or homogeneous. The mineral rich states of

[1] Estimated population based on figures offered by Weeks and Ham, 1992, p.6

Chihuahua and Coahuila were founded more than 400 years ago, since the colonial days. Tamaulipas, the gulf state, also developed early in Mexican history, due to the port activities of Tampico, and its geographical location that made that state a natural pathway towards Texas and the large and atractive markets of the northeastern USA. Sonora and Nuevo Leon developed a cattle economy and an industrial economy respectively at the start of the 19th Century, with Baja California developing as late as the 1940's, mirroring the development of Southern California.

For the young and growing latin-american labor force, Mexico's northern border region has been seen not only as a stepping stone to the promised land across the border, but also as a more developed and dynamic land of transition, heavily impacted by the US economy and containing some of the features of the US lifestyle. During the late sixties and early seventies, an industrial program tailored to reap the advantages of the border area was created. It was widely known as the *maquiladora* program, an industrial assembly plant setup in which parts of the manufacturing process was undertaken in Mexican territory with low skilled-low wage labor. Today, more than 2000 maquiladoras exist at the border strip, with the cities of Tijuana, Baja California and Ciudad Juarez, Chihuahua ostensibly becoming the two settings in which this program has flourished. For the multilateral industrial firms, the maquiladora program has provided a reduction in labor costs, while maintaining highly skilled supervisors and management on the job. For Mexico, the maquiladora program has been a fast way of increasing the labor market and an expansion of a relatively weak tax base.

The US border cities perceived this program as a way of reducing the migrational pressures across the border, since jobs were being offered within Mexico. Be it myth or reality, the perception of more jobs being created in the field of manufacturing close to the US but still in Mexican territory, and an increasing demand from the US public for policing to reduce immigration, demographic pressure has fallen heavily on the mexican border cities in the course of the last 20 years, not only because of the maquiladora effort, but also due to synergistic factors that the development of the border area has engendered. The growth of an urban sprawl on any side of the border has proven to become the best promoter for the development on the opposite side. Hence, nine twin cities account for more than 85 percent of the population along the border strip, creating binational metropolitan conurbations of almost 4 million, as in the case of San Diego and Tijuana, mid-sized, relatively manageable ones of 150 to 200 thousand population like Nogales and Nogales in the Arizona-Sonoran border, and even miniature ones like in Tecate, California and Tecate, Baja California of no more than 60,000.

Today, Mexico as a whole is experiencing dramatic change. The passing of the North American Free Trade Agreement (NAFTA) is only a sample of this change. Mexico is rapidly becoming an extension of the US economy, while struggling at the same time to solve the growing pains associated with the globalizing trend it has followed. Timothy Macdonald describes these growing pains as "many difficult transitions", associated with "moving rapidly from a lesser-developed country to an industrialized one". He suggests that "perhaps the most important transition for the Mexican society as a whole is the bureaucratic transition", emphasizing a "strong push to decentralize the government and give more control to the states,...". Further examination of the effects of NAFTA on the country as a whole can be obtained within this monograph from Macdonald's work (Chapter 7).

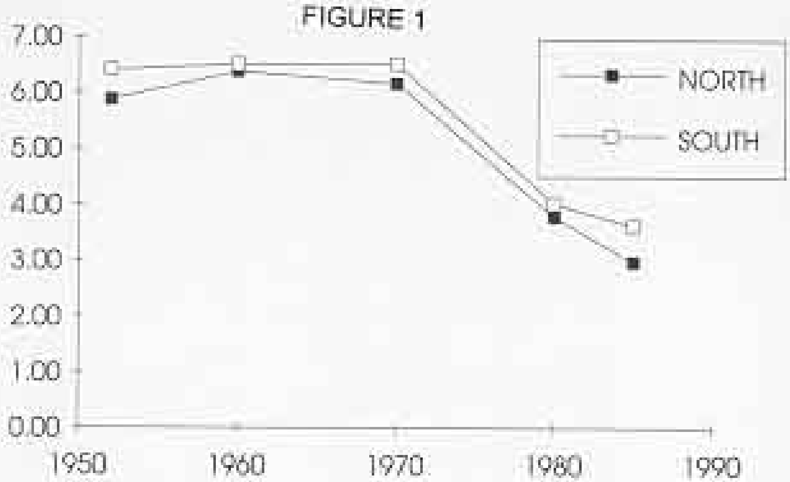
In the closing years of the 20th century, it is safe to say that the border area within Mexico has acquired a culture, a rhythym and a personality of its own. It is an area that runs on a different economic system from the rest of the country; it lives a different culture than the rest of the country, and deals with social problems that no other region in the country has encountered. One of the main characterisics of the border region is that it harbors a high percentage of population that is non-native to the area, i.e. it has a smaller rate of natural growth and a higher rate of social growth than other regions of the country (FIG.1 & FIG.2). Cultural mix, heavy pressure on urban infrastructure, direct contact with international issues involving the United States and influence in the state of affairs of the bilateral relations between both countries is just part of the atmosphere that makes the border area unique. The border area has for decades enjoyed a "free-zone" status, which has allowed a vrtually free flow of American goods into the area. In a sense, the US-Mexico border strip has experienced NAFTA-like conditions for quite some time now. It has been at the forefront of international commercial policy and has no doubt become a gradual phase-in to the United States for the rest of the country.

The theory of transitions at the US-Mexico border.

There is considerable evidence that the border area has shaped itself into a lesser developed version of the US. One aspect where this phenomenon is thoroughly evident is in the demographic transition. The total fertility rate of women at the border area has descended below the national average (FIG.1). The research performed by Urbina (1992) and Warren (1992) prove the existence of a noticeable difference in the use of contraceptive measures in the border population when compared to the rest of the nation. One obvious factor is that the economic dynamism of the border area has incorporated a larger percentage of the female population into the labor force, than in other places of Mexico. A higher educational level of the population as a whole is another reason inferred for the lower fertility rates.

TOTAL FERTILITY RATES FOR NORTHERN STATES AND THE REST OF MEXICO

FIGURE 1



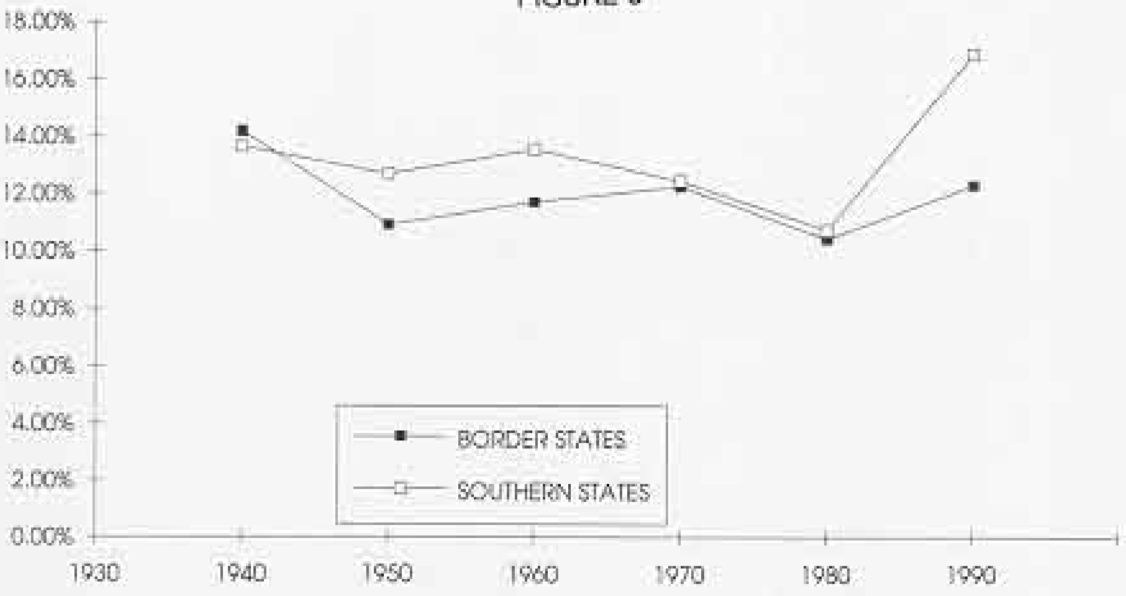
So, while other places within Mexico might be experiencing the intermediate stages of the demographic transition, the border area appears to be closing its cycle to a level of stability comparable to the more advanced Anglo cultures of the north. In a recent study conducted by *El Colegio de la Frontera Norte* (El COLEF) (EMIF, 1994), a regional border studies center, 5 states of inland Mexico can be identified as being the most frequent origin of the migratory labor force occurring in the northern border area. Guanajuato, Jalisco, Michoacán, San Luis Potosí and Zacatecas contribute with more than 31% of the newcomers to the US-Mexico border area, with the border states providing 25.1% more of the workers on the move, migrating out of their city of origin but within their own state. The 5 states mentioned show a higher natural growth rate (birth minus death), a trend which depicts an earlier stage within the transition in its route to a lower level of growth rate (FIG.2), and a greater influence of natural growth in the total population growth figures (FIG.3)

NATURAL POPULATION INCREASE (Annual rate)

But the evolved phase of the demograhic transition in the US-Mexico border area is not reflected in its total population growth rate, a pace which has barely stemmed. Gone are the years of close to 8% annual growth in the area, experienced during the forties and fifties, but the absolute number of migrants continues to be at least as great today as it was before. The drop in the annual growth rate is just a

PERCENTAGE OF TOTAL GROWTH ATTRIBUTABLE TO NATURAL GROWTH

FIGURE 3



figment of the numbers game: as the population increases in the area, the percent impact of equal amounts of newcomers is reduced (FIG.4). In raw numbers, the migrational phenomenon is greater and beginning to concentrate towards the western portion of the border. The shift in migration to the

California-Baja California region caused a rekindling of higher growth rates during the eighties in that area, pushing population growth in the state of Baja California to a 3.6% and the city of Tijuana close to a 5% annual rate (Zenteno, 1994).

ANNUAL RATES OF POPULATION GROWTH

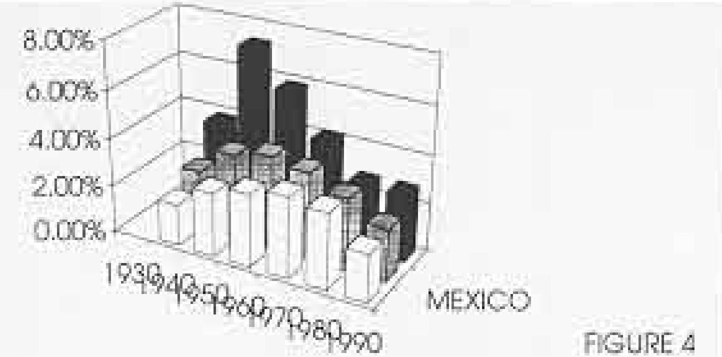


FIGURE 4

The demographic transition seems to be an adequate tool in assesing the stability of a region, provided the region has a relatively low degree of incoming population. Achieving a decline in the death rate first, then the birth rate, thereby arriving at a greater degree of demographic stability, is really a function of how that society has evolved in medical and educational terms. Subsequent transitions, such as the urban transition, the epidemiological transition, or others, respond to the same evolution factors, provided that migration is not a major factor. In essence, transition theory is a tool that is not designed to deal with the migration element. It is intended to assess the rate of change of a given population sample, provided that the sample is somewhat encapsuled or closed off from exogenous changes to itself.

In attempting to use transition theory to assess the stability of the US-Mexico border region, it is my suggestion that our analysis should go beyond the demographic transition or the urban transition. In this paper I will attempt to point out the factors which have produced the explosive population growth of the border region, and define ways of modelling their evolution. It is my goal to accomplish some comprehension of the stage of development in which the border region is in the present time, and at what point of its future development the rate of change in the area might become stable.

The urban transition.

Describing the urban transition is a major task. The first problem is trying to agree on what an urban area is within Mexico. Is it any area comprising more than 15,000 inhabitants, as is defined by the National Statistics, Geography and Information Institute or *Instituto Nacional de Estadística, Geografía e Informática* (INEGI)? Is 20,000 population enough to call a settlement urban? The ambiguities in tipifying an urban settlement is only part of the problem. In order to measure the degree of urbanization of a region, the obvious approach would be to map human settlements through satellite imagery and monitor their growth. The problem is that not all human settlements are urban and that assessing from satellite images at what point they do "turn" urban is really very difficult.

Another approach to defining urban and rural is the old numbers threshold method. When a certain community surpasses the designated threshold you scratch it from the list of "rural" and you move to the column under the "urban" heading. So, for example, a community that happens to have 14,000 population during a census year will be recorded as rural by INEGI, and if it takes either one or 10 years for it to accumulate 1000 more residents, the results in the next census will show a 14,000 reduction in the rural population and an increase in 15,000 in the urban category; a shift from rural to urban of 29,000 inhabitants in ten years -or less, if a middle of the road unofficial population count takes place-, hardly an accurate description of reality. Another problem becomes the way figures are handled. Since the minimum political unit is a municipio, 4 communities of 4000 each actually compile an urban municipio, when in reality all four settlements should be regarded as rural.

[2]Still, agencies and people do classify populations as either rural or urban, and so, I have gone through the motions of monitoring how the northern border states "urbanize" in comparison with the southern states, using INEGI's criterion of 15,000 inhabitants as a threshold, and the agency's record of "urban" and "rural" population at the state level (FIG.5).

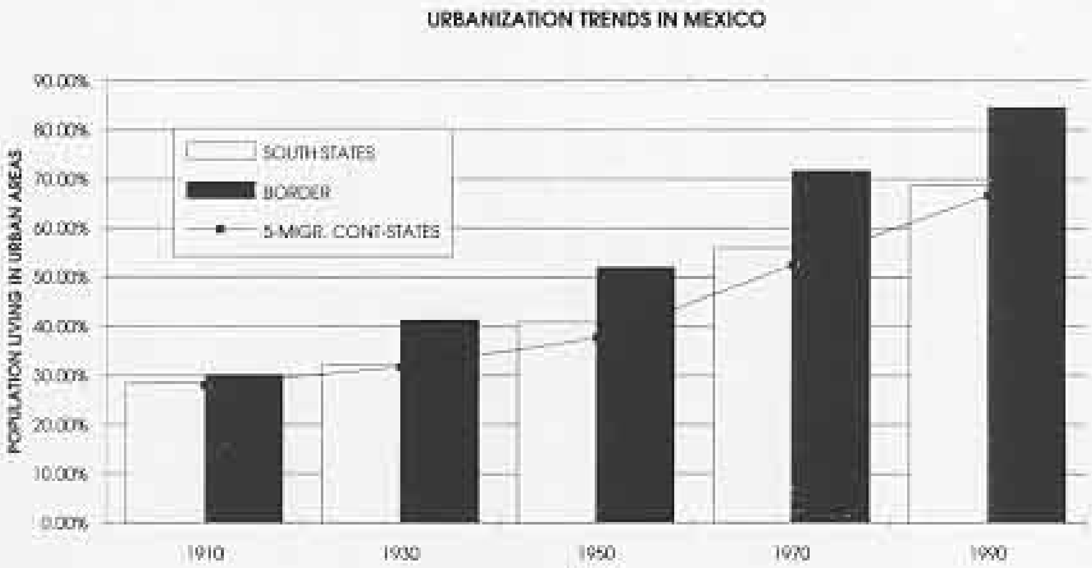


FIGURE 5

[2] The most distinctive feature of urban settlements, as opposed to rural, is the collective, networked approach to solving public services, more noticeably water, sewage disposal and solid waste disposal. Collective public services are often used as definitions of urban, yet statitics of urban and rural settlements are not recorded under this criterion.

Border dynamics.

The US-Mexico political boundary maintains a very strong presence in Mexico's economy. The offer of goods from the north, both capital and consumer, has made trade balance between the two countries very advantageous to the US. The presence of capital, purchasing power and a gigantic market, plus the demand for labor has been a magnet to a variety of corporations and individuals from Mexico. An additional "*pull*" factor luring people across the border is the diminishing supply of low skill-low wage labor force in the US, an element which has triggered much controversy over the immigration issue in the US-border states.

The important point is that the US and its economy exists as an overwhelming presence, and creates a tremendous impact on the dynamics of the border area within Mexico. In COLEF's August 1994 Migration Survey (EMIF), results showed that out of the 7 million plus travelers who arrived at bus terminals and airports of all the Mexican border cities for a year, only 1.8 million declared work as the primary goal or object of their migration. One million stated their intention of staying within the Mexican border cities while close to 800 thousand listed the US as their projected final destination. This split in the numbers of people looking to cross the border and those seeking employment in Mexican border cities poses an interesting posibility towards assessing the pull factors that have created this migratory force in a northward direction, a phenomenon that I will refer to as a "***gradient***", a driving force which is composed of a "pull" factor in the north and in some cases a "push" factor in the south states or place of origin. Before venturing into a more detailed review of these *push* and *pull* factors, let us establish a common definition for the term gradient.

Gradients

A slope or degree of slope? Well, a gradient is actually a driving force, that in a simplistic way is defined by dictionaries as a slope[3]. Groundwater flows under the influence of gradients also, and not necessarily downhill. Differential in pressures is what groundwater responds to, and these pressures can be caused by a difference in elevations within an acquifer (truly a slope), by overlying bedrock or a combination of both, either acting in the same direction or offsetting each other partially, applying pressure in opposite directions.

*A **gradient** is a net resulting force after all intervening forces have been weighed.* Just as important as identifying the main or pulling force is identifying those that modulate it or reduce its effect. Applied to human behavior, specifically in the case of migration to the northern states of Mexico, as in most human migrations, socioeconomic factors are the main driving force. The identification of which factors constitute a gradient and which bear the greatest influence, while doing an exercise on modeling their

[3] In mathematical terms, a gradient is a vector force at a given point P_0, associated with a function (x,y,z), which can be measured by evaluating the partial derivatives of f at P_0. For a thorough definition of gradinet vectors, see Thomas and Finney, 8th Edition, *Analytic Geometry and Calculus*, p.870.

change, is one of the main purposes of this paper. Introducing the concept of *gradients* into the work done with *transitions,* and finding how both concepts can work together may prove a worthwhile contribution. Meanwhile, for the purpose of this paper, the concept of gradients was the only path I could identify to applying transitions in a bonafide and realistic effort in assessing the degree of stability present in the dynamic region of Mexico's northern border.

Gradients in the real world.

Referring to the migrational phenomenon, there really are only two kinds of "gradients": social and economic. The first kind deals with a variety of issues that relate to the community, and that influence the collective quality of life in a region. The second kind pertains to the individual, the opportunities that exist for personal progress and yes, the corresponding improvement in the quality of life they offer but at the individual level.

Economic factors like **average income** and **employment** carry the greatest influence when it comes to promoting migration. We live in a capitalist world, a free market world, where working in a competition environment is the path towards progress. So, moving towards an area of higher employment and/or better income on an average is a rule of occidental life. The US job market plus the **availability of capital** in the border areas in comparison with other areas of Mexico create opportunities that can definitely be regarded as a gradient. FIGURE 6 shows that the higher income jobs are more prevalent in the 6 northern border states, while low paying jobs are relatively more numerous in the rest of Mexico (also see map attached).

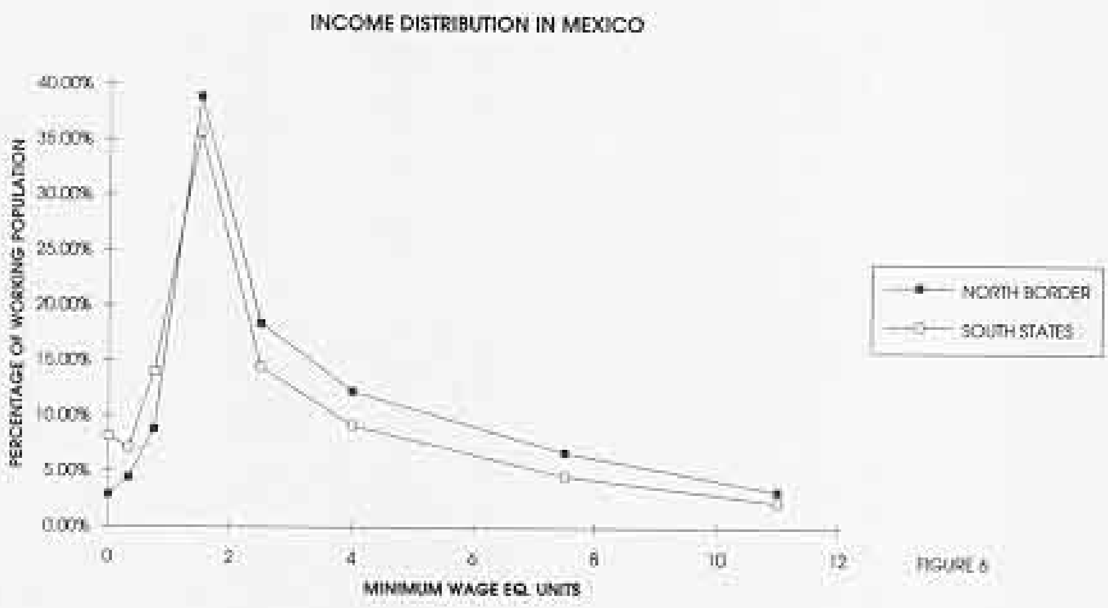


FIGURE 6

Social factors, such as **social order**, **health services** and **environmental quality**, all affect the quality of life in a region and can be measured through different means. Public safety may be the single most importat social issue, which tends to promote migration. If people feel threatened by the degree of social disorder in their place of residence and can afford moving to a new city they will tend to do so. Violence ridden cities in the past like Chicago, New York or Mexico City are living proof of this reality. We will use delinquency as in the number of **prosecuted federal offenders** to measure social order (or disorder).

Natural population growth is a social factor that figures into the equation but in a different vein than others. A high natural growth rate does not automatically promote the exodus of people from a region, although it tends to strain the local resources, deteriorate the environment and cause individuals to compete for local goods and services. An additional element is that a reduced natural population growth also allows for immigration to take place, especially if the economy of the region is growing at a rate in which it can incorporate more labor than that supplied by the local population. For these reasons, we have included **total fertility** in the monitored variables.

The economic gradient

We have already seen that the higher paying employment opportunities are located in the northern border states. But to say that this alone determines the northward migration within Mexico would be to ignore a major factor: the US economy. Going across the US-Mexico border or simply harboring expectations of doing so, either with or without proper documentation, is a major thrust of the migrational phenomenon. In 1980, the average income of the border strip in the US was just slightly over $10,500, while the Mexican border towns registered an average income of $2935 US-dollars (Peterson and Arriaga, 1992).

So every migrant worker who reaches the border area potentially represents a new resident of a Mexican border town or of the USA. Deciding where to settle down may involve a process similar to the one described by Terry Clark (1994) in his conceptual framework on international boundary effects on the market system. Clark's conceptual model involves *cross-border market size* (M_{ijx})[4], here translated into the ***migrant labor force***, in nation "j" (border towns in Mexico). The demand is related in the model to *cross-border market area* (A_{ijx}) (***border population in Mexico***), the *density of buyers* (¢) (***unemployment, depressed economic conditions***) and *per-capita income* (Yj) (***lack-of or low-income, low salary levels*** for our purposes). The market size or migrant labor force is described in the following equation:

(1) $$Mijx = \mathbf{A}_{ijx}\ b_o\ ¢_j\ b_1\ \mathbf{Y}_j\ b_2$$

where b_o, b_1 and b_2 are related parameters.

[4] The term is read as "market in nation "j" for "x" commodity or atribute in nation "i". As you can read on in our analogy, the "x" attribute is for our purposes higher payng jobs or employment and nation "i" is the USA

Clark offers propositions with regards to the model, which I will transcribe in a form translated into appropriate terms for our discussion topic:

-**P**$_1$: The population at border towns in Mexico and the potential cross-border migrant labor force are directly related.

-**P**$_2$: Cross-border migrant labor force and unemployment or depressed economic conditions in Mexico are also directly related.

-**P**$_3$: Cross-border migrant labor force and low salary levels in Mexico are directly related.

Clarks market model analogy can be extended even further. *Differential presures* described in the article are equivalent to ***urban social pressures*** which can be accumulated in the border area, as a result of increased border resistance or reduced ***permeability***. Finally, a *preference gap* (G_{ijx}) is identified, analogous to our concept of **gradients**. Here, preference gap is defined as "the sum of weighted aggregate preference score differences..." through the following equation:

(2) $$G_{ijx} = \text{SUM}\ [\pounds_{yj}(X_{yi} - X_{yj})]$$

where

X_{yi} = preference score in nation i on attribute y of product X,

X_{yj} = preference score in nation j on attribute y of product X, and

$\pounds_{yj}$ = weighing factor on attribute y in nation j.

For our purposes, product X becomes employment or a given professional contract, and attribute y translates into the hourly fee or salary earnings. We complete the use of the model by taking:

-*cultural distance*, to develop ***cultural fixation*** or ***expectations***, a reference to an innate tendency of preference by a given individual to (in our case) working in the US,

-***border permeability***, using it in the same vein as in the market excercise,

-*transfer costs* to add ***crossing difficulty*** into the formula, acknowledging that official policies will tend to increase or decrease the difficulty or time investment in crossing the border, and

-the *L-distance* or distance at which secondary boundary effects can be experienced within nation "j", analogous to a distance up from the bottom of the social strata, which would correspond to a ***percentage of the economic active population susceptible to migrating*** for labor related reasons.

Five final propositions:

- **P**$_4$: Expectations are directly related to the gradient

- **P**$_5$: Border permeability and urban and social pressures in border cities are inversely related

- **P**$_6$: Urban social pressures are directly related to the crossing difficulty

- **P**$_7$: Percentage of population susceptible to migratory practices is directly related to urban social pressures

- P_8: Percentage of population susceptible to migratory preatices is inversely related to crossing difficulty

Our adaptation of Clark's conceptual model is seen in FIG.7

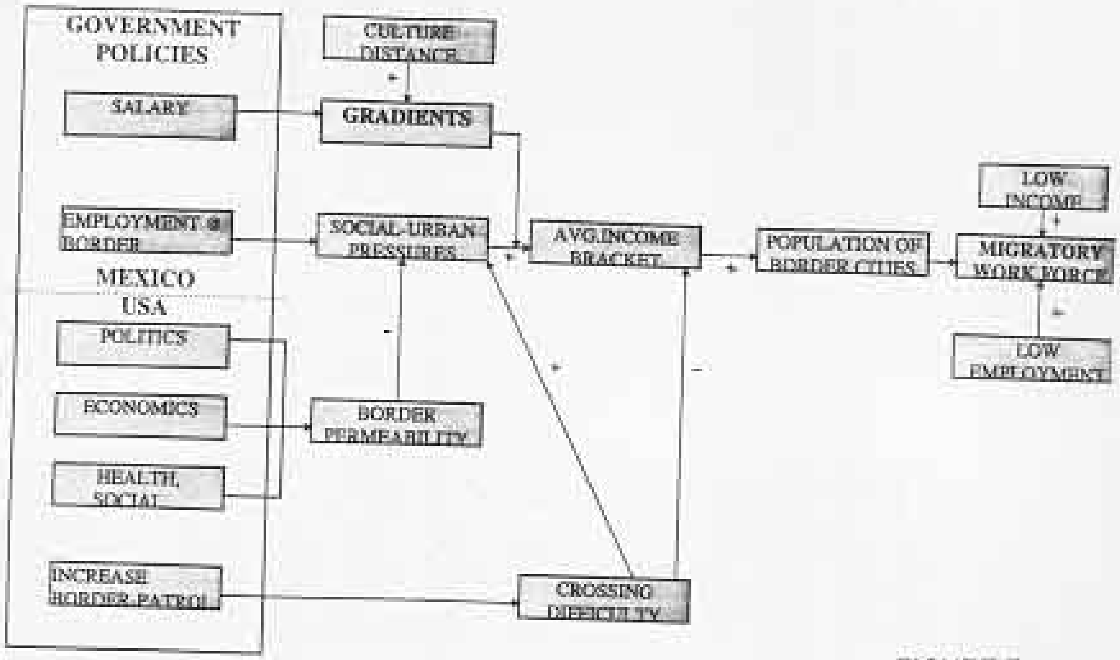


FIGURE 7

It is pertinent to point out that COLEF's study found a 10/8 split in the flow of people arriving at border towns between Mexican border towns and the US. That is, out of 1.8 million that arrived to the border area for labor purposes, 1 million intended to stay in Mexico and 800 thousand said to be headed for the US labor market. This means that in spite of the average income differences, the majority of the migratory workers arriving to the border area appear to be settling within Mexico, which may be explained after all other factors are added properly into the formula. To the extent these factors shift, changes will occur in the distribution of social pressures caused by the migrational pheomenon between the border cities and the USA.

However the root causes of this migration may be traced to the lack of employment in the 5 states of southern Mexico which contribute 41% of the migration into the US and 23.4% to the northern border cities and 31.1% of northward migration overall. Both employment and financial activity appear to be occurring in the northern states. Since official unemployment figures seem to underestimate reality, we proceeded to analyze the figures of registered workers in the Mexican Institue of Social Service (Instituto Mexicano del Seguro Social or IMSS), a government run institution which provides health services for employees of the private sector. All federal and state employees are excluded from the record, as well as the self-employed or under-employed population (FIG.8). To monitor the financial

EMPLOYMENT INDICATOR: SOCIAL SERVICE BENEFICIARIES (IMSS)

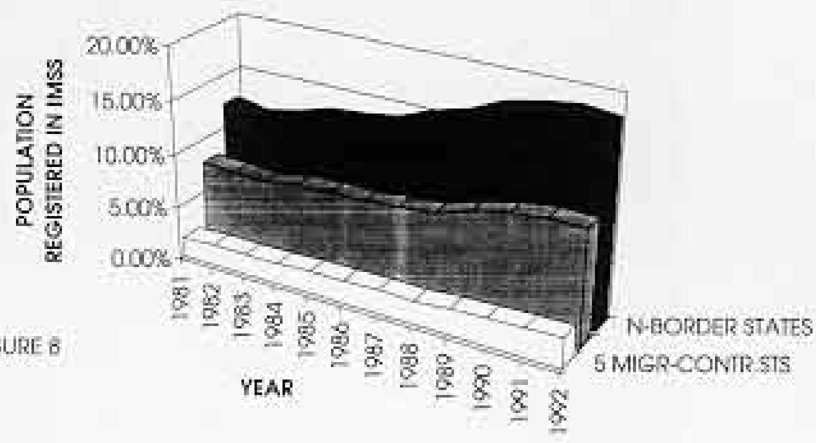
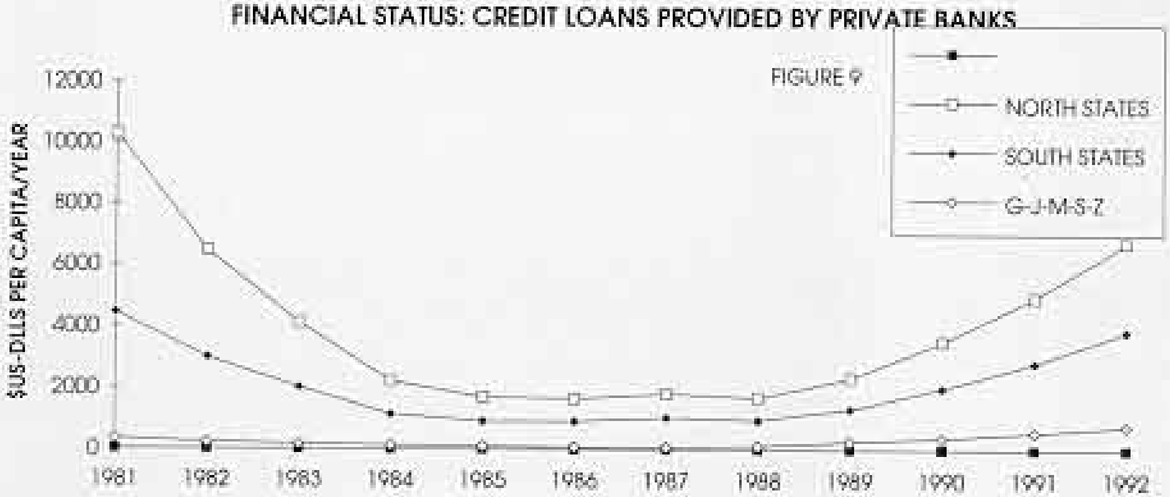


FIGURE 8

activity within different states, I have used the amount of credit awarded by private banks as the indicator variable (FIG.9). Both items show a definite imbalance between regions, with the flow of capital and the employment opportunities are clearly in the 6 northern border states. Together with higher income averages and the proximity to the US, the economic gradients promoting northward migration are evident.

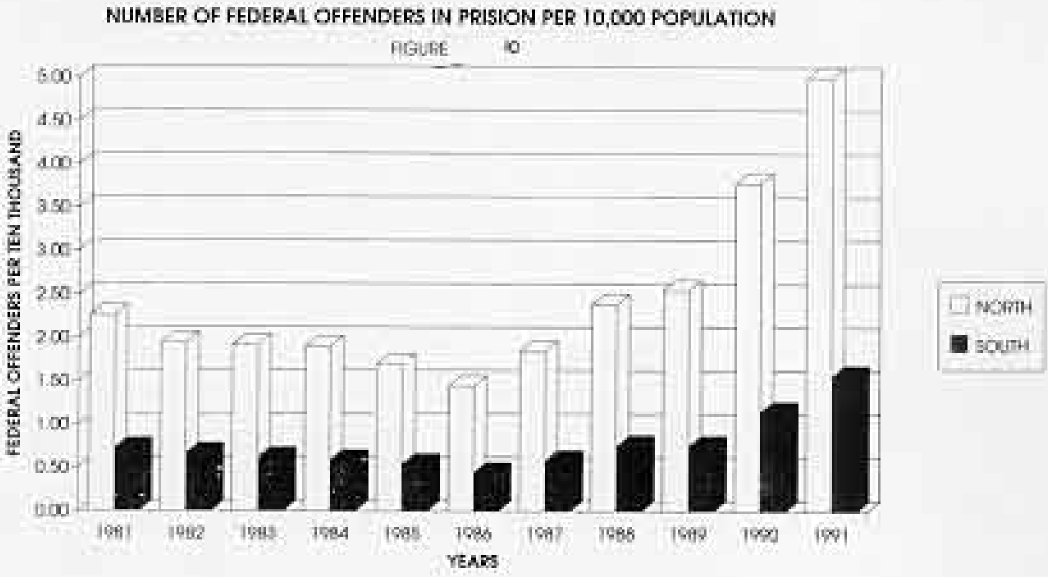
FINANCIAL STATUS: CREDIT LOANS PROVIDED BY PRIVATE BANKS

FIGURE 9



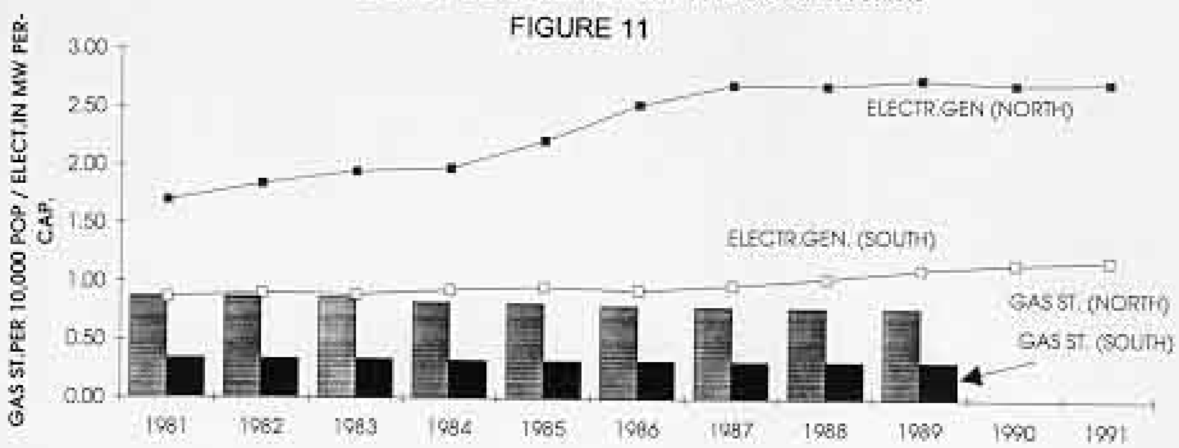
The social gradient

The social evolution occuring in the population of northern states has been documented in previous charts. Coupled with a moving economy, the reduced natural growth rates of the northern population is a social gradient promoting migration.



Under high economic activity and a variety of social pressures, crimes prosecuted by federal authorities have increased noticeably in the northern states (FIG.10). The onslaught of toxic substances is another side effect from the rapid industrialization and the limited infrastructure present in the area. Studies by Sanchez (1990a, 1990b) and Denman (1991) provide evidence of environmental and social repercussions of the fast pace at which the border area is developing. These effects, if projected to the coming years might become a disincentive to growth or even worse, a set of conditions that the less privileged societal groups in the border states will have to withstand. Little data exists that can document the degree of chemical pollution being experienced in the waterways and solid waste disposal sites of the border region, but the work of Sanchez, Denman and other border studies scholars do reflect cause for concern.

ENERGY CONSUMPTION ON A PER-CAPITA BASIS
FIGURE 11



Even if environmental disregard is on the mend, the development of the northern border region of Mexico reflects typical environmental pressures associated with fast development. Energy consumption seems to be higher in these states, on a per capita basis (FIG.11), and I have used it here as a posible indicator of atmospheric emissions. Cities like Mexicali and Ciudad Juárez experience poor air quality due mostly to a high incidence of suspended particles (PM10) beyond the recommended standard. But very few studies exist to date that monitor air quality in the border region in a consistent fashion, so it is in a warning sense that figures reflecting energy consumption could be used to protect future air quality in the border area before it becomes a serious problem.

The border area: seeking stability.

The passing of the North American Free Trade Agreement (NAFTA) holds promise of development for a rapidly industrializing Mexico, in the context of a world economy. All of the data presented here as economic and social indicators are prior to the passage of NAFTA and are therefore not associated with any posible effects it might have. But the symptoms of today's economic growth point towards a continuation of present trends under the terms identified in this paper, with our *gradients* acting to promote a greater economic growth in the border area than in other regions of Mexico.

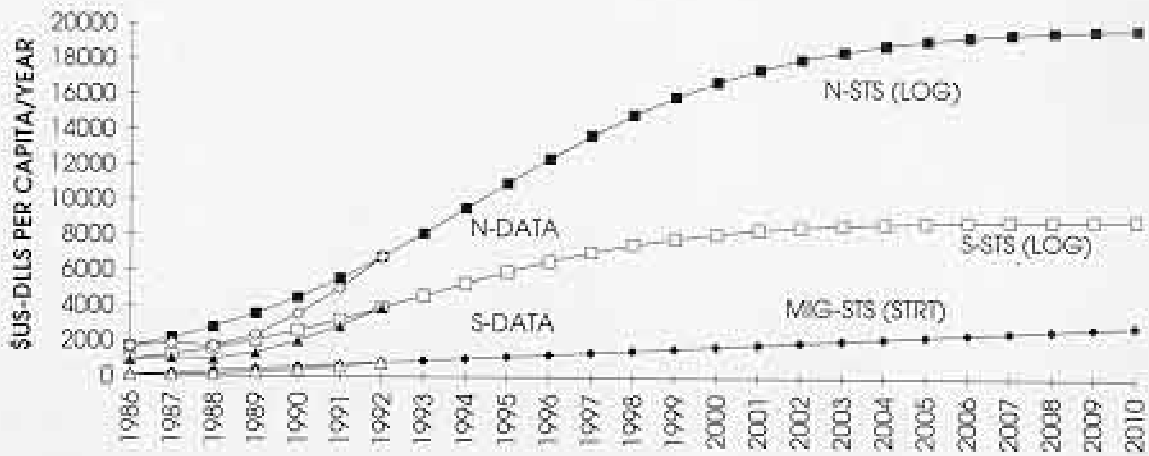
In the context of NAFTA, investors are expected to prefer the northern states for several reasons. To the extent that the northern border states are more urbanized than the rest of Mexico, the physical infrastructure required will be easier to obtain in these states. The proximity to the US market network is also a factor, as it has occured with the maquiladora program. Social factors like the educational level, a certain technological preparedness or orientation, obtained precisely from the exposure to the maquiladora program and overall contact with a higher technology/greater automation approach to manufacturing. These social, urban and technological factors tend to acquire a "snowball effect", feeding off a positive interactive loop and promoting economic activity of a different nature. As stated in Chapter

7 by Macdonald, the environmental concerns that go along with greater development have propelled the Mexican government into a higher bracket of expenditures for environmental protection. The bureaucratic enforcement needs associated with the continued development of the border region can be seen as an outgrowth of the same set of circumstances.

The models developed for future scenarios of financial disposition (FIG.12) is in agreement with what I have stated above. Projections can be seen for three different regions of Mexico (Northern border states, South states and "Migration" states), which show the available credit that private banks have offered in recent years in the country. The figures show an exponential trajectory to date, but have been fitted with a logistic curve in anticipation of a reduction in the rate of availability of capital. Still, a continuation of the present economic gradients pushing population to the north can be seen. Figure 13 shows us the IMSS figures on registered workers (our employment indicator used previously), which also has been fitted with a logistic curve (and a greater correlation factor than the investment curve) and coincides (as one would expect) with the projections on investment.

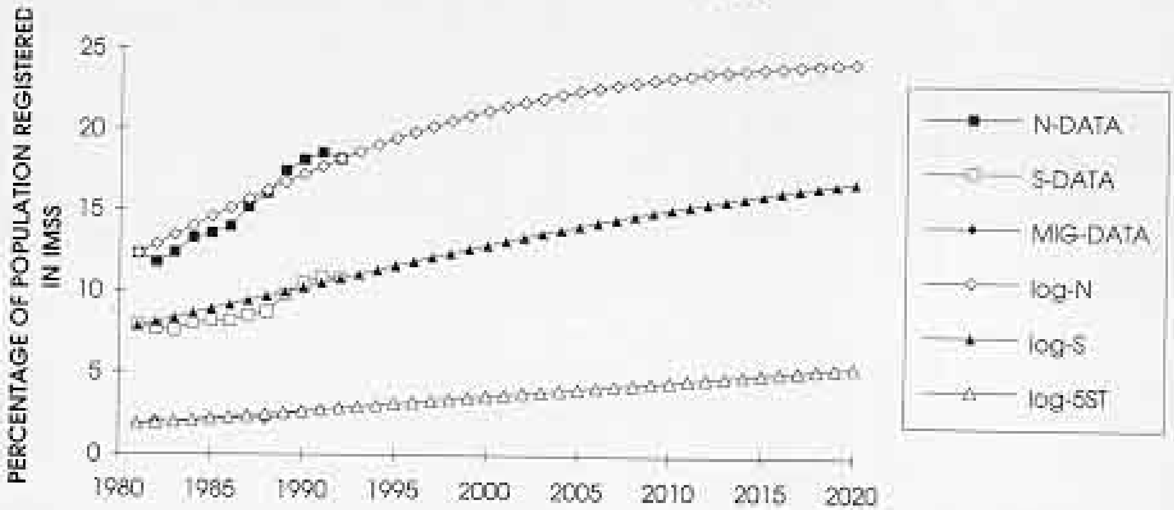
FIGURE 12

FINANCIAL RESOURCES: PROJECTIONS FOR CREDIT FROM PRIVATE BANKS



It is apparent then that the northern border area figures to remain a more dynamic region than southern Mexico, continuing to pull migration to the area. Even government expenditures on a per-capita basis (FIG.14) appear to be preferencing the northern border states over the rest of the country, showing a greater gap between regions in ecent years than in the past. The northward flow of resources, government attention and hence, population, is a reality and an attitude that bears consequences which must be reviewd with greater detail by decision makers now.

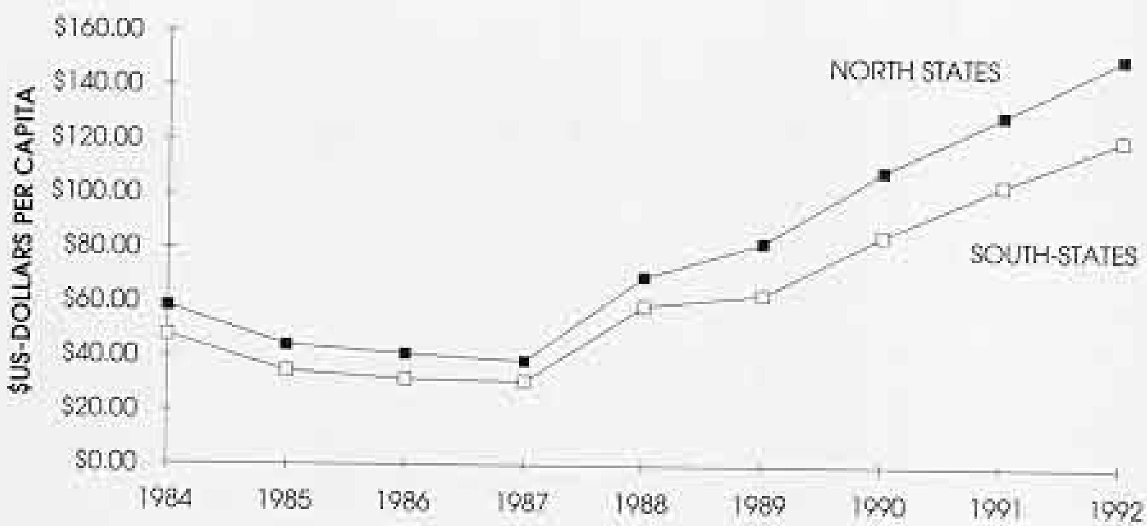
FIGURE 13
EMPLOYMENT PROJECTIONS BY REGIONS



Conclusions and Policy Recommendations.

Great controversy has existed over which area stands to gain and which areas looses economically in a migration context. The political discourse shared by many in California overtly displayed by Proposition 187 of the November 1994 election points to immigration as an "economic sink", forcing the receiving region to tend to the social needs of immigrants at the expense of the local economy.

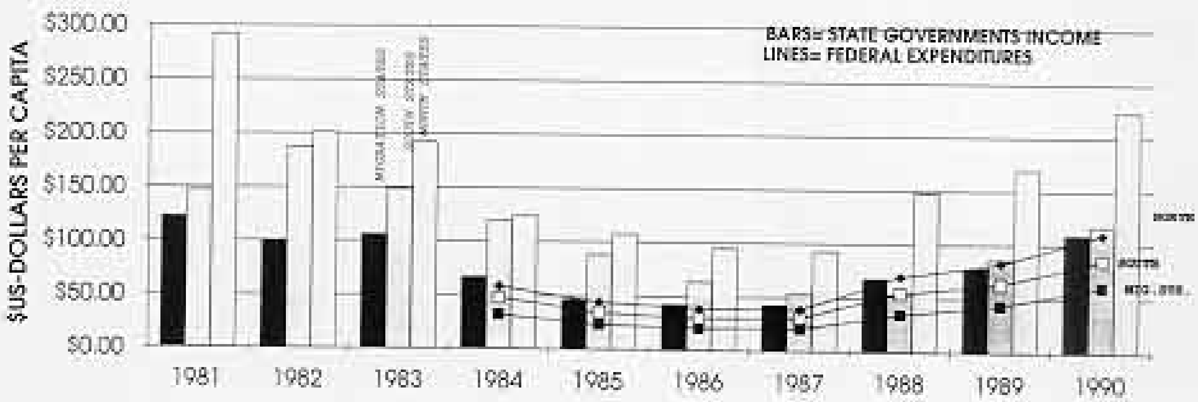
FIGURE 14
DISTRIBUTION OF FEDERAL EXPENDITURES



Inherently, there is an underlying statement which suggests that only under these circumstances (migration) the market economy fails to address social needs properly. It is a political irony that public officials in the northern states of Mexico display the same philosophy when dealing with the central (federal) government but reject the notion when stated by politicians across the US-Mexico border.

From the data we have seen in this essay, it is clear that market forces with added help from social and cultural factors are determining a migrational movement northward within Mexico. We can also conclude that social and environmental consequences are occuring, both in the rapidly developing border regions as in the lesser developed south. It is wrongful to signal out migration as the evil term in the equation. The shifts in population only serve to magnify the inequalities under which socioeconomic system operates. "Scapegoating" migration does nothing to solve the social problems that Mexico faces today.

DISTRIBUTION OF PUBLIC FUNDS FIGURE 15



The explanation to the migration phenomenon in Mexico is no secret. The evidence shown here can be regarded as an effort in "unveiling the obvious" within the framework of transition theory. With it, we can acknowledge that the instability caused by the rapid rate of change within the various transitions occuring today in Mexico, some of which are inferred to be acutely present in the border areas (the toxics transition, the urban transition)[5] can be stemmed by addressing the *root causes of migration: **gradients**, social and economic.*

Perhaps the future of migration is appropriately sketched out by Soonae Park when referring to international migration in Asian Countries. Park suggests a migration transition that will see migrant workers returning to their place of origin but having its "root to the movement of goods and capital and ...(engendering) a political movement towards the legalization of foreign workers...".

Although one might find appropriate for more fiscal resources to be spent in the northern border states, mirroring the income of the state governments themselves (FIG.15), given the results the status quo has to offer, the task at hand for the Government of Mexico is two-fold: it must solve the empoverished, socially lagging realities of the south and face up to the development caused social and environmental needs of the north. So taking into account that there is an aggregated value that migratory

[5] Poor data on toxics incidence in the northern states or a solid way of recording urbanization and it effects leave me a feeling of being before an important national issue that is unclear or lessened by the lack of numbers

labor produces, and the economic benefits that are therefore brought into a region, the public sector must reap these benefits and appropriately allocate them to solve societal needs.

I offer two policy recommendations:

1. Government policies must be directed at bridging the investment gap between north and south states projected in our investment model (FIG.12). Tax incentives in southern states and greater taxation in northern states is a frequently utilized tool to promote parity (reduce gradients). The increased fiscal resources in northern states should be applied to investment opportunities (specifically industry) and serve to address the social pressures that are caused by migration in that area.

2. A redistribution of federal funds should compensate for the "labor flight" occurring in the south, specifically in the form of educational services. The illiteracy rates and general educational level of the southern states confirm the need for greater spending (investment) along these lines (Table 2). Other avenues of investment, such as bolstering urban infrastructure to attract investment and that associated with environmental preservation (wastewater and solid waste treatment) should also be taken up by the federal goverment.

So while the task of gevernment is indeed two-fold, so will the benefits of a reduced migration to the north. It must be clear that migration will continue as long as the economic opportunities or the hope of progress remain as a privilege for those who dwell in the north.

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POPULATION–ENVIRONMENT TRENDS IN THE MODERNIZATION OF THAILAND

Cheri DeRosia

Thailand has one of the fastest growing economies in Asia. However, double-digit economic growth throughout the late 1980s and into the 1990s has come at the expense of the Thai environment. This paper examines the population, urbanization, epidemiology, industrialization, and environmental toxicity trends in Thailand from the perspective of Drake's transition theory (Drake, 1993). This theory holds that as a society modernizes it experiences transitions from relative stability through periods of rapid change, and then on to relative stability again. In addition to the transitions that are considered in this study in Thailand, agricultural, forestry, fossil fuel, technology, educational, and possibly many more transitions can be observed in most modernizing societies. An important aspect of all transitions are the influences they have on one another. For example, this paper examines the effect the growing industrial sector has on air quality in Thailand. In conclusion, the Thai government's response to the industrial pollution problem and the pressures that might be effective in prompting the government to take remedial action are considered.

A Brief History of Thailand

Thai history offers insight into their current situation. Known internationally as Siam until 1939, Thailand was the only Southeast Asian state to maintain its independence through the colonial period. No war took place, the Thai monarchy was never displaced, and its social and religious structures remained intact. There are a number of possible explanations for the Thais' response to the colonial threat. First, they had less faith in their military prowess than some of their neighbor states. Thailand had suffered many defeats at the hands of the Burmese and Chinese over the centuries. Secondly, because of Thailand's insulated location in Southeast Asia, it could observe its neighbors' experience with the colonialists to learn that even powerful Asian militaries were no match for the western militaries. Their position was also beneficial because the English and the French were not eager to confront each other and so maintained Thailand as an informal buffer zone. Maybe most importantly, the Thais had a well-established beneficial economic relationship with westerners, as Bangkok had been a commercial trading port since the 1680s.

Many historians assert that Thailand's independent history has allowed it to modernize in a gradual manner compared to the sudden and often violent modernization periods of some of its neighbors. Even though the Thais were willing to negotiate with the westerners instead of going to war and suffering militarily-enforced colonial rule, they did not escape the era unscathed, and made many concessions to the British and the French. Under military pressure from the French the Thais conceded their vassal states of Cambodia and Laos, and they also made many trade concessions to the British in the 1850s. However, Thailand's relationship with western states continued to be much better than that of most other Southeast Asian nations that were occupied by colonists.

The Thai monarchy made great strides in modernization in the nineteenth and early twentieth centuries, improving the government finance ministry to bring in a more reliable income which was used for education, government improvements, railroads, and the military. As a result of the financial support, the military gradually became stronger until 1932, when they staged a coup and took over the government. Although the monarch still remains the head of state, the country is run by an uneasy balance of a parliamentary legislature and a military enforcement branch, with the head of the military often serving simultaneously as prime minister.

Changes to the traditional way of life in Thailand occurred in the 1960s and 1970s as a result of rapid improvements in transportation and communication technology during that time, but as late as 1982 scholars could still note that "the great mass of the Thai people continue to follow a lifestyle amazingly similar to their ancestors" (Thorelli and Sentell). Thailand's economic development began to accelerate impressively in the 1980s, even compared to its prosperous neighbors. Thailand had higher average GDP growth between 1981 and 1990 than Singapore, Indonesia, Malaysia or the Philippines and this economic growth is projected to continue well into the future (Seda, 1993). The recent economic prosperity has led to a more complete modernization of Thai society.

The Demographic Transition in Thailand

In addition to indicating Thailand's progress as a developing nation, a look at the population estimates for birth, death, life expectancy, and total population brings the relative accuracy of the data used in this paper into perspective. Data from the World Resources Institute (WRI) database for these population figures is valuable because it offers projections to 2010, where most other data sources do not. However, when examined together with population-related estimates from other sources, some if not all of the WRI figures appear to be based on projected estimates instead of real data. For example, as shown in Figure 1, WRI data shows crude birth rate dropping from approximately 47 births per thousand population in a smooth s-shaped curve pattern to approximately 15 births per thousand population in 2010. Supplemental crude birth rate estimates from the Thai Office of the Prime Minister and the *Far East Economic Review* show more variation, suggesting that the data may be actual instead of projected, but both sources are available only for a short period of time.

One possible explanation for the variation is that each source may rely on different data collection techniques or assumptions. For example, Thailand is the home to several populations that are not considered ethnically Thai including the hill tribes in the highlands in the north and refugees from Laos and Cambodia in the northeast. Many of the hill tribes are semi-nomadic, and many of the refugees hope to be moved to the United States or to return to their home country. None of the sources make it clear whether these peoples are included in the data.

All of the WRI population figures for Thailand in this section have at least two other data sources which are used in comparison. However, many of the supplemental sources are no more reliable and most are only available for a limited time period. The extensive look at the population figures in this section emphasizes the variability between data sources and the ultimate unreliability of the data in the other sections of this paper where there is only one source of information. Confirming the reliability of all of this data would help to improve the reliability of the conclusions made in the paper.

Figure 1 shows birth and death rates in Thailand between 1950 and 2010. The sources show that birth rate in Thailand has gone through a transition and is reaching stability at around 15–20 births per 1,000 population per year, while crude death rate in Thailand also seems to be stabilizing at about 6 deaths per 1,000 population.

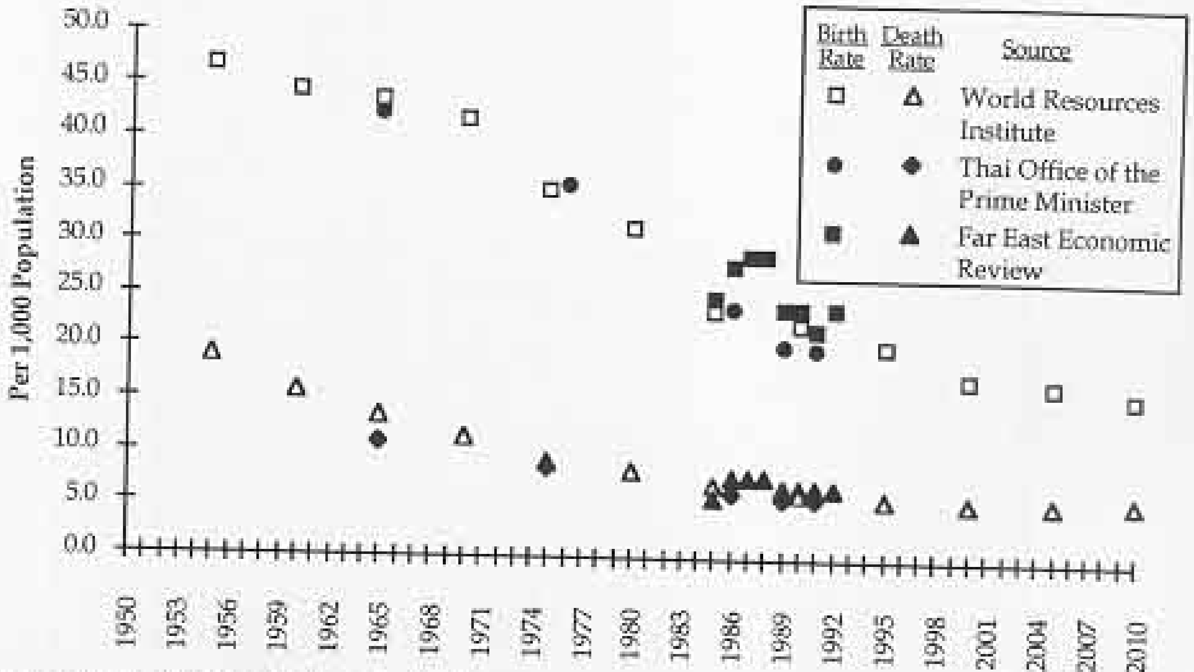

Figure 1 Crude birth rate and crude death rate.

The decrease in birth rates seems to have started about 1950, while the drop in death rates appears to have begun well before then. The convergence of the difference between birth and death rates by 1994, which is projected to continue, indicates that Thailand is well on its way through its demographic transition.

As a result of the drop in death rate and a general improvement in access to medical care, total life expectancy in Thailand is approaching a stable level of approximately 70 years, as shown in Figure 2.

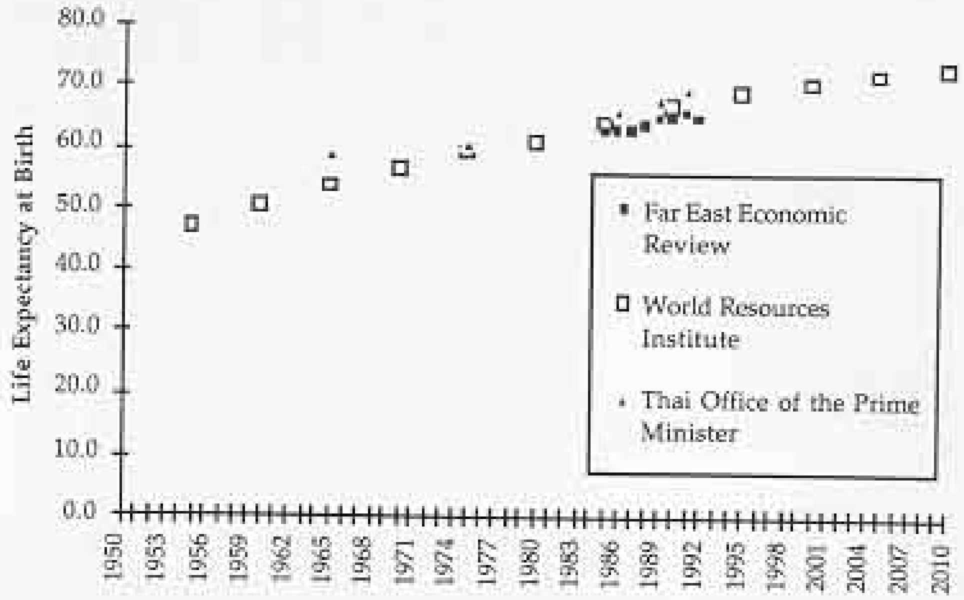

Figure 2 Total life expectancy.

Taken together, the estimates for total population figures vary between sources but seem to indicate that Thailand's population has gone through a transition and is reaching stability. Different sources' estimates for total population are approximately 57 million and seem to be closer to each other than estimates for other population-related factors. Even though it is clear by Figure 3 that WRI has curve fit an s-curve to the population figures to estimate a projection, it seems to be fairly close to both the estimates from Arbhabhirama and the Ministry of the Interior.

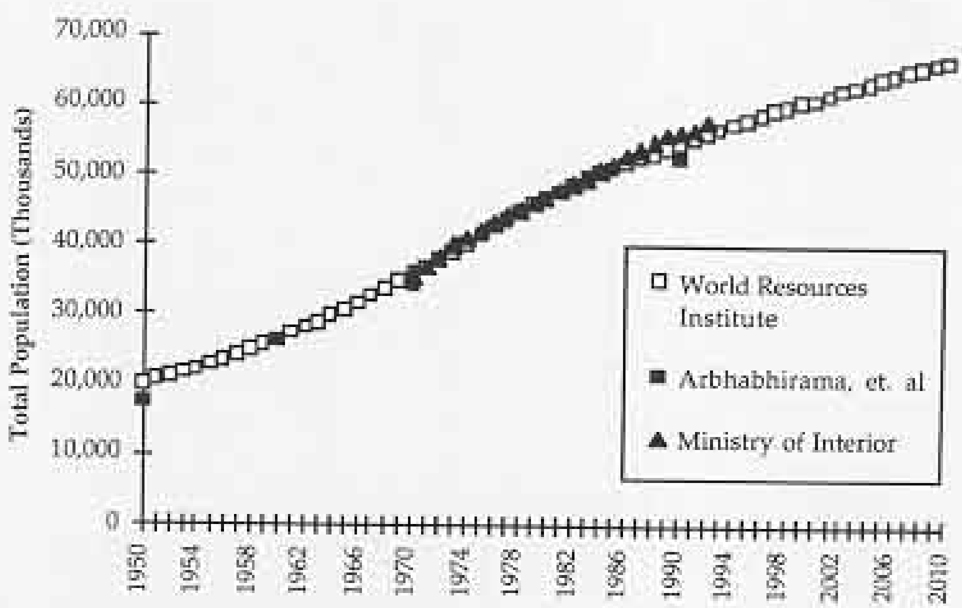

Figure 3 Total population.

Thailand has six major regions, as shown in Table 1 and in Figure 4. The Bangkok Metropolitan Area (BMA), which includes only Bangkok, and the Bangkok Metropolitan Region (BMR), which includes the five provinces around Bangkok, are by far the most densely populated areas in Thailand. The Central region is the least densely populated area in the country, followed closely by the North.

TABLE 1: POPULATION BY REGION

Region	Estimated Population 1994 (Thousands)	Percent of Total Population (1994)	Approximate Land Area (Square Kilometers)	Population Density (Persons per Square Kilometers)
Bangkok Metropolitan Area (BMA)	5,562	9.7%	1,100	5,056.4
Bangkok Metropolitan Region (BMR)	5,839	10.2%	5,200	1,122.9
Central	6,562	11.5%	98,700	66.5
North	11,682	20.5%	169,200	69.0
Northeast	20,059	35.1%	169,300	118.5
South	7,402	13.0%	70,500	105.0
Total	**57,106**	**100%**	**514,000**	**111.1**

(WRI, 1994)

The BMA and the BMR, are the fastest growing regions in the country, both in population and economically. The Thailand Development Research Institute (TDRI) predicts that population in the BMR will continue to grow 80 percent faster than the national average at least until 2000. The North is also growing at a similar pace, as shown in Figure 4.

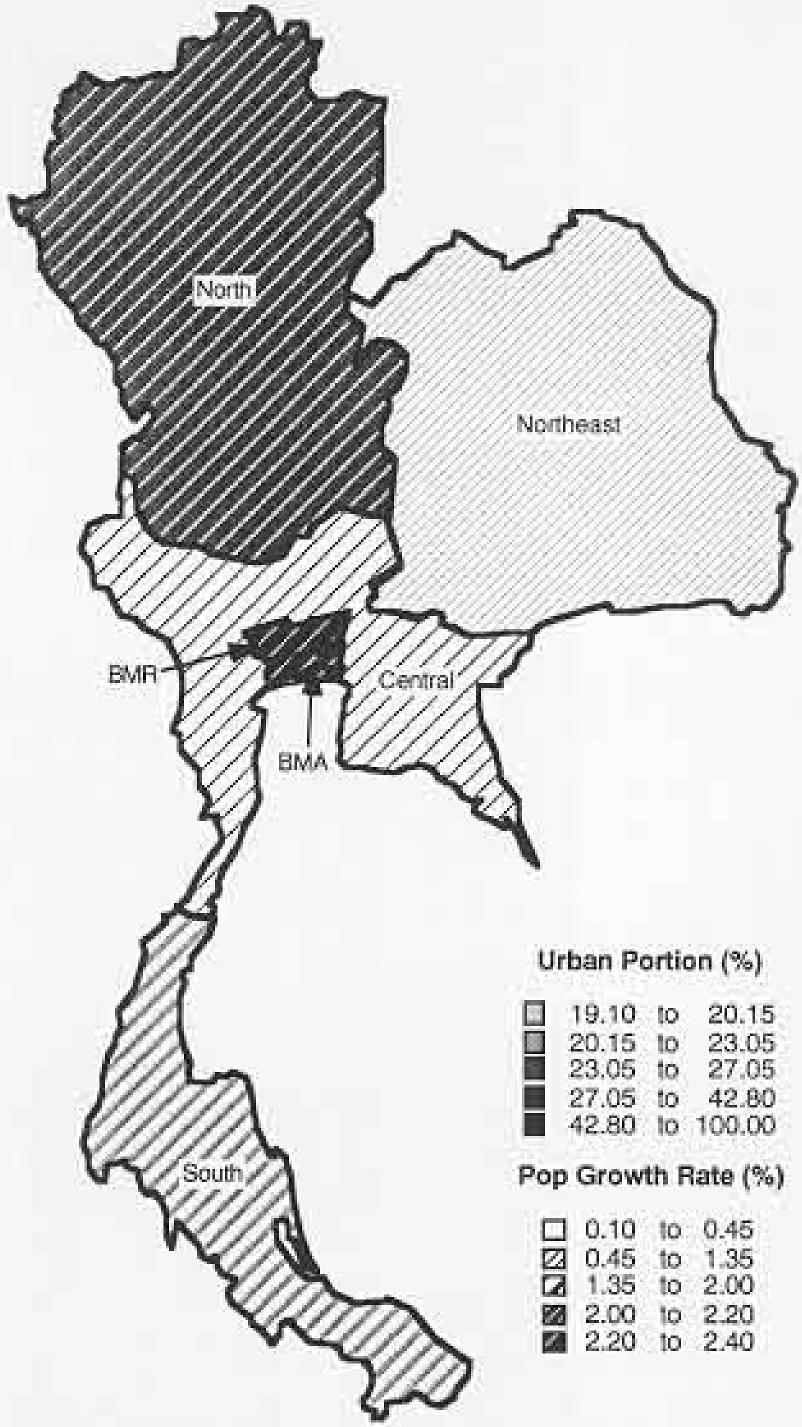

Figure 4 Thailand's regional urban population and population growth rate (Ministry of the Interior, 1991, and TDRI, 1990).

Thailand's Urbanization Transition

Even though the Bangkok area is very densely populated and dominates the growth projections for Thailand, the country's population is still very rural. Growth of the rural population is projected to continue to increase through the end of the decade and then slowly decline. Urban residents are not expected to out-number rural Thais until 2030 as shown in Figure 5.

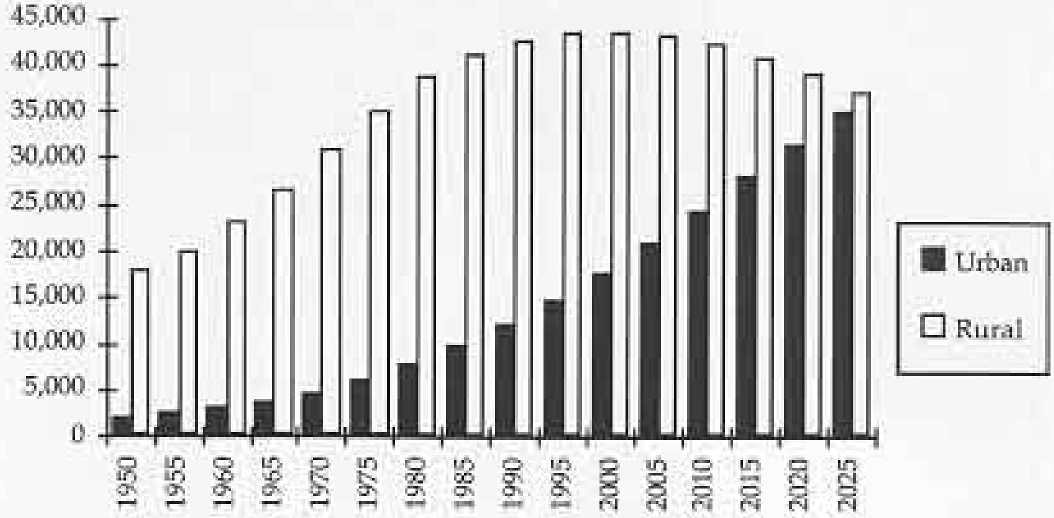

Figure 5 Urban and rural population and projections (WRI, 1994).

Figure 6 shows that the Thai population is currently about 22% urbanized, and the trend toward urbanization in Thailand probably will continue well into the twenty-first century, as projected by WRI.

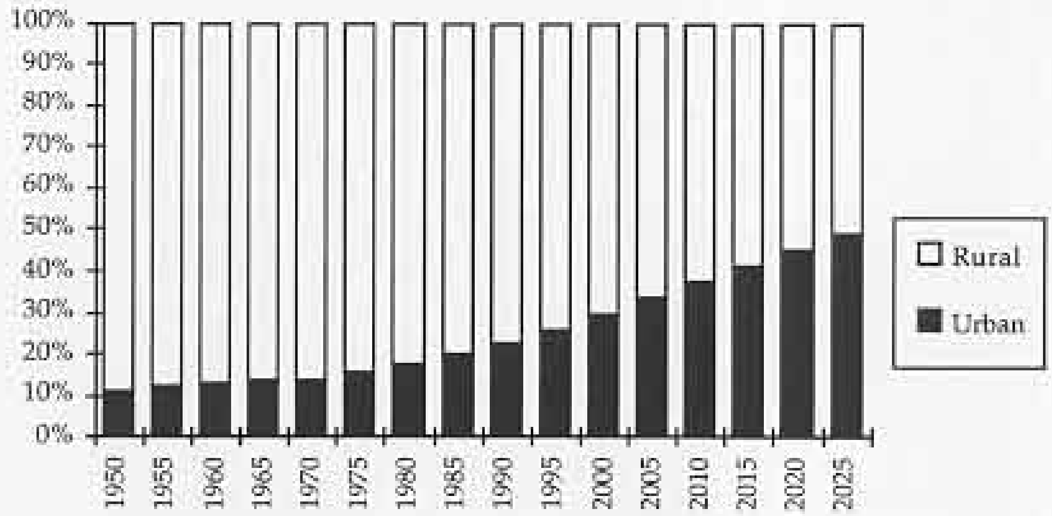

Figure 6 Rural and urban portions of the Thai population (WRI, 1994).

The urbanization trend in Thailand is well behind most developing countries in Asia and South America, especially if one compares urbanization to per capita GDP. Thailand's per capita GDP is higher than some developing countries that are 70% urbanized such as Columbia and Peru, as shown in Figure 7.

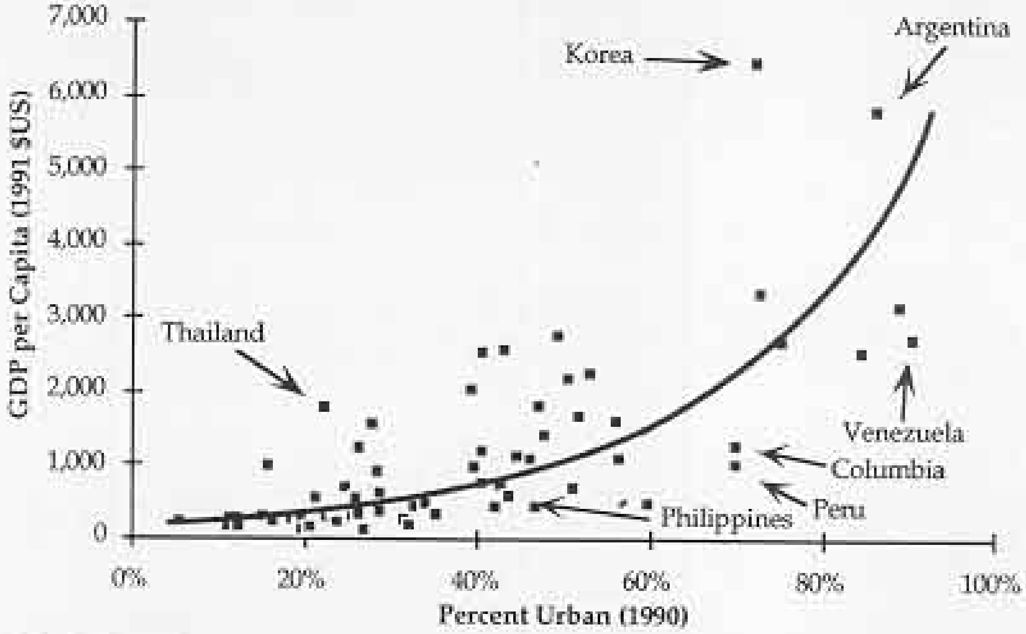

Figure 7 Per Capita GDP compared to percent of population which is urban among developing countries (TDRI, 1990, and WRI, 1994)

Note that there may be a difference in what portions of the population each of these countries considers to be urban.

The Epidemiological Transition in Thailand

The epidemiological transition occurs when the sources of morbidity in the population shift from infectious diseases that result in deaths at relatively young ages to degenerative diseases that result in deaths at old age. There are a number of indications that Thailand is at the end of its epidemiological transition. One is the reduction of the rate of death of children under the age of five, which indicates that more people survive childhood to have the chance to grow old. Figure 8 shows that mortality rates under five drop from approximate 145 per 1,000 population in 1960 to less than 40 per 1,000 by 1990.

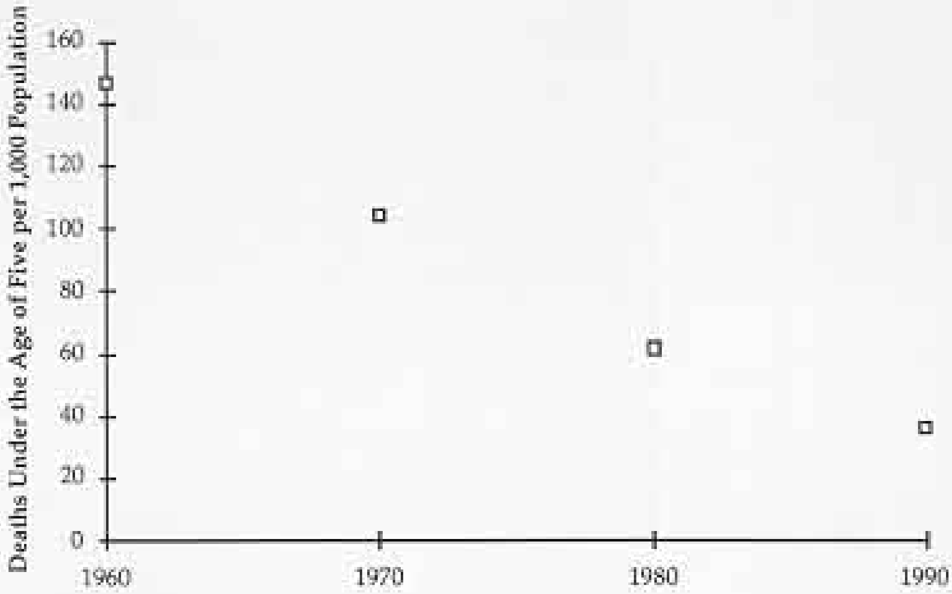

Figure 8 Mortality rate under the age of five (WRI, 1994).

Another indication that Thailand is moving through the epidemiological transition, an increase in degenerative disease rates while infectious diseases are decreasing, as shown in Figure 9.

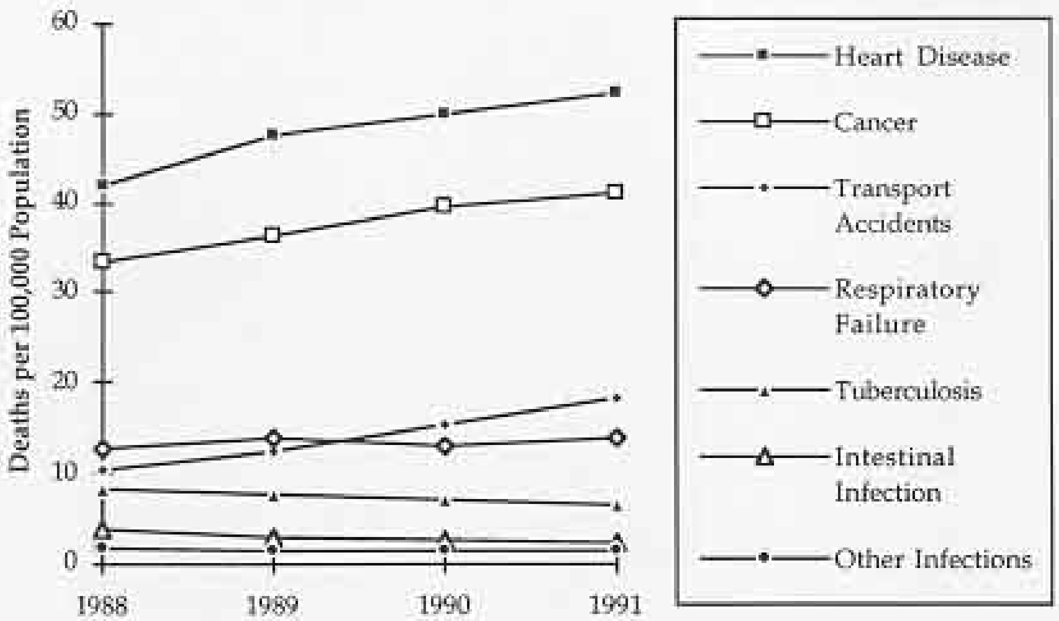

Figure 9 Incidence of degenerative vs. infectious diseases (Office of the Prime Minister, 1993).

There are probably many causes of the epidemiological transition in Thailand. Until 1980, government health programs that administered vaccinations and introduced other modern medical techniques probably did the most to reduce the morbidity due to infectious disease. However, indications are that even though government expenditures on health programs have decreased over the past decade, public health problems such as child wasting malnutrition has also decreased (Drake, 1994). This is probably because economic prosperity during the 1980s allowed Thais to avoid malnutrition. Child wasting malnutrition is a good indicator of whether the basic needs of the population are being met, and the economic prosperity is probably also allowing Thais to meet other health needs, which will in turn prolong their lives.

The Industrialization Transition

The industrial sector in Thailand has grown steadily over the past decade, as demonstrated by a number of indicators. Figure 10 shows that the manufacturing portion of the Gross Domestic Product (GDP) has increased from $11 billion US in 1984 to almost $18 billion US in 1990, even though manufacturing portion as a percentage of the total GDP has remained relatively constant at about 27%. By contrast, the agricultural portion of the total GDP as a percentage of total GDP has shrunk from about 20% to 12% in the same time period. Total GDP is projected to reach about $165 billion US by 2000, with the manufacturing share approximately $27 billion US. All estimates in Figure 10 are given in constant 1987 $US.

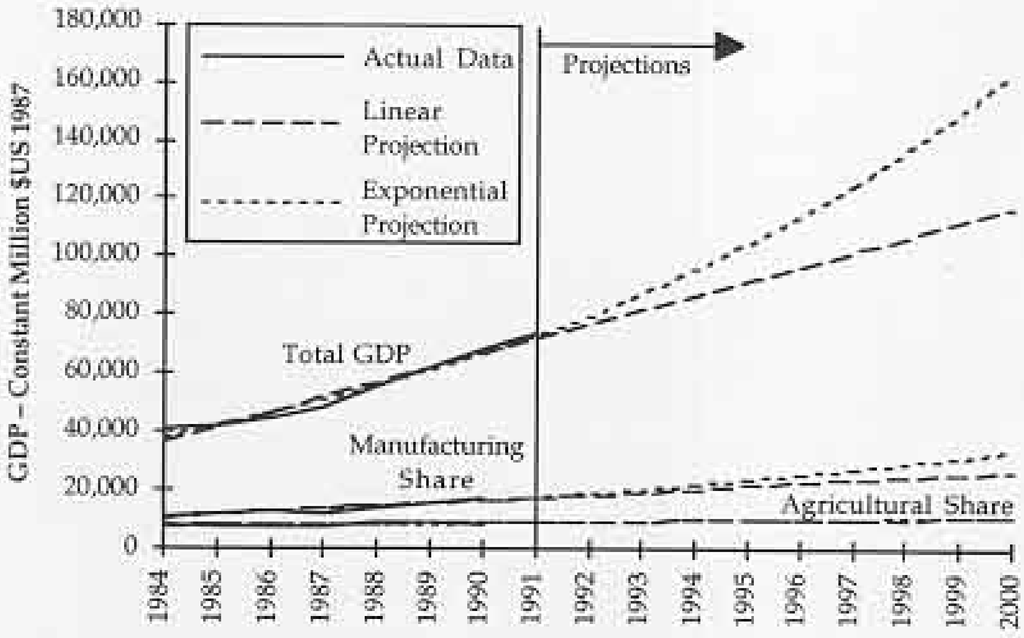

Figure 10 Total GDP, agricultural and manufacturing share of GDP, and projections (WRI, 1994, and *Far Eastern Economic Review*, 1984–1993).

Although all regions are experiencing industrial growth, the number of establishments is growing fastest in the Northeast at an average annual rate of almost 13% over the time period, compared to the lowest growth rate of 5% for the Bangkok Metropolitan Area. Figure 11 shows that the rate of increase in the number of factories is also high in the North and BMR regions.

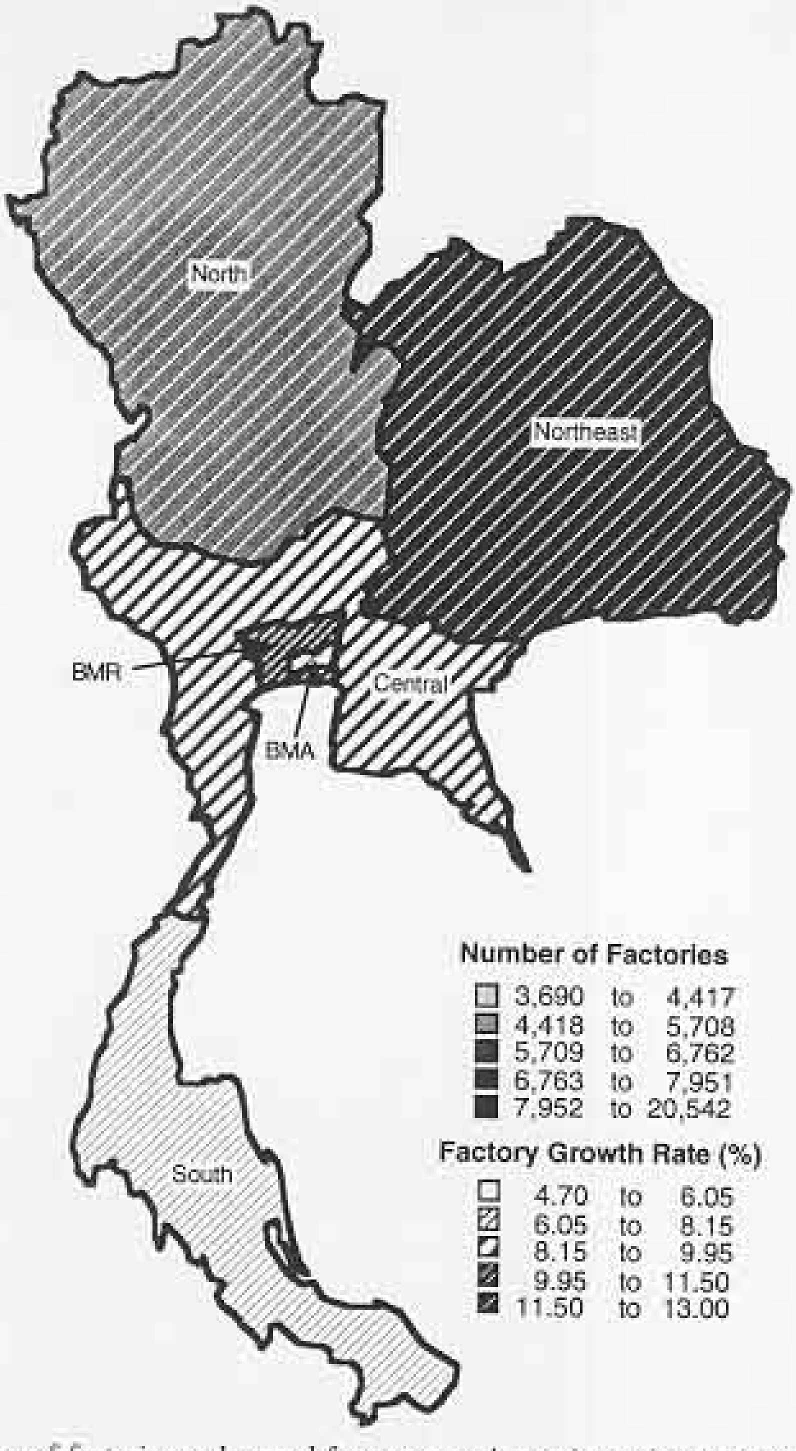

Figure 11 Number of factories and annual factory growth rate by region (Kritiport, 1991).

Note, however, that even though the rate of increase is slowest in Bangkok the actual number of new factories per year is still largest, as shown in Table 2. In addition, data was not available that describes the kind or size of factory by region. It is very likely that individual factories in the Bangkok area are larger in size, growing faster, employ more people, and emit more air pollutants on average than factories in the other regions.

TABLE 2: NUMBER OF NEW FACTORIES BY REGION, 1989

Region	New Factories
BMA	1,429
BMR	657
Central	710
North	639
Northeast	571
South	321

(Kritiport, 1991)

The Toxicity Transition

During the economic boom Thailand's environmental record, which has never been exemplary, took a turn for the worse. In 1988 the United Nations Environment Programme observed, "Ever since Thailand opened up its economy to the West in 1855, the country's development has been based upon the steady exploitation of its natural resource base" (UNEP). Double-digit economic growth has accompanied an acceleration of environmental destruction. Thailand had a higher rate of deforestation in 1988 than Indonesia, Laos, Malaysia, Myanmar, the Philippines, or Vietnam (Seda, 1993). In Asia only Nepal had a greater rate of forest destruction than Thailand during the 1980s (Handley, 1991).

The environmental impact has not been limited to overuse of natural resources. This study examines the levels of oxides of nitrogen (NOx) and sulfur dioxide (SO_2) emissions from manufacturing facilities present in the air. The negative environmental effects of these compounds in the air are numerous: SO_2 forms particulates that reduce atmospheric visibility, and contributes to the formation of acid rain. Acid rain has altered the chemistry of many thousands of lakes and streams in the world so much that they no longer can support life, and may also be a serious threat to crops and forests world-wide. Acid rain can also mobilize toxic metals from soil and water pipes which threatens drinking water quality. NOx contributes to ozone, a principal constituent of smog, which may cause lung damage and other respiratory diseases (WRI, 1990).

Note that industry can not be held responsibly for all air pollution in Thailand. It is estimated that 70% of Bangkok's air emissions are attributable to motor vehicles (Handley, 1991). As shown in Table 3, Thailand's rate of automobile ownership in the region is second only to Japan. The Thai government has not been successful in introducing unleaded fuels for use in the country, and the effect on public health is becoming apparent. Reported blood lead levels in Thais are inconsistent, but due to the predominant use of leaded fuel for motor vehicles even the lowest reported blood lead level average is three times that found in the United States (TDRI, 1990).

TABLE 3: NUMBER OF RESIDENTS PER REGISTERED AUTOMOBILE

Country	Residents per Registered Automobile
Thailand	20.3
Japan	2.1
Indonesia	62.5
Philippines	103.7
China	191.5
Laos	255.0
Myanmar	610.5

(WRI, 1994)

Figures 12 and 14 show NOx and SO_2 emissions for industrial, transportation, and other sources. Industrial pollution estimates include emissions from power generation facilities and refineries in addition to manufacturing facilities. Other pollution sources include agricultural, residential, and commercial activities. As shown in Figure 12, NO_x emissions from transportation are more than twice as high as those from industrial sources. However, industrial NO_x emissions are also increasing.

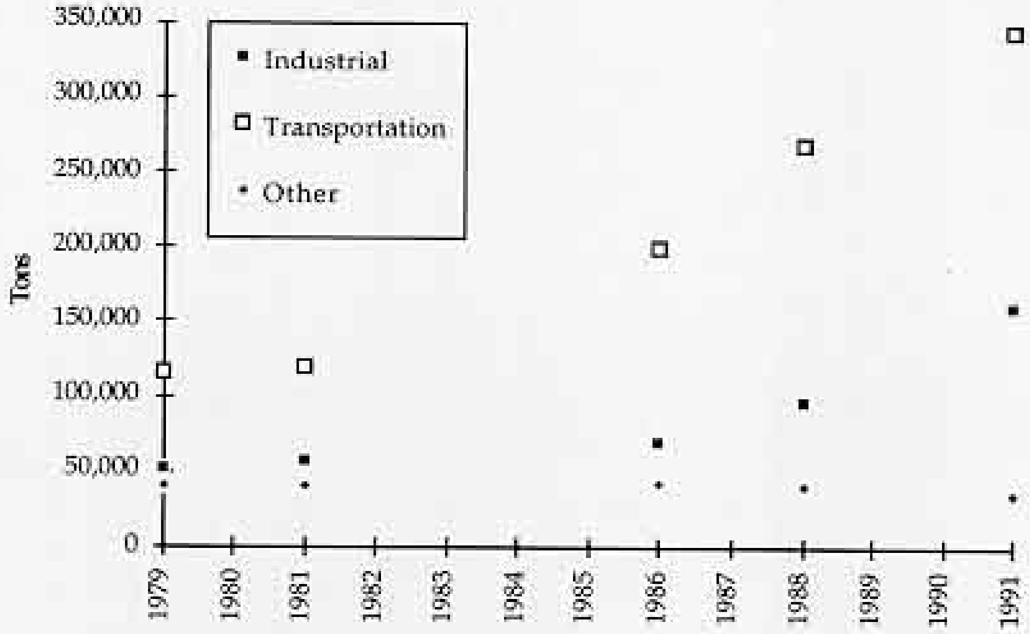

Figure 12 NO_x emissions (Kritiport, 1991).

Industrial NO_x emissions are projected to increase to between approximately 225,000 and 350,000 tons per year by 2000, depending on whether a linear or exponential projection model is used, as shown in Figure 13. Note that NO_x emissions for 1990 and 1991 were even higher than the exponential projection, which suggests that NO_x emissions may be much higher than 350,000 tons per year by 2000.

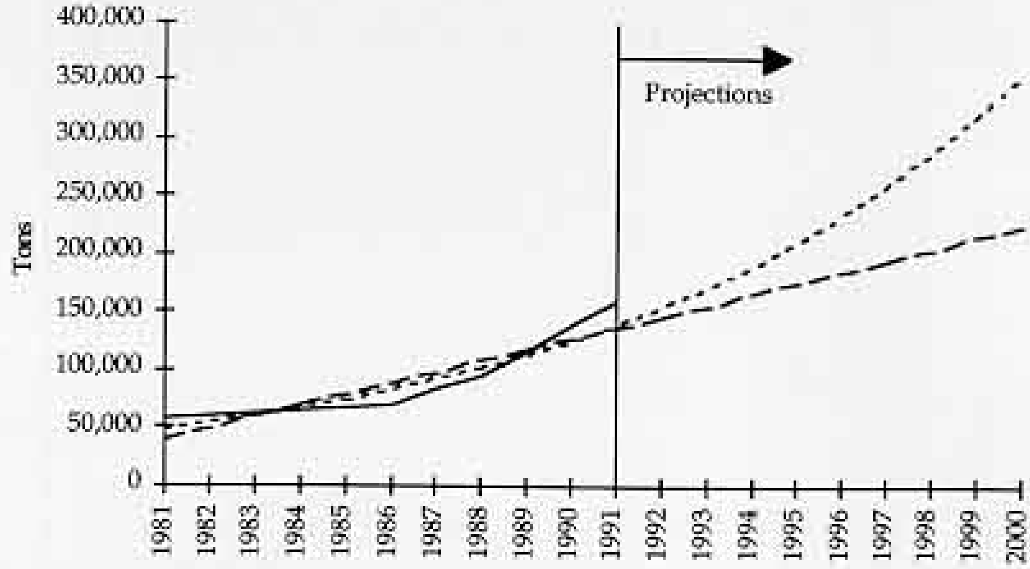

Figure 13 Projected industrial NO_x emissions.

Figure 14 shows that industrial SO_2 emissions are estimated to be about 770,000 tons per year, or more than four times higher than SO_2 emissions from transportation sources.

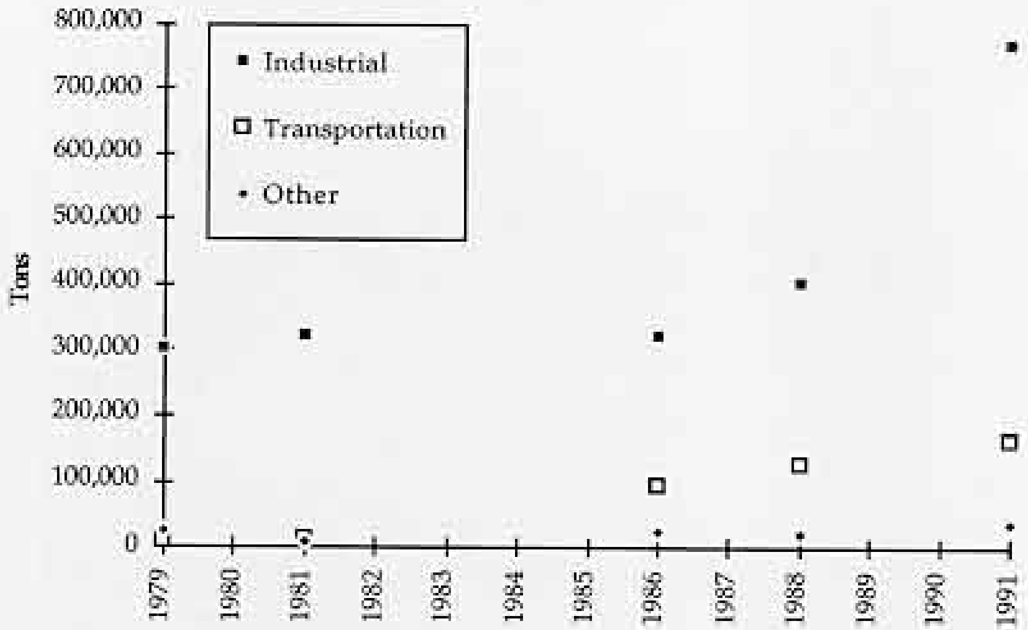

Figure 14 SO_2 emissions (Kritiport, 1991).

SO_2 emissions for 1989, 1990 and 1991 were also even higher than the exponential projection, as shown in Figure 15. If these trends continue, SO_2 emissions could also be much higher than the exponential projection estimate of 1.2 million tons by 2000.

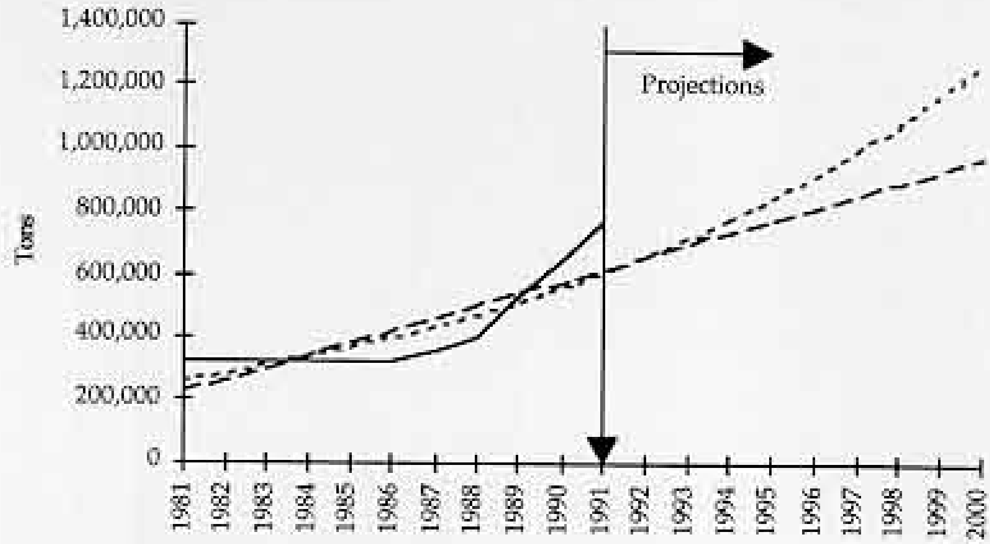

Figure 15 Projected industrial SO_2 emissions.

Correlation Between Industrial Growth and Industrial Pollution

Between 1984 and 1990 industrial NO_x and SO_2 emissions have grown as the manufacturing share of GDP has grown, as shown in Figure 16. In fact, SO_2 seems to be rising faster than the manufacturing share of GDP.

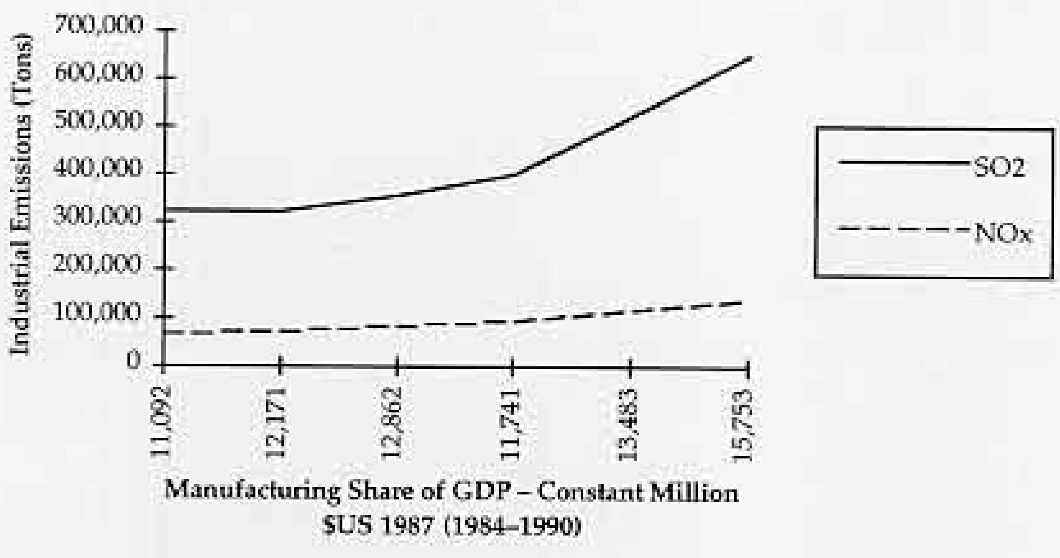

Figure 16 NO_x and SO_2 emissions as functions of GDP (*Far Eastern Economic Review*, 1984–1993, Kritiport, 1991, and WRI, 1994).

Figure 17 shows that both NO_x and SO_2 emissions are projected to rise faster than the manufacturing share of GDP if trends continue.

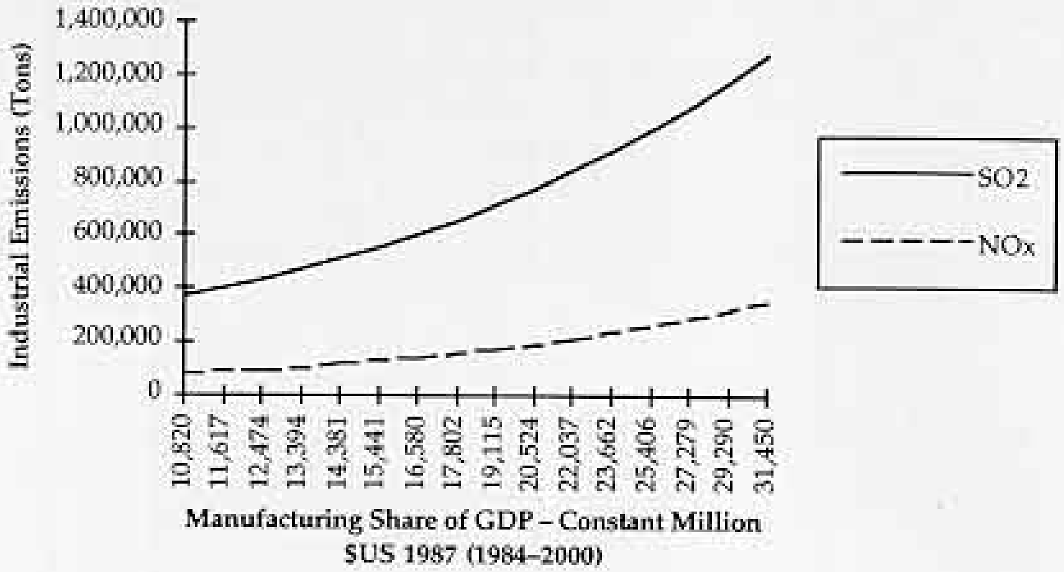

Figure 17 Projected NO_x and SO_2 emissions as functions of GDP.

Government Response to the Environmental Crisis

The Thai government has not been effective in dealing with the country's environmental problems, probably because the government has been relatively unstable over the past two decades. From 1932 to 1973 the military government held power without serious challenge. A popular uprising in 1973 resulted in a civilian-led democracy that lasted only three years until the military returned to power in 1976 in a bloody coup. Parliamentary elections were reintroduced in 1979, but in 1980 army chief Prem Tinsulanond began an eight-year reign, marked by two failed coup attempts. In 1988 Prem bowed to public pressure for an elected leader, and was replaced by Chatichai Choonhavan, leader of the Chart Thai Party. Chatichai's government appeared to be heading toward true democracy when it was overthrown bloodlessly in February 1991 by the army, partially fueled by political instability and largely supported by the middle class because of charges of widespread corruption in the government. After public protest, the army installed an interim prime minister, Anand Panyarachun, until elections could be held. Anand, a respected businessman and former diplomat, was a popular choice and kept his seat as a result of elections in March, 1992 (Far Eastern Economic Review, 1992). However, by May 1992 army chief Suchinda Kraprayoon had taken over as prime minister, leading to a popular uprising in Bangkok that left as many as 100 dead. Suchinda was ousted, Anand was returned as the prime minister, and general elections were held again in September 1992. At that time Chuan Leekpai, leader of the Thai Democrat Party was elected prime minister leading an uneasy coalition with four other parties. Although the governing coalition could fail at any time, since the violence in 1992 it has been considered unlikely that the military would try to take over again (Tasker, 1993, and Fairclough, 1994).

Until recently the government's inability to respond to the environment was supported by public apathy regarding the problem. Even with increasing evidence that the Thai environment was in danger, in the late 1980s politicians could state without fear of public reprisal that environmentalism was a concern for rich nations (Jolly, 1992). Without much legislative support, agencies charged with the care of the environment have also been ineffective. Thailand's Board of Investment (BOI) plans economic development, yet despite their policy of not promoting industry in the BMR, that region still receives the largest share of industrial investment in the country (TDRI, 1990). The National Economic and Social Development Board published *The Seventh National Economic and Social Development Plan* (1992–1996), which targets a reduction in air pollution levels in the Bangkok Metropolitan region and to discontinue sales of leaded gasoline (National Economic and Social Development Board, 1992). However, no clear legislative measures have been taken in response to that recommendation, and in 1993 the Institute of Population Studies at Chulalongkorn University still found it necessary to prescribe more specific directives. Their report included very specific recommendations, including introducing unleaded gasoline, setting maximum levels of air pollution emitted by motor vehicles, and promoting efficient public mass transit (Wongboonsin, 1993). No plan for actually implementing these recommendations, either from the National Economic and Social Development Board or Chulalongkorn University, has been developed.

A change in public sentiment, although perhaps only temporary, may have resulted from two environmental crises during the Chatichai government. In turn, this public pressure brought about two positive responses from the government. First, conservationists had organized a campaign of rural villagers against logging companies that were destroying traditional irrigation systems in the North. The effort segued into general public concern over mud slides which were caused by extensive deforestation and resulted in the deaths of hundreds of people died and the burial of whole villages in the South in November of 1988. In response, the government finally approved a nationwide logging ban in January, 1989 (Seda, 1993). Secondly, in 1990 and 1991 a string of hazardous substance-related disasters occurred that killed almost 300 people in total and injured many thousands more by spewing toxic fumes into the air. After the third accident public outrage finally pressured the government into action. The National Institute for Improvement of Working Conditions and Environment set up its Major Hazard Control Section whose first, formidable, task is to identify all major hazard sites (Piprell, 1991).

A growing call to environmentalism is also coming from private interests, which may be heeded by the government. TDRI has warned, "The sustainability of growth could be undermined if resources degradation, poverty and resource conflicts persist for long" (1990). Indeed, potential foreign investors interested in water supply and other environmentally-influenced factors may look elsewhere when trying to site factories (Handley, 1991). Some in Thailand have worried that pollution restrictions would discourage investment. However, Sarawoot Chayovan, director of the Federation of Thai Industries' Industrial Environmental Management Programme, says, "Most of the foreign companies are subject to strict regulations in their home countries and are quite prepared to adjust to more regulation in Thailand" (Jolly, 1992).

Perhaps as a response to growing pressure from the public and private sectors, the Anand government attempted to address problems of sewage treatment, mining, motor vehicle emissions, and industrial pollution by drafting a series of laws addressing the pollution problem. This effort restructured pollution prevention enforcement authority within the government, made regulation of industrial pollution easier, and attempted to reduce energy used, and therefore pollution created in energy production, in manufacturing (Handley, 1991). However, this legislation was flawed and is unlikely to be adequately enforced because the pollution inspection staff in the Ministry of Industry, whose charge it is to inspect factories, is understaffed and underpaid, and therefore considered vulnerable to bribery. And because the enforcement mechanisms for these measures were not in place, Thai politicians still could have a large role in determining whether they would be effective. However, the change in government made the implementation of the measures even more unlikely.

Because the Thai government is so unstable, it is unlikely that any really effective effort to address industrial pollution or any other environmental problem will be enacted. The only defense of the environment will come from the public if one comes at all in the near future. However, it remains to be seen whether the environmental movement in Thailand will be able to gain enough widespread public support to influence real change without having to wait for crises to develop.

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A CITY IN TRANSITION:
URBAN DEMOGRAPHIC CHANGES IN DETROIT
AND THEIR IMPACT ON
URBAN GREENNESS & CLIMATE

Rohinton Emmanuel

Introduction

That cities create their own micro climates is now well established. Ever since the concept of urban climate, epitomized in the so-called "urban heat island" (UHI), was first introduced by Luke Howard in 1811, observations have confirmed a set of changes to climate that are characteristically urban. These include: increase in summer night-time temperatures, lowering of day-time relative humidities and sometimes air temperatures, increase in precipitation, and reduction in macro-level wind movement. These changes have been recorded in cities from climate types as diverse as temperate tundra to the equatorial tropics (see Oke, 1974, 1979 & 1991 for reviews).

Although urban changes to the micro climate are well known, the causes for such changes are not. Even the few identified causes are not universally agreed upon by workers in this area. Studies in causes of urban climate are either based on solar energy balance (Oke, 1982) or urban hydrological balance (Oke, 1976, Changnon, 1978). The former emphasizes the urban alterations to the reception, conduction and storage of solar radiation while the latter deals with alterations to urban water balance. Both these broad causes are ultimately linked to the demographic changes in urban areas.

Much less is known about mitigation of urban climate changes. The few theoretical constructs that exist can loosely be grouped into two design goals: improvements to the urban geometry so as not to capture, transmit or store too much solar energy and, improvements to urban texture so as to alter the heat transfer in favor of evaporation (due to the presence of water, vegetation, etc.). The three-dimensional form of cities is taken as the urban geometry, with streets lined with buildings as its basic morphological element. Two buildings abutting a street on opposite sides form an urban canyon.

Implementation of urban design strategies for the mitigation of negative impacts of urbanization is seldom done. While gaps in knowledge, particularly with respect to causes for urban climate change may be one reason, other more subtle reasons exist as well. These reasons have to do with some of the fundamental assumptions about urban climate changes. For example, it is generally assumed that urban climate changes are linear. Thus early studies in the field attempted to find linear relationships between climate change and city population size and/or land area (Oke, 1976, for example). However, there is evidence that changes in urban climate are closely tied to urban socio-economic and political factors, many of which do not change linearly. As Drake, et al. (1990) pointed out, they go through phases of transition. It is therefore more reasonable to hypothesize that urban climate changes too, are a form of transition involving many phases. In order to develop successful climate mitigation strategies, it is necessary to identify such phases in urban climate changes, both in terms of rate and direction. Considering that modifications to the urban fabric occur only slowly, identification of phases in urban climate change may prove useful in determining the vigor and the extent to which a given urban design policy should be applied.

It is in this context that the current paper studies the urban climate changes in Detroit, Michigan, in the light of its demographic trends. Certain observations about the city lead to an initial suspicion of a city in transition and resulted in this paper.

A comparison of two LANDSAT images made in autumn of 1975 and 1992 revealed a greening trend in the heart of Detroit. It is well known that urban decay has long been the trend in the city. However, it seemed significant that this decay has lead to an unexpected "environmental revival" in the heart of the city. Such greening trends in the city makes Detroit unique among the world's urban centers for two reasons.

1. Detroit seems to have gone through the full cycle of urban demographic trends (establishment as a small trade post, relatively slow growth, a period of rapid and chaotic change, decline in population, urban flight and eventual abandonment). As such, it offers lessons for cities yet to go through the full cycle of transitions;
2. The decline and growth of urban vegetation in Detroit, mostly unplanned, may have climatic implications for the world's mature urban agglomerates that are also going through similar demographic transitions.

Lessons from Detroit can also be useful for those world cities that are still growing rapidly. The time lags between demographic transition and urban climate changes in Detroit may offer empirical data for building climate change models for the still growing cities.

An attempt was therefore made to analyze changes in urban greenness in Detroit as a consequence of urban demographic changes. Such changes are then super-imposed upon urban climate changes in and around the city. Trends in urban greening and urban climate changes are also grouped into phases of urban environmental changes. Finally, changes in the city are posited as possible lessons for efforts in urban climate mitigation in Detroit and elsewhere. Recommendations regarding quality of data needed for further study are also made.

Why should the urban environmental changes be studied now? By the year 2000, over 50% of world population will live in urban centers (Givoni, 1989). Urban climate changes associated with such rapid urbanization is not well understood. Lessons in urban environmental transition from more mature cities like Detroit can be helpful in designing intelligent mitigation strategies for currently growing cities.

Furthermore, urban hinterlands around many world cities have already lost a considerable amount of forest cover. In the face of rapid global urbanization, might it be a prudent strategy to treat cities as places where nature can take a foothold? It may well be that cities have the only regional greens of the future. It is rapidly becoming the case in the tropics (Corea, 1989). Understanding of the climate effects of urban greens and their natural growth in such altered environments as cities may offer lessons for sustainable urban planning and design.

Perhaps the strongest justification for studying urban climate trends is that such a study offers hope for arresting the negative changes to local climate. If the different phases of transition in urban environmental changes can be identified, there is a possibility of arresting the negative changes to urban environment, particularly during the early phases of such changes when changes are easily made. Certainly many aspects of urbanization (like urban policy, zoning ordinances, etc.) will have to be transformed for this to occur. But an overall goal of urban greening, at least during the early phases of climate change, seems able to direct urban centers towards climatically pleasant environments. This study shows that such a transition is occurring in Detroit, in spite of man's worst efforts. Can it then be amplified by prudent urban design practices?

The analysis for this study is in two parts. In the first, trends in urban demography in the Detroit metropolitan region are analyzed in conjunction with greenness change in the region. Greenness changes are quantified by comparing two commercial satellite images taken 17 years apart (1975 & 1992). A "Green Index" is developed by quantifying greenness change between these two images. All color increases in a given band above a certain threshold were coded green while decreases were coded red. No change in greenness between these two images (or changes less than the threshold) were coded black. The index was then computed by counting all the pixels in a given area displaying the color green and was expressed as a percentage of total number of pixels in that area. The process of color coding of pixels from the two satellite images were done by the Environment Research Institute of Michigan (ERIM) (Wagner, et al., 1994).

The second part of the study records trends in monthly temperature (both maximum and minimum) and precipitation in the Detroit Metropolitan Area (DMA). Climatic data for DMA comprising three counties (Wayne, Macomb and Oakland) was obtained from published records of the National Climate Data Center (NCDC), Ashville, N.C.

Additional analysis using information on vacant land within the city of Detroit was also made. Efforts in identifying vacant lots by the City Planning Commission were used for this purpose (Bruhn & Baran, 1990). Only qualitative judgments were possible from this source, since the actual values were not available.

Urban Climate Changes

Urban climate changes are collectively known as the "Urban Heat Island (UHI). The English term was probably coined by Gordon Manley in an article written in 1958 (Landsberg, 1981). He studied the urban climate of London and found significant departures from the climatic norms of the surrounding area. Thus, although the concept of urban climate modification was known for centuries (for example, Vitruvius, a first Century Roman architectural writer spoke of the climate modifications in Rome), modern research in this area is only about thirty to forty years old.

A heat-island is best visualized as a dome of stagnant warm air, over the heavily built-up areas of cities. These have been observed practically in all parts of the world except in extreme cold climates. The effect is not so much felt during the day, as the increase in the maximum temperature is minimal. However, heat-islands are intense at night, occurring a few hours after the sunset.

Table 1

Long-term Urban Climatic Changes in Selected US. Cities

Source: Landsberg, 1981: 90-91.

City	Period of Record	Warming Rate (^{0}C/year)			
		Winter	Spring	Summer	Autumn
Cleveland, OH.	1895-1941	0.010	0.021	0.028	0.015
Boston, MA.	1895-1933	0.016	0.018	0.026	0.021
Washington, D.C.	1893-1954	not sig.	0.008	0.024	0.015
Tampa*, FL.	1895-1931	0.026	0.014	0.016	0.019
Baltimore, MD.	1894-1954	not sig.	0.011	0.017	0.015

Notes: * Tampa has 12% more sunshine hours in winter than in summer.

not sig. Not Significant.

Heat-islands are strongly felt in calm nights. In the long-term, a faster rise in minimum temperature and a slower rise in maximum temperature result from urbanization (Landsberg, 1981:87). Table 2 summarizes all the known UHI effects.

Table 2

Effect of Urbanization on Climatic Parameters.

Sources: Khemani, *et al.*, 1973; Chandler, 1976; Landsberg, 1981.

CLIMATIC PARAMETER	EFFECT OF URBANIZATION
Temperature	Rise in daily minimum temperature: Some change in maximum temperature.
Humidity	Reduction in daytime humidities, but increase in night-time values.
Precipitation	Higher increases in summer (up to 21%) and smaller increases in winter (5-8%). In the tropics, the increase is attributed more to air pollution than heat emission.
Wind	Increases in the number of calm periods observed. Up to 20% reduction in wind speeds are known. The effect is greater upon weaker winds.
Solar Radiation	Though incoming radiation values are not changed, the apparent values are, due to the containment of reflected radiation by the heat dome.

2.1 Causes of Heat-islands

Research in the recent past has unearthed a series of causal relationships between a wide range of urban factors and climate. These range from urban geometry to work week patterns, from anthropogenic heat to thermal characteristics of urban surfaces, and from obstruction of wind flow to lack of vegetation. However, the widely prevalent view among the urban climatologists is that at neighborhood and smaller scales, urban geometry leads the list of possible causes for the heat-island. Other causes are listed in Table 3.

Table 3

Causes of Urban Heat-Island and their Effect on Micro climate

Sources: Chandler, 1976; Landsberg, 1981; Oke, 1982.

PHENOMENON	POSSIBLE EFFECT
Population Size	Urban-rural temperature difference increases proportionate to population size. The effect is pronounced as population increases beyond one million. In tropical cities, however, the relationship is much more complicated.
Topography	Air drainage caused by elevational differences and secondary wind circulation patterns created by topography tend to reduce the heat-island effect.
Rivers & other waterbodies	The heat-island dissipates at or near waterbodies, even if the waterbody is right in the middle of a heat-island.
Wind speed	Proportional relationship between macro-level wind speeds and the heat-island is usually found. But urban wind flows are much smaller at macro-level.
Anthropogenic heat	Some effect is felt, though minimal in comparison to solar energy trapped by buildings and other urban structures. The presence of many air conditioners can aggravate the heat-island.
Water run-off	The heat-island effect is more pronounced if more rain water is allowed to drain away quickly from cities. Availability of water helps partition more heat by evaporation.
Vegetative cover	A proportional effect on heat-islands can be found. The presence of sufficient vegetative cover not only insures more evaporation but also reduces radiation received at earth's surface (due to photo-synthesization).

Oke (1977) was one of the first to point out that the urban climate system is composed of two distinct layers: the Urban Canyon Layer (UCL) and the Urban Boundary Layer (UBL). UBL is the overall atmospheric system that extends for many miles above cities. The characteristics of UBL are partially determined by the city below (Oke, 1982:2). UCL on the other hand is that layer of atmosphere where most life occurs, from ground up to the mean height of roofs. Understandably, climatic effects of urbanization are strongly felt in UCL.

Ignoring the smaller heat fuxes like human-generated heat, heat balance in the UBL is given thus:

$Q^* = Q_H + Q_E + \Delta Q_S$, where

Q^* = Total heat received at the surface (Heat Flux),

Q_H = Sensible turbulent heat transfer,

Q_E = Evaporative turbulent heat transfer, and

ΔQ_S = Net heat storage (Oke, et. al, 1981:46).

The primary difference in urban and rural thermal processes, as identified by Oke, is in the partitioning of heat between Q_H and Q_E. In rural areas, more turbulent heat is lost by evaporative cooling than by sensible means. (Oke, 1982) In cities where impervious surfaces abound, the primary turbulent heat transfer is by sensible means. Sensible heat transfer, being what it is ("sensible" i.e. perceivable by humans), causes thermal stress to those who live in the UCL.

Urban surface materials like asphalt, also have higher thermal capacities than their rural counterparts. The stored heat in the urban mass dissipates at night and thereby increasing night-time temperatures of cities.

As Oke points out, the impact of urbanization is "to favor partitioning more solar energy into sensible rather than latent heat and increase the importance of heat storage by the system" (1982:16). He therefore points out that any system of urban classification in terms of benevolent/malevolent systems as related to the urban heat-island should take into account its water storage capacity and surface moisture availability.

> Water provides a buffering or modifying influence, because gradual moisture depletion allows for evaporative cooling to extend over a period of days or more. On the other hand, impervious elements in urban landscape experience an almost dichotomous wet/dry behavior.(p 8)

Water in urban areas is found either as surface water (in streams, rivers, lakes, etc.) or in urban vegetation. Thus green areas can also alter the energy balance of cities in favor of latent heat transfer. Unlike surface water however, urban vegetation can also control the amount of evaporation by holding and only slowly yielding water over a longer period of time.

3. Urban Vegetation & Climate Changes

Contrary to popular perceptions, urban areas contain a large volume of green surfaces. Over 30% of the land area of typical American cities are covered with trees. Another 30% is grass-covered (Ebenreck, 1989). The leaf and stem area of urban vegetation typically outnumbers man-made areas by 4-to-1 (Rowntree, 1984). The photosynthetic and transpirational processes associated with such a massive green cover should not be under-estimated.

While the potential effect of such a large green mass is considerable, the actual environmental effect is limited by various factors. Size and location of urban green areas are the most important parameters of urban vegetation. In terms of climatic influence therefore, urban vegetation can be divided into three categories: isolated trees, urban parks and urban forests.

3.1 Individual Trees

The isolated urban tree lives in urban gardens where it may be well managed, or in street canyons and parking lots, poorly managed and highly stressed. Its thermal balance is greatly affected by three factors:

1. Reflected short-wave radiation from canyon walls and floors
2. Long-wave radiation from surroundings that screen out part of the cold sky
3. Advection of sensible heat from air (only if air temperature is higher than leaf temperature) (Oke, 1989: 337) (see Fig. 1).

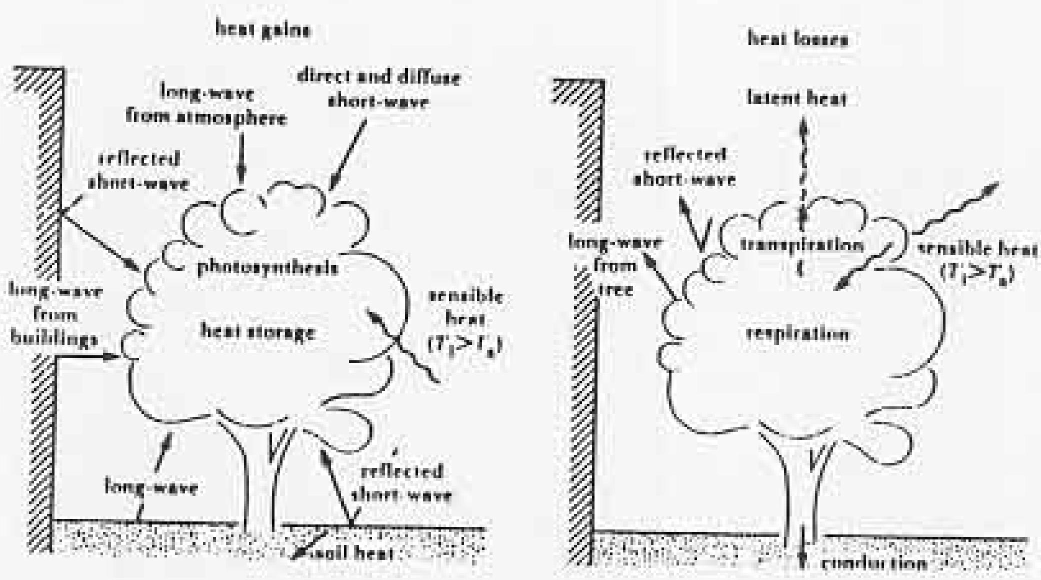


Fig. 1 Energy Balance of an Isolated Tree

Source: Oke, 1989

Note: T_l = Leaf Temperature; T_a = Air Temperature

The amount of heat impinging upon the isolated tree as well as its environmental impact depends upon the availability of water and wind. Water supply in urban areas can be rather restricted. Contamination of street water may diminish trees' ability to draw upon urban water. Furthermore, high air pollution in urban canyons may physically block the stomata. Similarly, wind too, may be funneled away from trees by urban canyons. Also, night-time cooling may be prevented by the blocking of cool night sky by the urban canyon. For these reasons, the actual environmental effects of isolated urban trees may be very restricted (Oke, 1989:337,338). However, possible effects are much wider, and improvements to urban canyons (like changes in orientation, proper H:W ratio, etc.) might enhance the environmental performance of individual urban trees.

3.1.1 Climatic Effects of Isolated Trees

The primary climatic effect of vegetation comes from evaporation of water from leaves (Givoni, 1989). Most of solar energy impinging on vegetation is partitioned into latent heat, leading to a significant reduction in heat available for sensible transfer. A small portion of the heat energy is also transformed into chemical energy by photo-synthesis, but plant's effectiveness in doing so is very minimal (less than 2% of solar energy received [Givoni, 1989: 290]). As such, climatic effects of photo-synthetic processes can be ignored.

The ability of plants to partition most of the impinging solar energy into latent heat means that areas near vegetation are always cooler than man-made surfaces. Thus, human beings in the vicinity of green areas are subject to lower heat stress (Givoni, 1989). The effect of vegetation on air flow however, depends on the size and type of vegetation: grass fields have no effects and evergreen forests block wind almost totally.

It is widely believed that isolated trees exert tremendous climatic influences. Parker (1983) reported surface temperature reductions of up to 15^{o}C in hot, summer days in a Miami, Fl. house, by having the walls shaded by a combination of trees and bushes. Hoyano (1988) studied the climatic effects of various configurations of vegetation around buildings (pergolas, ivy screens on wall, rows of trees, etc.) for Japanese buildings and reported up to 90% reduction in solar radiation transmission. Air temperature reductions of up to 10^{o}C was also noted.

However, not all studies exhibit such enthusiasm. Rowntree (1984) compared urban streets in Syracuse, N.Y., with and without trees, and found no difference in air temperature levels below trees. On the other hand he also estimated a 25% decrease in urban heat for Dayton, Ohio. Herrington, et al., (1972), Plumley (1975) and McGinn (1982) found no evidence for reductions in air temperature and humidity by street trees. Shading of trees by urban canyons, oasis advection, and the fact that much transpiration occurs from the top of the trees without proper mix at street level, are some of the explanations given for the lack of empirical support for the benevolence of street trees (see Oke, 1989). Having reviewed many studies on the micro climatic effects of isolated trees, Oke concluded that the *observed facts confirm the sign but not the size of environmental expectations from isolated trees* (1989: 338).

Whatever their energetic contribution maybe, street trees definitely play an important role in modulating rain water runoff from city streets. They can also act as buffers against air pollution. A close tree canopy over streets however may result in polluted air remaining trapped at street level.

Individual trees are also welcome for a variety of other reasons. Willeke (1989) listed the following "qualitative" benefits: "A sense of identity", "education & imagination", "a sense of place". Street trees can also fulfill "a longing for security", "longing for dignity", "need for symbolism", and "a longing for peace".

Another factor that eludes calculations is the amount of urban heat stress prevented by street trees. Lowry (1988) estimated that an urban street lined with six trees with a leaf area of 25m^2 each, result in a total cooling of 0.3K/hr, while their absence can lead to a heating rate of 1.0K/hr. Therefore even if the environmental effects of isolated trees are minimal, their hidden benevolence must not be forgotten. However, a few saplings will certainly be inadequate (Oke, 1989: 339).

3.2 Climatic Effects of Urban Parks

The climatic effects of urban parks spread well beyond their physical boundaries. The cooling effects in particular, are noted in a variety of cities.

Oke (1989) categorized urban parks as garden parks and forest parks. The climatic effects of the former are somewhat similar to isolated trees, as these parks are merely collections of well-spaced trees, primarily grown for the purpose of urban leisure. Forest parks with more of their natural growth unmanaged, can have significant climatic influence upon their surroundings.

Examples of studies in park cooling can be found for tropical as well as temperate cities. One of the first urban climate studies carried out in a tropical city found a significant amount of cooling in and immediately around urban parks (Nieuwolt, 1966) Studying the daily variations in temperature and relative humidity at various locations in Singapore, Nieuwolt found that urban parks are somewhat cooler during the daytime, very much cooler during early evening and night, but warmer at early morning until sunrise (See Fig. 2). Rural air temperatures were mostly well below even the urban park air temperature (except at nights).

Sani (1973) investigated the urban air temperature and relative humidity in Kuala Lumpur, by undertaking many climatic traverses in the city. His data shows that urban park temperature is remarkably lower than both suburban and city center air temperatures at night. He did not mention air temperatures at other times of the day nor at rural locations (Fig. 3).

Jauregui (1970) studied the distribution of near-surface air temperature in the vicinity of an urban park (Chapultepec park - 500 Ha) in Mexico city. Under calm cloudless conditions, the early morning (before sunrise) air temperature of the park was up to 6°C cooler than its built-up surroundings within a 2 mile radius (Fig. 4). Such a high temperature difference was found between the center of the park and the most built-up surroundings. At the park edges however, air temperature began to rise by about 2°C above the park center.

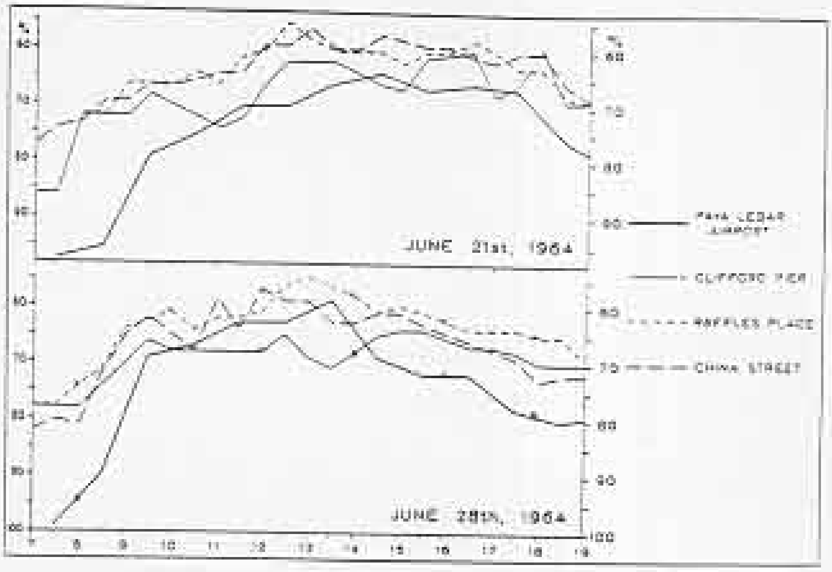


Fig. 2 Diurnal Temperature Variations in Singapore
Source: Nieuwolt, 1968.

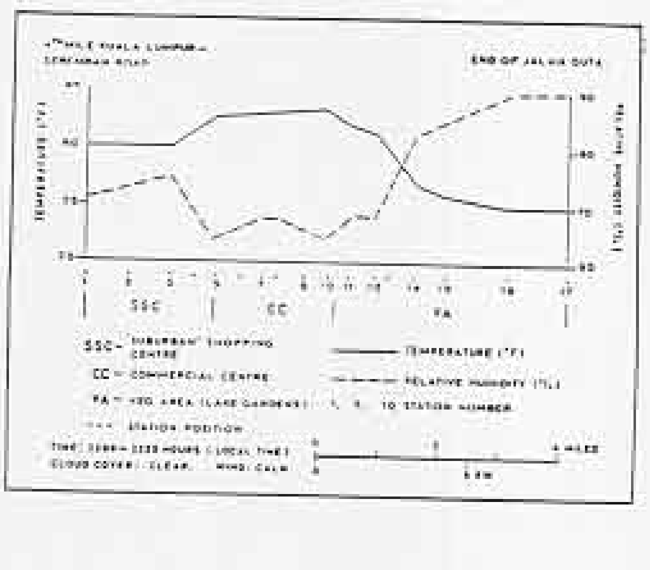


Fig. 3 Night-time Traverse Through Kuala Lumpur, Malaysia
Source: Sani, 1973.

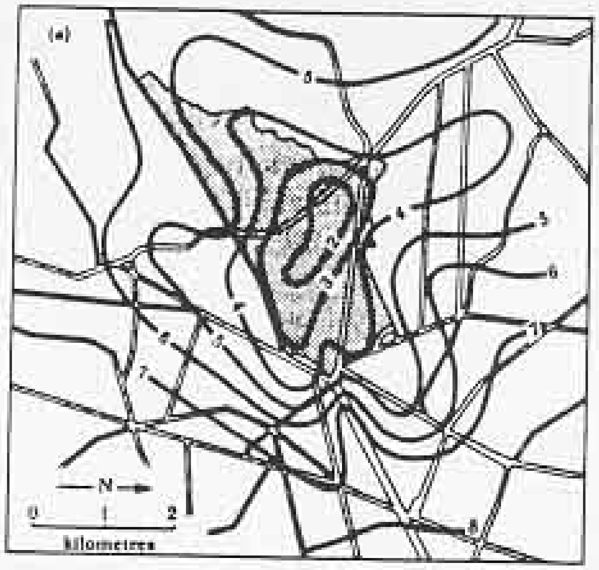


Fig. 4 Distribution of Near-Surface Air Temperature in and around an Urban Park

Source: Jauregui, 1973.

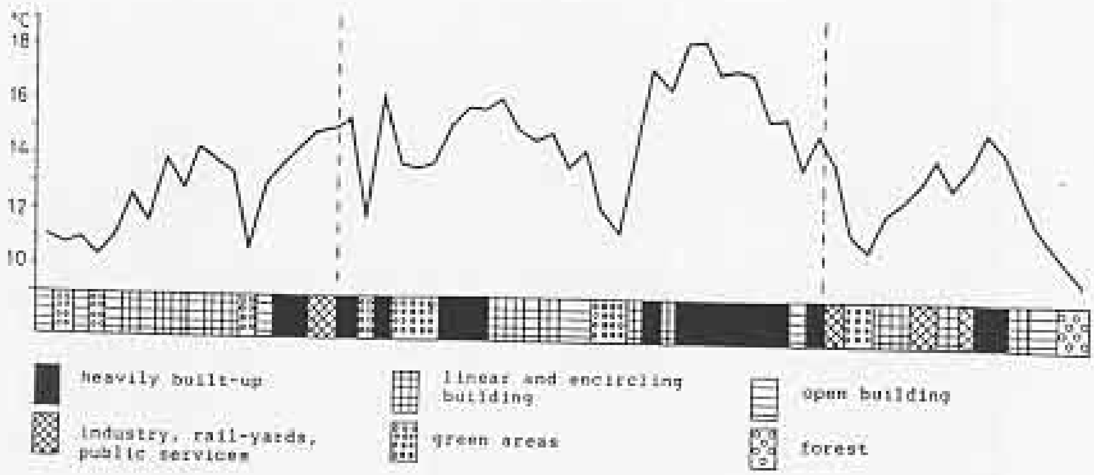


Fig. 5 Air Temperature Traverse @ 2m Above Ground Through (West) Berlin

Source: Stulpnagel, 1990

Stulpnagel, et al., (1990) found a similar pattern in Berlin. Carrying out both a point temperature survey and a city-wide traverse, they were able to show that night-time cooling occurs in and around urban parks. Daytime cooling is little or insignificant. At nights however, a temperature difference of up to 6^{0}C was noted between certain Berlin parks and their immediate built-up surroundings (Fig. 5).

A clearer pattern seems to emerge from these empirical studies. Under conditions that favor a strong urban heat-island (i.e. calm, clear nights), urban parks exert a significant cooling effect upon their immediate surroundings, irrespective of the local climate of the city. Oke (1989) having reviewed some other studies conducted in Syracuse (Herrington, 1977), London (Chandler, 1965) and Montreal (Oke, unpublished) found similar results.

In addition to the night-time cooling observed at urban parks, Stulpnagel (1990) made the following observations about park-urban temperature differences for Berlin:

1. As a rule, the larger the park area, the larger the range of climatic effect.
2. The range is usually greater with the prevailing wind than against it.
3. Higher wind-speeds frequently increase the range.
4. Adjoining small pockets of green areas or relatively low concentration of buildings tend to enhance the temperature differences.
5. The range is drastically reduced if the park is surrounded by walls , heavily built-up areas or if it lies lower than the surroundings (since cool air sinks lower).
6. Roads through green areas reduce the overall effect (Stulpnagel, 1990:185-186).

Stulpnagel (1990) studied the climatic effects of variously sized urban parks in Berlin and attempted to find a linear relationship between park size and temperature difference between park-urban surroundings. Fig. 6 shows a scatter plot for a clear calm night (2300 hr., local time) in summer for Berlin.

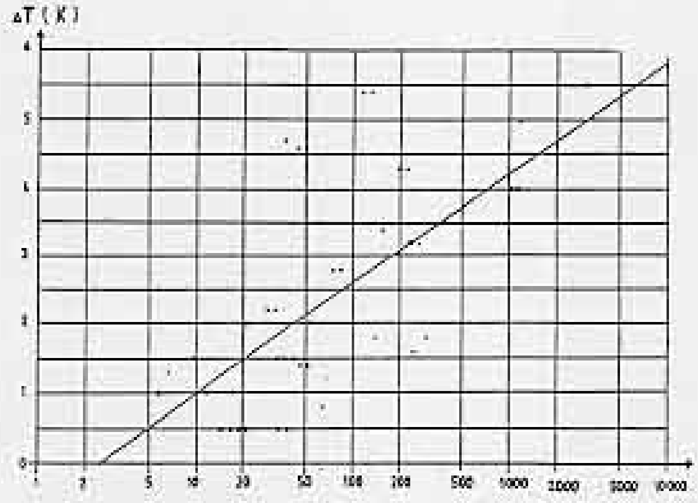


Fig. 6 Size of Green Areas in Berlin and Air Temperature Differences Around Them

Source: Stulpnagel, 1990

Oke (1989) summarized the cooling effects of urban parks well: "it is not only *what the urban parks do* that is important, but also *what they prevent other urban elements from doing*" (emphasis added).

3.3 Climatic Effects of Urban Forests

Shuttleworth (1989:299) defined forests as "vegetation sufficiently dense that the individual interaction of each plant with the atmosphere is influenced by that of its neighbors". Thus large areas of undisturbed vegetation in cities too, can be considered as forests.

The environmental effects of forests are different from that of other forms of vegetation for three reasons:

Higher solar radiation capture

Regulation of precipitation, both runoff, as well amount of rainfall

Stomatal Control (Shuttleworth, 1989).

While the color, size, shape and orientation of leaves play an important role in determining how much solar radiation is captured by a tree, what makes forests unique is their rather well organized peaks and depressions in the upper surface of forest vegetation. According to Shuttleworth (1989: 303), this undulation ensures that much of the incoming solar radiation is well below the top of canopy before it undergoes its first scattering.

Forests not only capture solar radiation very efficiently (scattering as little as 10%), they also rob the momentum from solar radiation. Thus the potential of solar radiation to create large scale air flow regimes are modulated by forests. This effect is said to be similar for forests in all the major climatic zones of the world (Shuttleworth, 1989).

Forests are selective reflectors. They have a very low reflectance in the visible spectrum (annual range 4.0 - 6.9% for urban forests, 8.1 - 9.6% for city downtowns: higher values for forests occur in snow-covered months), but their infra-red reflectance is remarkably high (12.4 - 34.0% for urban forests as opposed to only 9.0 - 14.5% for downtown areas). Albedo values are an order of magnitude higher in the case of forests (12 - 15% as opposed to 9 - 12% for downtowns). These data came from an analysis of 27 calibrated Landsat images in the 4th and 7th bands (visible and near infra-red) for Hartford, CT., (Brest, 1987). The selective reflectivity of urban greenery was also useful in distinguishing greenness changes from the satellite images used in the current study.

4. Case Study: Urban Environmental Effects of Demographic Changes in Detroit

In the light of clear evidence of environmental cooling associated with urban greens, it seems relevant now to look at the climatic effects of urban greening currently underway in a city in transition as a case study. Certain sections of the city in question, Detroit, MI., have long experienced urban decay and neglect. These are slowly turning into green oases. Three distinct trends can be seen in the magnitude of urban green changes in the city:

1. Increase in population and decrease in greenness if population increase occurs in already urbanized area (increase in greenness occurs if land is converted from agricultural to urban uses).

2. A transitional phase where population declines and greenness oscillates between more or less green.

3. A mature phase where population declines and greenness increases.

It must be remembered that in Detroit, urban vegetation changes are largely unplanned. If climatic effects can be shown from such unplanned vegetation, extrapolations of climatic effects of deliberate greening may also be made. Similar situations in other climatically-compatible cities too, may profit from such a study.

4.1 Demographic Trends in Detroit

The city of Detroit, has long been an industrial and commerce center for the great lakes region. The original French settlement of the village of Detroit (French for "The Straits") was established in 1701, (Silas, 1884) but a great fire destroyed most of it in 1805. Modern history of Detroit began with rebuilding after the city was incorporated in 1805 (cf. Burton, et al., 1922).

Although established as a trading post, Detroit came to be dominated by manufacturing industries from early on. Stoves, adding machines and pharmaceuticals were some of the early manufactured goods for which the city was world renown. However, it was the automobile industry that gave rise to the rapid expansion of the city and ultimately lead to its decline.

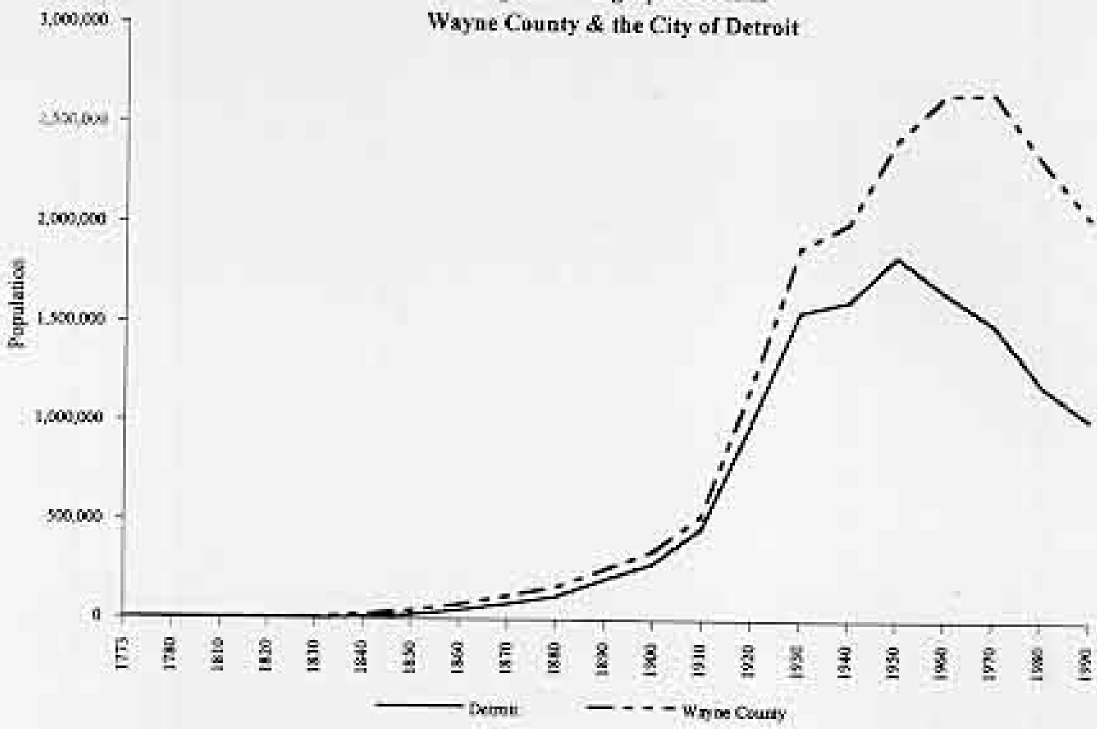
The automobile industry made good use of infra-structure used by the coach-building services established in the city in 1853. The first automobile built in Detroit was by Henry Ford in 1895. Within twenty-five years, Detroit auto industries were making up to 58% of the automobiles made in US. (Burton, et al., 1922).

The growth of automobile industry gave rise to a rapid growth in city population as well. Table 4 shows the population growth and the number of employees in the automobile industry.

The growth in population associated with the automobile industry was boosted by the world wars, particularly the first world war. City population in the teens and the twenties grew by 121% and 60% respectively. However, growth rates became smaller since then, with the exception of the 40's when demand from world war II kept the industries busy and in-bound city migration high.

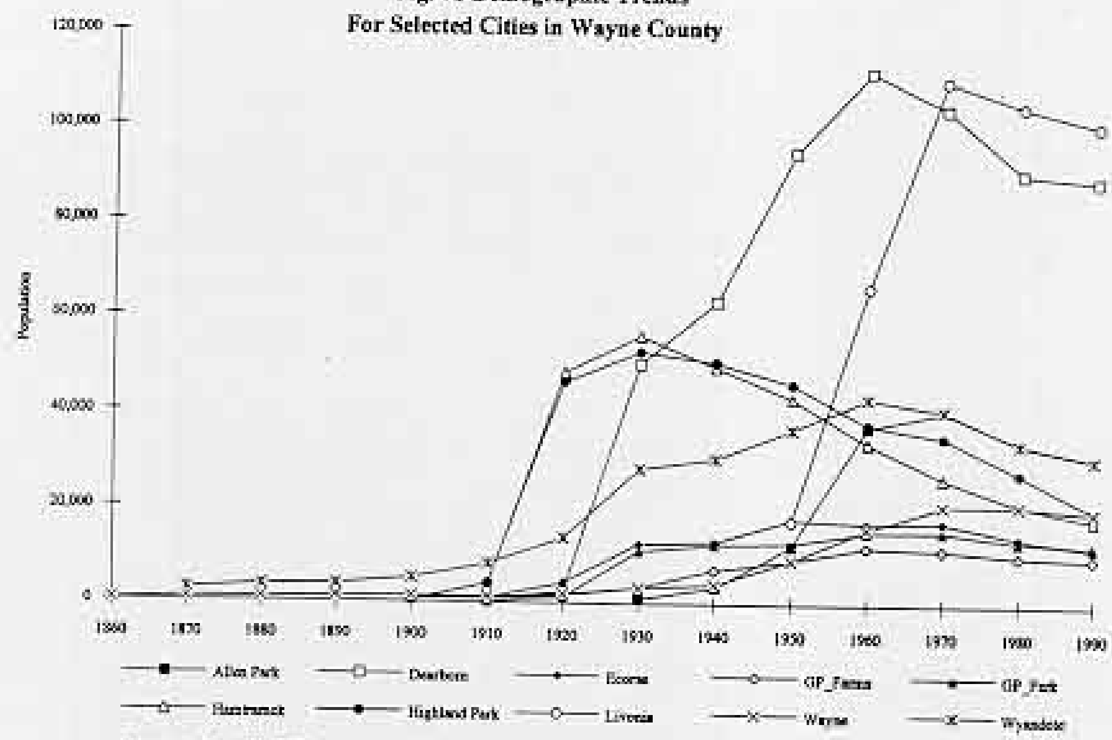
The trend of increase in city population however, came to an end in the fifties. The loss of Detroit, from then on, became the gain of its suburbs and adjoining rural regions. Thus, a pattern of "dough-nut" like development settled on the region, with city losing population at a rate of 1000 or more per square mile per decade and the surroundings gaining population at the rate of 5-25 persons per square mile in a decade (Doxiades, 1966).

Fig. 7a Demographic Trends
Wayne County & the City of Detroit



Sources: Burton, et al., 1922; U.S Census Bureau, 1992

Fig. 7b Demographic Trends
For Selected Cities in Wayne County



Sources: Andriot, 1983; U.S Census Bureau, 1992

Table 4

Population Growth & Automobile Industry Growth in Detroit

Source: Burton, 1922; Adopted from Andriot, 1982

YEAR	CITY POPULATION	NO. OF EMPLOYEES IN AUTOMOBILE INDUSTRY
1908	426,592	7,250
1909	440,412	17,437
1910	462,676	29,243
1911	552,276	45,585
1912	567,994	57,293
1913	614,486	67,432
1914	658,970	60,835
1915	673,498	81,594
1916	734,562	120,000
1917	820,738	135,000
1919	993,739	136,000

The pattern continued in the seventies and the eighties as well. However, the eighties also saw more areas of the Wayne county losing population. Except for the communities located along the western border of the county, every sub-division in the county lost population in the eighties (Figs. 7a & 7b). Unlike the urban flight of the previous decades, the current demographic changes seem more like a "regional flight".

Changing demographic conditions lead to more dwelling units left vacant. A survey of the city land use by the Detroit City Planning Commission found that in the inner city areas of Detroit, up to 70% of land is vacant. Most of the land falls in the 10-30% vacant category (Fig. 8).

4.2 Urban Vegetation Trends

Urban areas contain a surprisingly high amount of vegetation. Given long periods of neglect however, this high volume of vegetation can turn into an urban forest. Every available source of data indicate this to be the case in central areas of Detroit.

Fig. 9 illustrates the changing patterns in urban vegetation in Detroit. The image used the "greenness change" (both in direction and magnitude) of ground surfaces as recorded by commercial satellites. It was computed by comparing two satellite images taken at about the same time of the year, but 17 years apart (May 10, 1975 & May 16, 1992). The green areas indicate increase in vegetation in 1992 and red

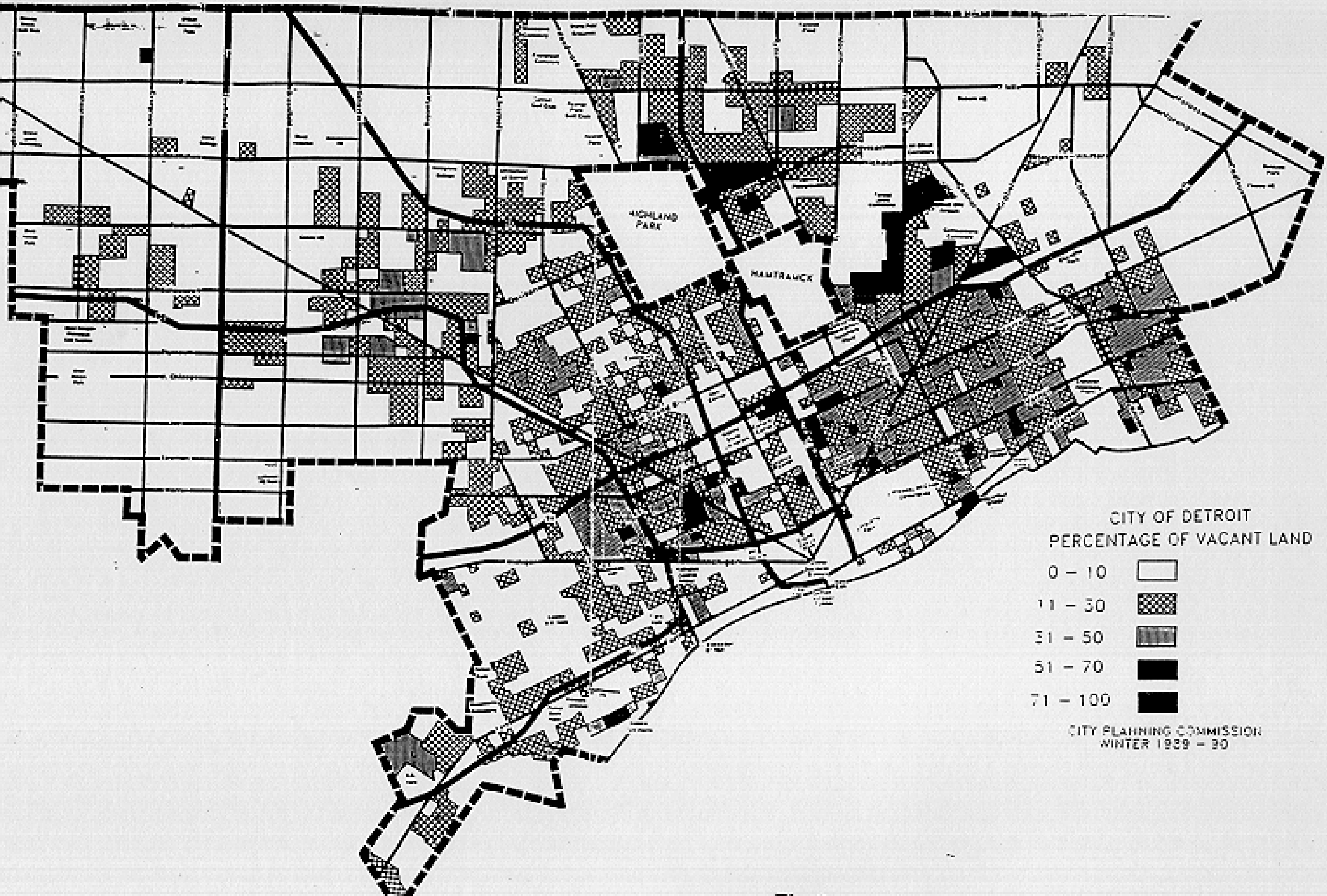


Fig. 8 **Vacant Lots in the City of Detroit**

Source: Bruhn & Baran, 1990

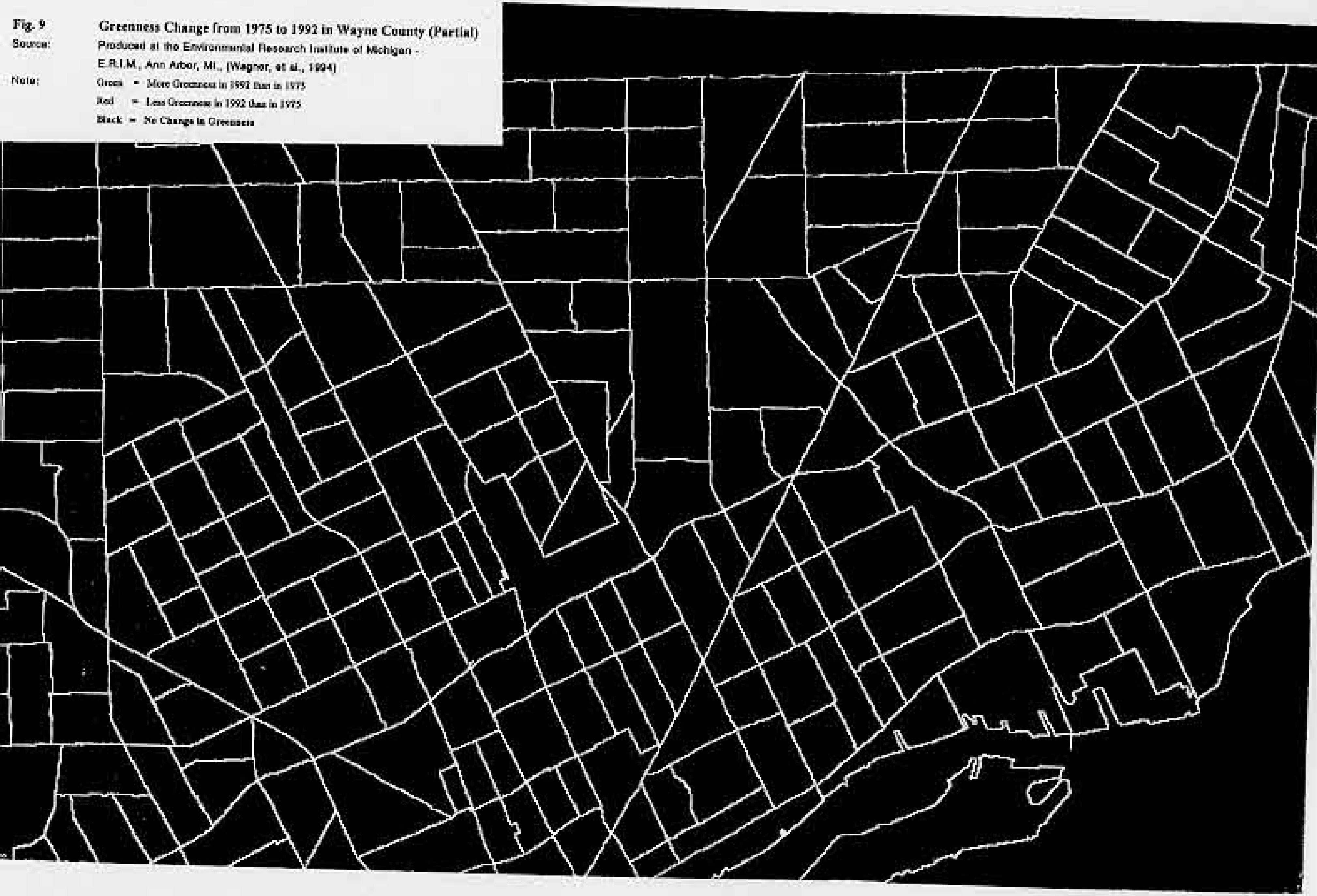
Fig. 9 Greenness Change from 1975 to 1992 in Wayne County (Partial)

Source: Produced at the Environmental Research Institute of Michigan - E.R.I.M., Ann Arbor, MI., (Wagner, et al., 1994)

Note: Green = More Greenness in 1992 than in 1975

Red = Less Greenness in 1992 than in 1975

Black = No Change in Greenness



shows decline in 1992 compared to the 1975 image. Black indicates no change in urban vegetation between the two dates.

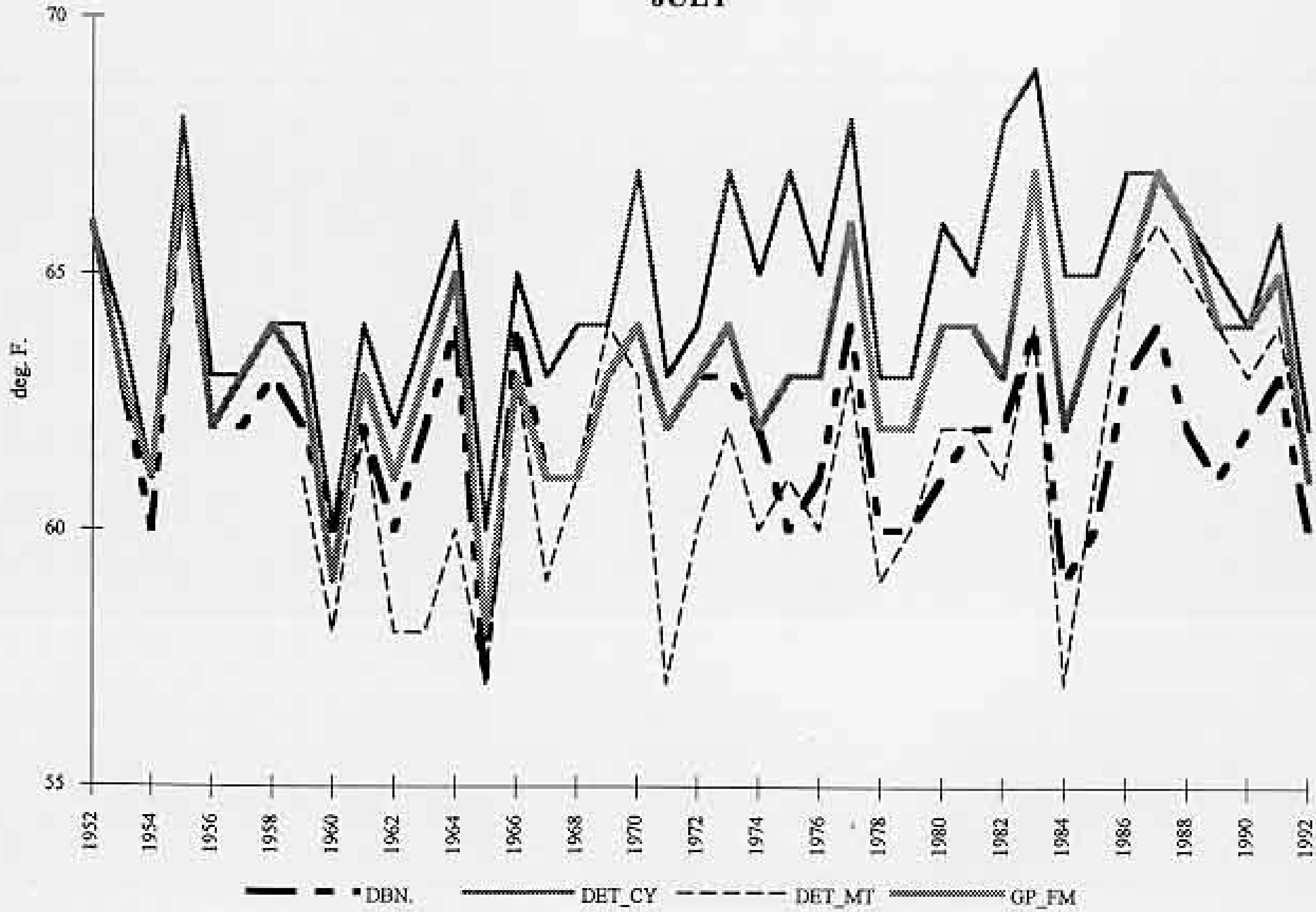
As mentioned before, the "greenness" of a ground surface is identified by the amount of reflection of visible and near infra-red spectral bands. When chlorophyll-containing leaves are exposed to sun, they absorb blue and red light (thus appear green to human eyes), but reflect a great amount of near infra-red (NIR) wavelengths. This peculiarity of green surfaces (lower visible light reflection and high NIR reflection) enable remote sensing techniques to determine the amount of greenness on ground. By comparing two images from different periods and assigning threshold values beyond which the changes are assumed significant, a thematic map representing changes in greenness can be made (Wagner, et al., 1994). Such maps are also capable of distinguishing between types of vegetation (like trees vs. grasslands), though quantification of vegetative cover is not possible.

From Fig. 9 it is clear that the inner city areas of Detroit are experiencing a resurgence of urban vegetation. Most of the stable residential areas in the northwest and southwestern sectors of the city indicate no change in urban greenness. The agricultural lands in the western end of the county are also experiencing an increase in trees. The forested areas of northern edges of the city, and the adjoining urban regions in Oakland and Macomb counties show a decline in tree cover.

4.3 Urban Climate Trends

Since urban climate changes are more clearly visible in calm summer nights, it was decided to focus the attention on July, the mostly calm summer month of the region. Fig. 10 illustrates minimum (night) temperature trends in July for the 4 national weather stations in the Wayne county; Detroit City Airport, Detroit Metro Airport, Dearborn and Grosse Pointe Farms. It is clear that up to the early sixties, all 4 stations have recorded equal or very nearly equal nighttime temperatures. From the mid 60s or so, minimum temperature at the Detroit Airport has veered upwards with respect to the other three stations. However, the early eighties to present data shows a decline in minimum temperature. Interestingly enough, the more stable community of Grosse Pointe Farms shows signs of increasing night-time temperature. So is the rapidly developing region around the Metro Airport.

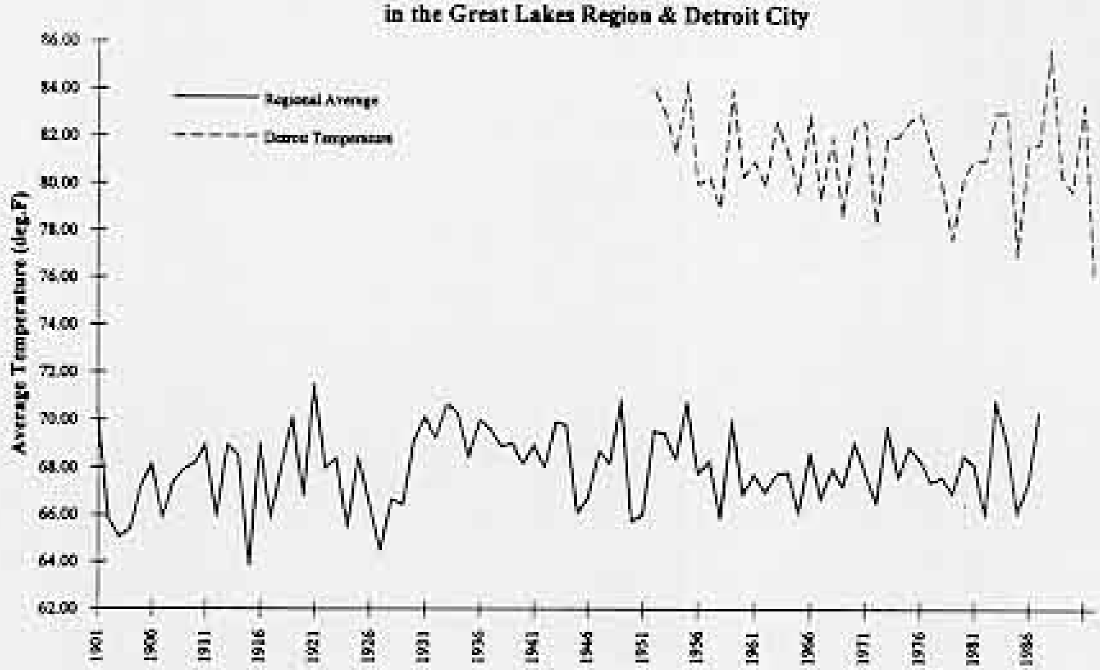
Fig. 10 MIN. TEMPERATURE TRENDS IN JULY



The decline in minimum temperatures in the city of Detroit is even more striking when compared to regional trends. Fig. 11 shows changes in average summer temperatures (for June, July & August) in Detroit and trends in summer average temperatures in the great lakes region (Michigan and the lake shore regions of Illinois, Indiana, Ohio, Minnesota and Wisconsin) (Karl, et al., 1990). While the regional average seems to have stabilized after mid 20s, Detroit's temperature has continued its drop. It is also noteworthy to point out the warmth of the city in summer compared to the regional average.

Trends in monthly temperature variations for the four Wayne county stations amplify the declining changes in the city. Figs. 12-15 show annual temperature trends at ten year intervals for the four stations. Trends in summer and late winter are interesting. In the metro airport area, little change in summer minimum temperature is seen, though a warming trend in winter can be noted. A similar pattern is seen in Dearborn as well. However, a significant drop in summer temperatures can be seen for Grosse Pointe Farms as well as Detroit city airport. City airport is not only getting cooler at a faster rate, but also is cooler than any of the other stations.

Fig. 11 Summer Average Temperature
in the Great Lakes Region & Detroit City

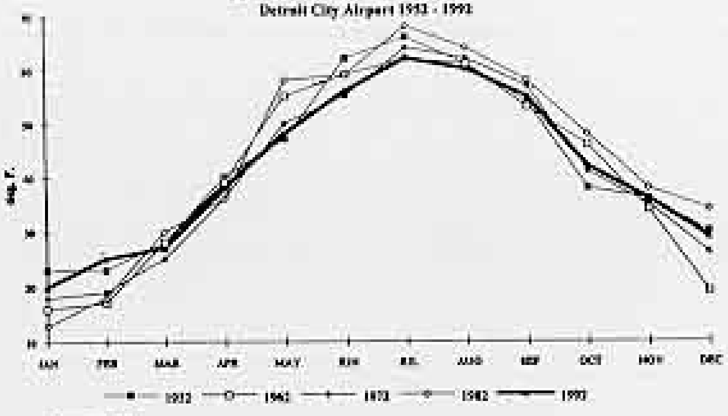


Source: Karl, et al., 1990; NCDC, 1993

4.4 Urban Air Quality Trends

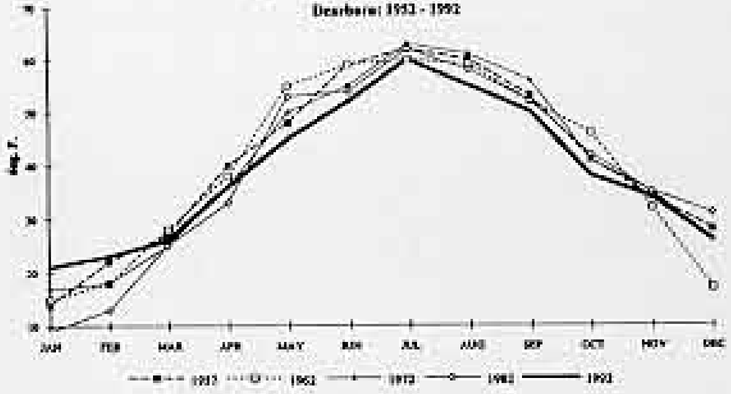
Most air quality data in the state of Michigan comes from company-operated sampling sites set up to monitor the maximum point-source emission by the facility. The following conclusions are made from the public data gathering sites (MI. DNR, 1993). Although many pollutants are monitored by the public sites, sufficient longitudinal data exist only for suspended particulate (PM10) and SO_2

Fig. 12 Annual Minimum Temperature Trends for Detroit City Airport 1952 - 1992



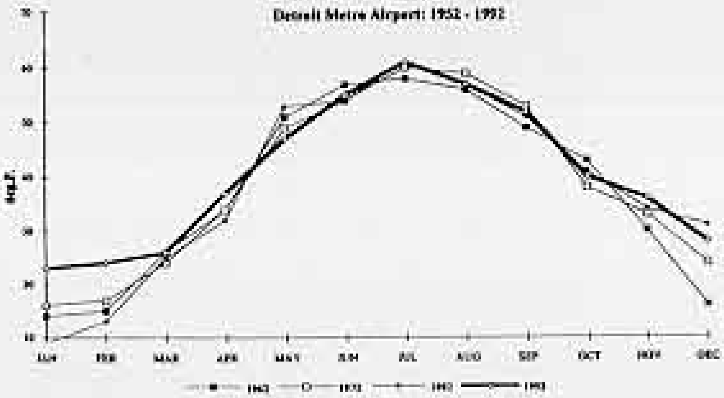
Source: NCDC, 1993

Fig. 13 Annual Minimum Temperature Trends for Dearborn: 1952 - 1992



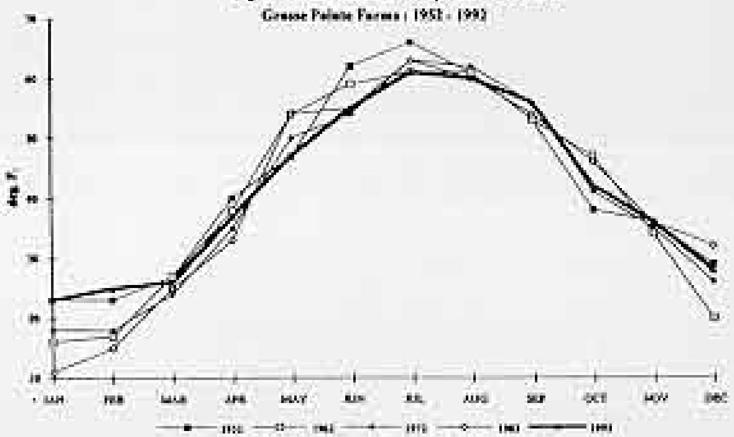
Source: NCDC, 1993

Fig. 14 Annual Temperature Trends for Detroit Metro Airport: 1952 - 1992



Source: NCDC, 1993

Fig. 15 Annual Minimum Temperature Trends for Grosse Pointe Farms : 1952 - 1992



Source: NCDC, 1993

Fig. 16 PM 10 Trends in Wayne County

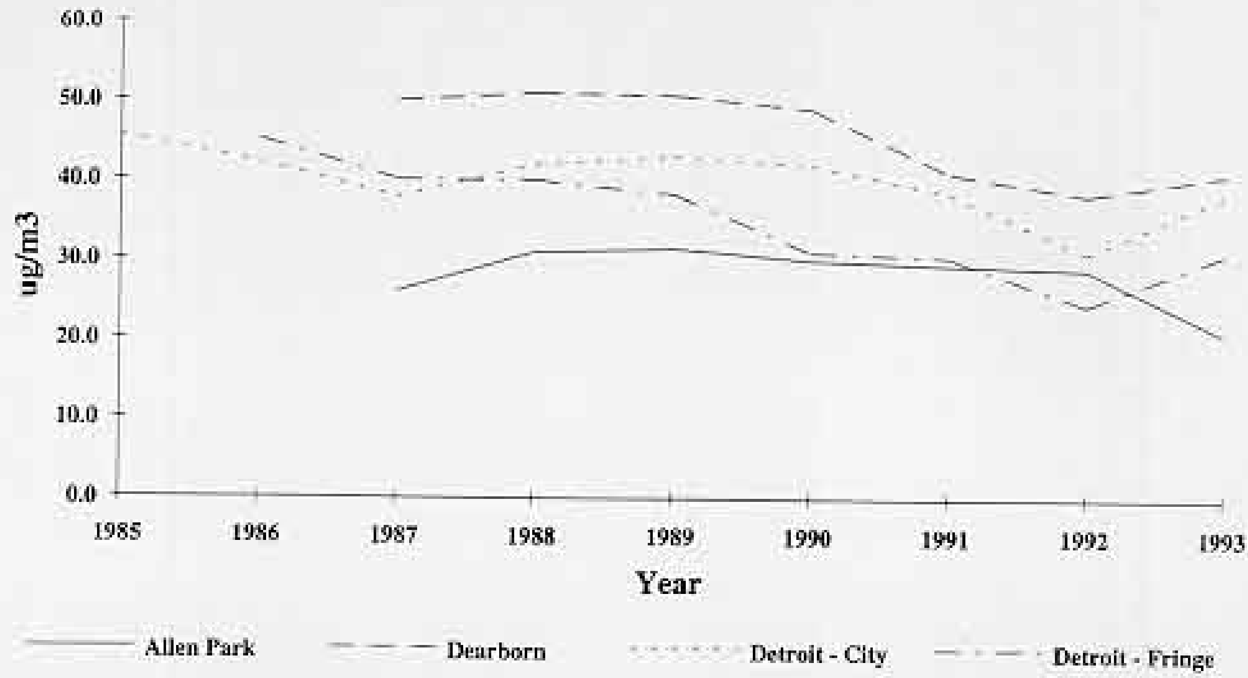


Fig. 17 Sulfur Dioxide Trends in Detroit

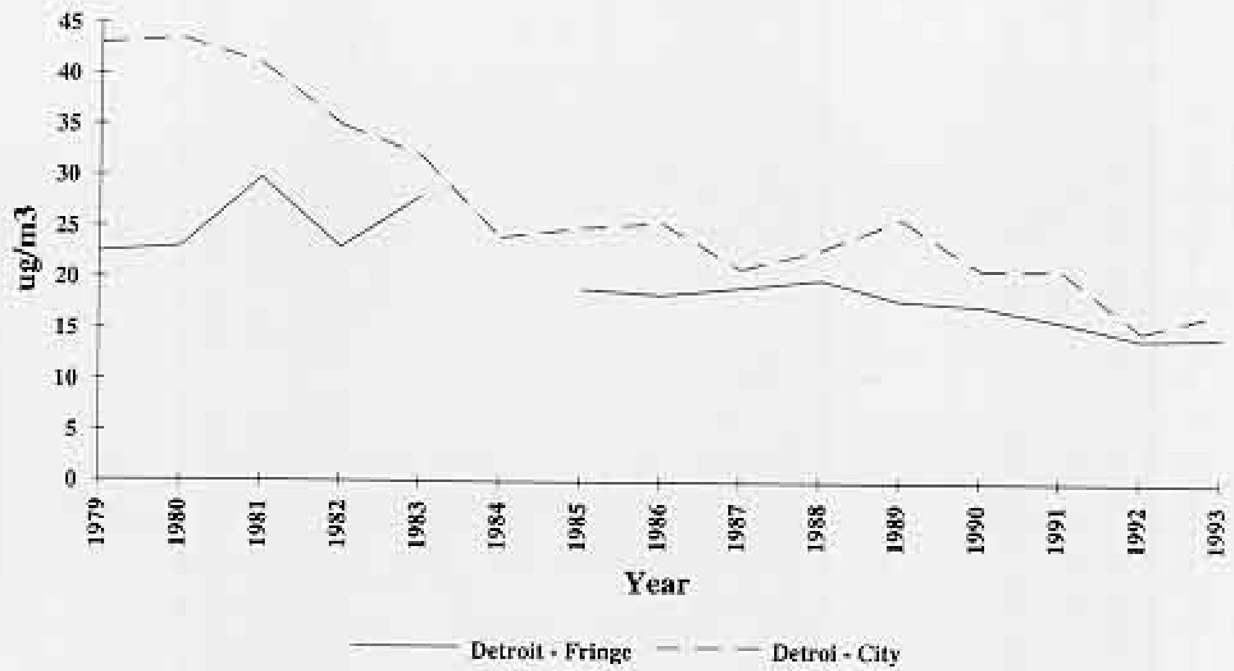


Fig. 16 shows trends in PM10 levels for four stations in Wayne county. PM10 correlates well with urban activities like automobile use. A general decline in pollutant level can be seen for all sites from 1989. However, Detroit's decline had begun earlier. No station exceeded the EPA standard of 50g/m (annual arithmetic mean).

Levels of SO_2 on the other hand, can indicate the general level of industrialization and automobile use. Trends in SO_2 shows even sharper drop (Fig. 17). A station in the heart of the city (Detroit 1) shows a marked decline . In less industrialized sections of the city, the drop is more even.

5. Environmental Transition: Lessons From Detroit

Fig. 18 shows the relationship between changes in greenness and population per census tract in the city of Detroit. Though not very strong, a relationship nevertheless can be found between population change and increase in greenness. There seems to be four distinct sections to this relationship.

a. Population decreases somewhat, and greenness increases slightly.

b. Population decreases moderately and greenness increase is linear, with a moderate slope.

c. Population decreases drastically, greenness change reaches high values and then begins to decline.

d. Population increases somewhat, and greenness also increases.

A somewhat clearer picture emerges if comparison is made between changes in greenness and redness in each census tract (Fig. 19). With the help of an $x = y$ line, Fig. 19 can be interpreted as indicating three stages: 1) All red, 2) All green, 3) Transitional stage.

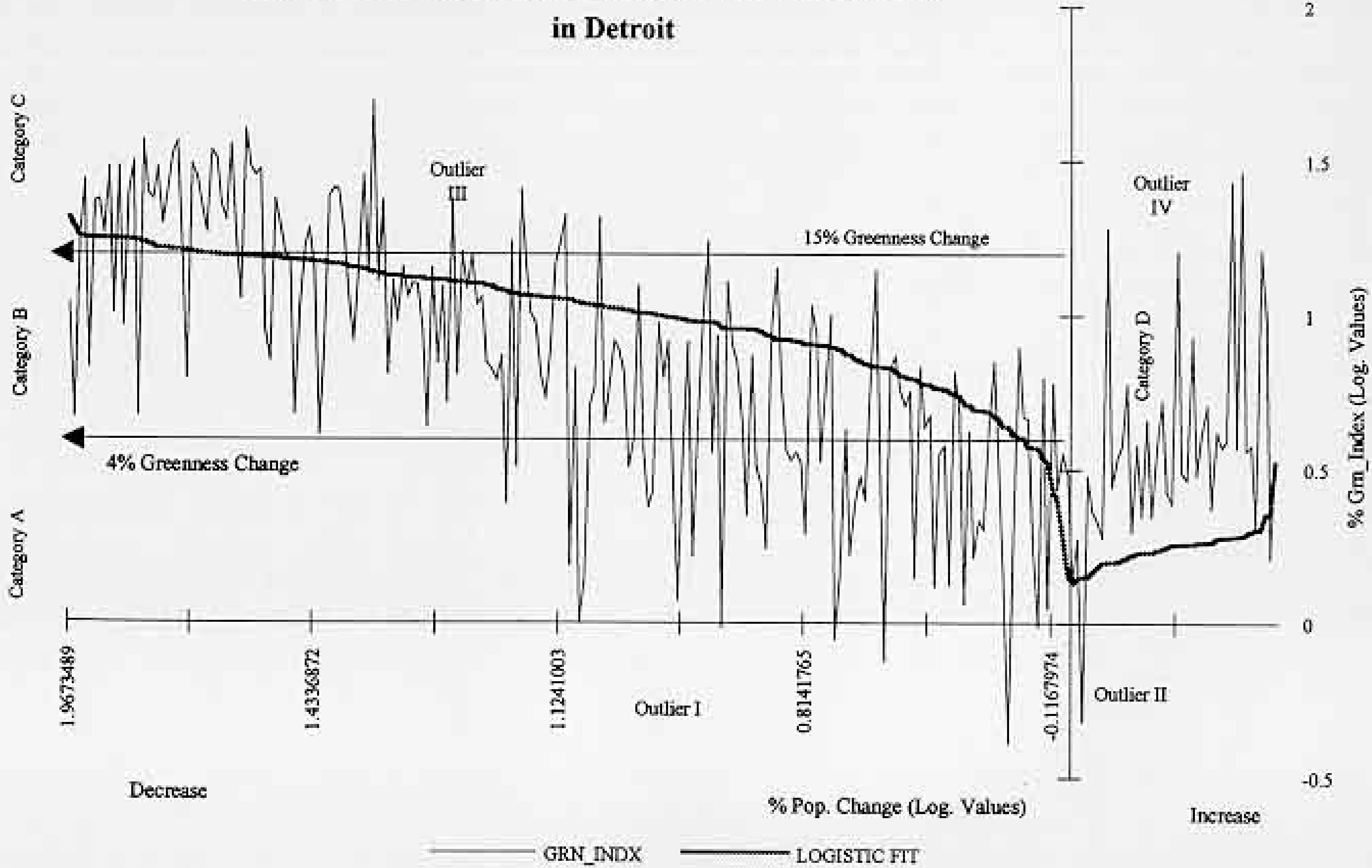
A comparison of both these graphs, leads to the following cut-off values:

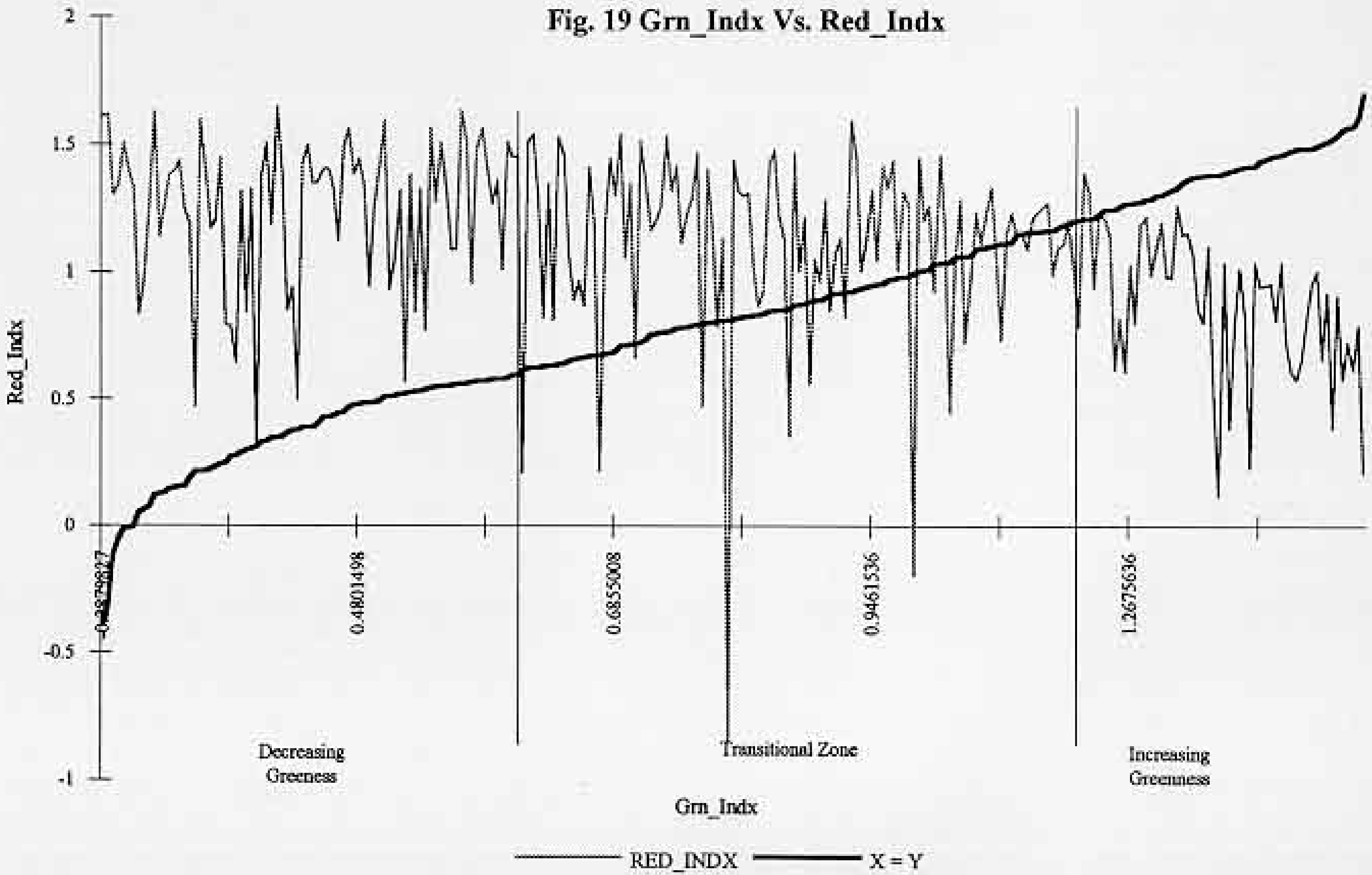
Greenness Change > 15%	-	All green or Category (c) in Fig. 18.
Greenness Change < 4%	-	All red or Category (a) in Fig. 18.
Transitional (4% < Greenness Change < 15%)	-	A mix of green and red or Categories (b) & (d).

Fig. 20 shows the spatial distribution of greenness as defined by the above cut-off values. Those colored green are areas that are predominantly greening (i.e. with greenness increase of more than 15%). Grey indicates areas with decreasing greenness (i.e. greenness change less than 4%). Yellow areas indicate the transition zone (areas with greenness change between 4and 15%). A pattern of concentric circles centered on the downtown, is clearly visible. It confirms the initial observation that the heart of Detroit, with most of its population gone, is greening the most. A ring of area furthest from city center shows no or little increase in greenness. Area in-between the two form a circle of transitional zone.

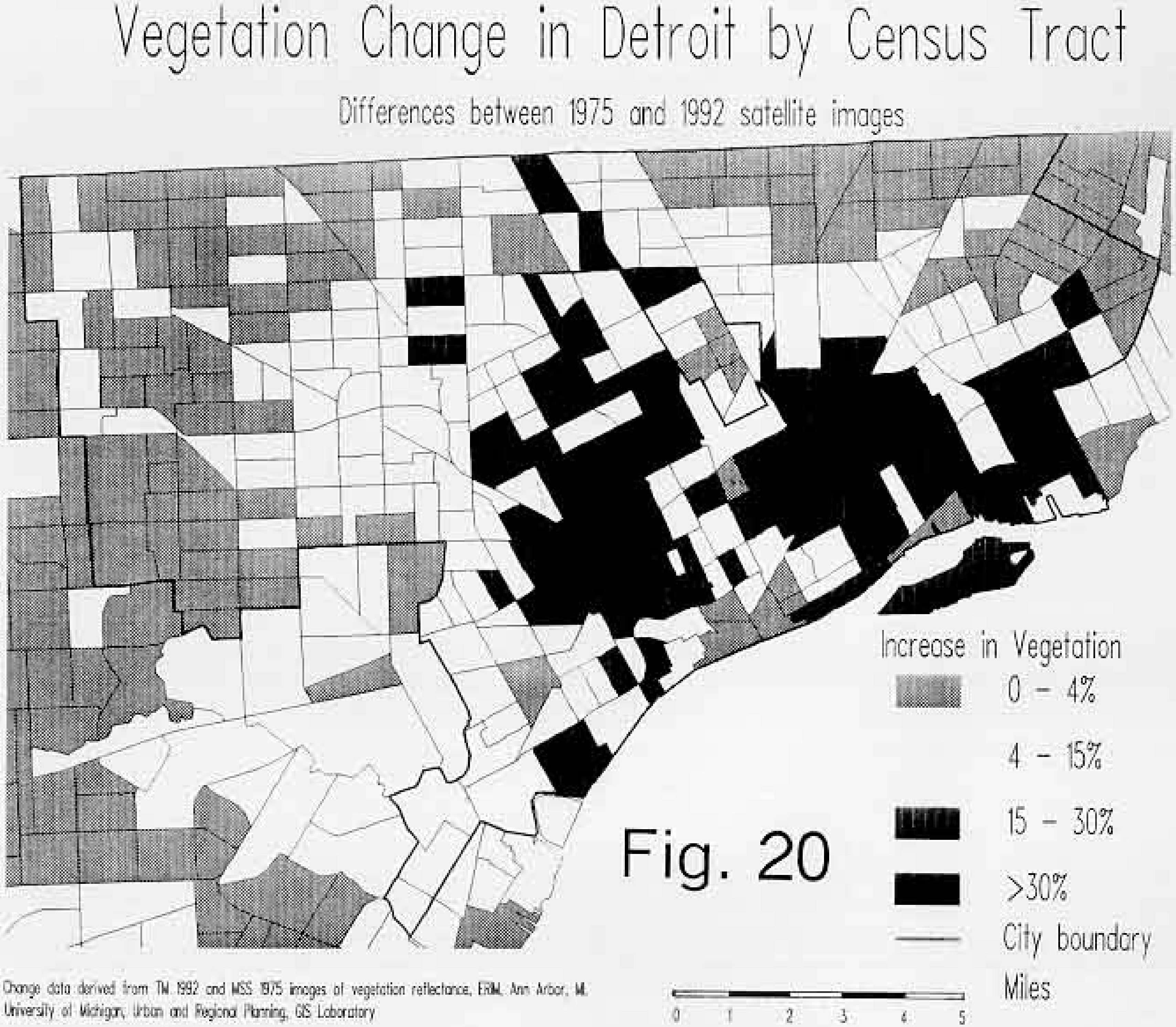
If climate records from the city airport (on the fringes of the downtown greening area) are to be believed, the unplanned greening is also causing decreases in summer night-time temperatures. Decreases in winter minimum temperatures are also seen, though the magnitude is smaller.

Fig. 18 Percent Changes in Population and Greenness in Detroit





Source: Wagner, et al., 1994



Vegetation Change in Detroit by Census Tract
Differences between 1975 and 1992 satellite images
Increase in Vegetation
0 - 4%
4 - 15%
15 - 30%
>30%
City boundary
Miles
0
1
2
3
4
5
Change data derived from TM 1992 and MSS 1975 images of vegetation reflectance, ERIM, Ann Arbor, MI.
University of Michigan, Urban and Regional Planning, GIS Laboratory

Fig. 20

Before further discussions are made, a note on the outliers seen in Fig. 18 seems appropriate. A field survey was carried out by the author and others to identify the ground conditions that might have caused these anomalies. Two kinds of conditions are suspected to have caused the outliers.

1. A drastic decrease in population but not a significant increase in greenness: This may have been the result of expansion in industrial plants into residential neighborhoods (Outlier group I where the expansion of Chrysler Motor Co., plant caused large exodus of people. Similarly a General Motors plant extension too, resulted in heavy loss of population in certain areas) or expansion of the airport (Outlier group II).

2. A small decrease in population but a large increase in greenness: This may have been caused by high density residential developments like apartment complexes, in formerly single-family housing neighborhoods (Outlier group III). The same phenomenon is also seen in areas where a small increase in population is noted due to the presence of high-density developments (Outlier group IV). It appears that such development frees up ground space which is then reclaimed by vegetation, intentionally or otherwise.

The scenario painted by the above analysis seems a bleak one at first: a city losing its population and slowly being taken over by nature. However, there are also some positive lessons to be learned from Detroit's experience.

<u>5.1 Urban climate changes may not be linear.</u>

Urban climate changes are closely associated with the socio-economic and industrial health of cities. As these conditions undergo transition, urban climatic changes too, are affected accordingly.

<u>5.2 There seems to be limits to urban climate changes</u>

The decline in industrial activity, population and use of automobile may set limits to urban climate changes. Climate changes in Detroit and cities that are at a similar stage in their demographic transition may have already peaked.

<u>5.3 It is possible to arrest the negative trends in urban climate</u>

Natural growth of vegetation due to neglect in Detroit is causing a decreasing trend in air temperature. A planned urban greening on the other hand, can retard climate changes or even reverse the trends, without necessarily destroying urban life.

<u>5.4 Population increase need not always cause decrease in urban vegetation</u>

As seen in outlier group IV, it is possible to design high-density development that are also places for nature to take hold. By freeing up land around buildings, it is possible to green urban areas while maintaining population densities sufficient for urban sustainability.

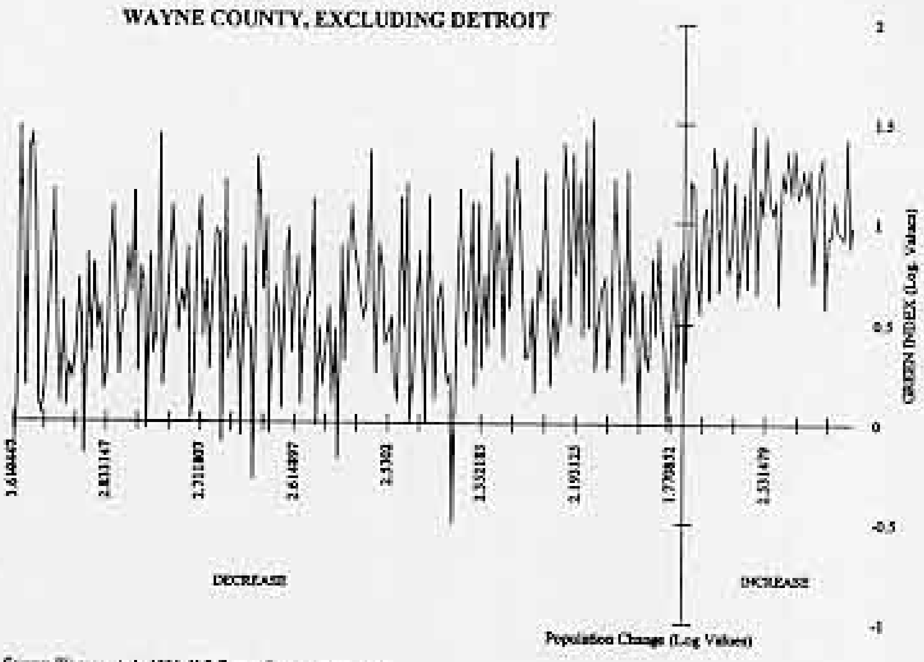
5.5 Demographic changes similar to those in Detroit may lead to similar environmental changes

Like the city of Detroit, many communities in Wayne county are losing population (see Fig. 7). Some of these communities like Hamtramck and Highland Park are still vibrant, but edging towards decay. The changes in Detroit may serve as a warning about things to come. It may as well offer hope for improvements to the urban environment (both climatic and air quality environments) without necessarily leading to urban decay.

5.6 A Conversion of unproductive agricultural land into urban uses is not always harmful for the environment.

Fig. 21 shows the greenness change in Wayne county excluding the city of Detroit. Interestingly enough, conversion of agricultural land to urban uses, particularly on the western edge of the county, has lead to an increase in greenness. Agricultural areas with short crops do not have a significant positive effect on climate. But the presence of large trees does induce greater rates of evapotranspiration and therefore can be expected to lead to substantial cooling. In a study conducted in Chicago, McPherson, et al., (1994) found that the presence of suburban parks and ruderal forests lead to decrease in average air temperature levels.

Fig. 21 CHANGES IN POPULATION VS.
WAYNE COUNTY, EXCLUDING DETROIT



Source: Wagner, et al., 1994; U.S.Census Bureau, 1982, 1992

6. Urban Climate Transition - A Hypothesis

The phenomenon of urban climate changes have long been accepted. However causes for such changes and strategies to mitigate the negative changes, do not enjoy such universal agreement. Three causes are somewhat universally accepted: urban geometry that traps solar radiation, urban fabric that stores radiation, lack of vegetation that deprive urban areas of evaporative cooling (cf. Oke, 1988; Grimmond, et al., 1994). A hierarchy of causes however seems harder to agree upon. The difficulties with mitigation strategies pointed out earlier, are made worse by the lack of coherent theories of urban climate changes.

In this light, the current paper proposes a theory of climate transition with temporally differentiated phases. It is proposed that the relative importance of causes of climate changes will be different for each phase. A three-pronged transition theory of urban climate changes is proposed.

1. Slow growth in urbanization, barely noticeable climate changes.

2. A greater increase in impervious urban surfaces like buildings and asphalt, increase in industrial activity, and population increase, leading to more solar heat trapping, loss of native urban vegetation and greater surface water runoff. The establishment of more alien forms of vegetation is also seen (urban climate changes are known to favor alien species [Sukkopp, 1981; Stulpnagel, 1990]).

3. Decrease in industrial activity, decrease in population and buildings, occurring in conjunction with mature colonies of alien forms of vegetation.

Attempts at temporal classification of urban climate changes is not new. For example, Yoshino (1989) proposed a theory of "three stages of urban maturity". The stages are distinguished by secular trends in climate parameters.

Yoshino (1989) suggested the following as possible causes for differential changes in urban climate: regional climate changes, trends in city size and activity patterns, number of automobiles, concentration of building and air pollution control regulations. According to him Tokyo passed the first stage in 1920 and entered the chaotic second stage in 1926 and remained until the end of world war II. A more settled third stage has been observed since 1961 (Yoshino, 1989: 8). Moscow reached stage III in 1955, Kiel, Germany in 1960 and Toronto just beginning to enter stage III.

Stage	I	II	III
Air Temperature	+	+	+
Vapor Pressure	0(-)	0(-)	-
Relative Humidity	-	-	--
No. of Fog Days	+	+(-)	-
No. of Good Visibility Days	-	-	+
Total Amount of Drizzle	+	+	0
No. of Heavy Rain Days	0	0	+(0)
Falling Soot, SO_2, etc.	+	+	-

Source: Yoshino, 1989: 9, Table 4

Notes: + increase; - decrease; 0 no change; -- rapid decrease; ( ) or

Landsberg (1976, 1981) also observed trends in climate changes. By monitoring a city from its inception (Columbia, Maryland), he was able to show the chaotic and rapid nature of climate changes, particularly in terms of air temperature and precipitation.

The hypothesis in the current paper is slightly different because, a closer link between urban climate changes and demographic changes are made. It is also suggested that climate changes follow urban demographic and industrial trends with a time-lag. For example, the city of Detroit began losing population from the 1950s and industrial decline began in early 70s. Yet a drop in night-time temperatures were not seen till early 80s.

How will a theory of urban climate changes benefit urban designers and others interested in creating livable cities? First of all, it will help identify cities in climate transition. Such an identification will help prioritize design goals. For example, if a city is identified as going through the earliest stage of climate transition, design strategies that regulate urban form in a climatically suitable manner (like ordinances that promote shaded street, discourage certain solar orientations, limits on building heights and setbacks, etc.) may be promoted. Those in the second stage of transition, with very little room to manipulate urban form or activities, may find legislative caps on industrial activity, mandatory air cleaning requirements, and promotion of non-polluting modes of traffic helpful. On the other hand, cities in the late stages of transition with greater urban decay, might profit from urban greening campaigns, encouragement of non-polluting urban activities (certain service-sector industries, for example) and experiments with high-density, low-rise development that might bring back the necessary population density to sustain urban life with minimal destruction to nature.

Secondly, a temporally-differentiated transition theory of urban climate changes can form the basis for development of mathematical models for each stage, based on the rate of change. Such models can be useful in predicting the future changes within a given climatic stage. Knowledge of immediate future changes in urban climate can be useful to architects, urban planners and urban engineering service planners and providers.

7.0 Conclusion

Before attempting to generalize the findings from Detroit, certain qualifications must be made. First of all, reliable urban climatic data are needed over long periods of time. It is regrettable that even the more urban counties in the U.S. have few city-based weather stations of high caliber. Urban climate is now well recognized as a distinct phenomenon and therefore monitoring the extent of this anomaly must be vigorous. Furthermore, changes to climate are usually local-to-regional in scale. As such, a closer network of stations are necessary to monitor both positive and negative impacts of urban development.

It is also necessary to monitor air quality of urban areas more intensely. Although many monitoring stations exist in and around cities, many of them are industry-based sites that monitor the impact of a particular point-source only. It is necessary to establish a more extensive network of urban air quality monitoring stations that not only collect data but also make them readily available to urban designers.

There is no doubt that urbanization will continue for many more years to come. However, as cities mature, certain environmental transitions will settle in, creating their own two-way dynamism: City on environment and environment on city. Environmental changes in cities like Detroit that have long gone through socio, economic and political transformations offer lessons that rapidly urbanizing cities may find useful. The manner in which nature seems to have taken hold of the inner city areas of Detroit may offer clues for intentional exploitation of nature in cities for climate mitigation purposes. Design strategies that allow for high-density, low-rise developments, changes to urban zoning ordinances that allow for mixed land uses (and reduces the need for long distance travel, thus reducing roadways), and intentional urban greening can help mitigate the negative impacts of urbanization upon the environment without destroying urban life. Together with socio, economic and political trends from other cities, urban climatic trends of Detroit can help develop prudent design practices for future megalopolii.

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COASTAL PROTECTION AND THE COASTAL POPULATION-ENVIRONMENT DYNAMIC

Noah Hall

Importance of Coastal Areas

The importance of coastal areas to both human and ecological systems must be discussed. The sociological and economic role of coasts is significant. Coastal areas are important in the generation of energy. They are often the sites of proven oil reserves, as well as ideal locations for energy generating facilities. The shipping industry, with all of its economic and cultural effects, is dependent on navigable ports. Other uses of human importance are even more directly linked to coastal ecology. Tourism, an essential industry in many economies, is often dependent on aesthetic and ecological quality. But perhaps the most important human use of coastal and marine areas is for fishing. In many parts of the world, seafood is the primary source of protein for the population. Fishing and harvesting of seafood often is the major source of income for the coastal population. More than ninety nine percent of the world catch of marine species is now taken within 320 km of land (Holt and Segnestam, 1982). Unfortunately, fisheries often suffer from the tragedy of the commons, and their nutritional and economic contributions to humans is diminishing. A decade ago, the International Union for Conservation of Nature and Natural Resources (IUCN) estimated that the world catch is perhaps twenty four percent lower than it would have been with sustainable management (Salm, 1984).

The ecological need to protect coastal areas is equally important. Fisheries are not just an economic resource to be optimized by human beings, but an inherent valuable aspect of global biodiversity. Holt and Segnestam also estimated that over half of the ocean's total biological production takes place in the coastal zone (1982). Areas of "upwelling", where ocean waters rise to the surface, are consistently acknowledged as perhaps the earth's richest biological resource (Beatley, 1991; Reid and Trexler, 1991). The three-dimensional aspect of coastal and marine ecology fosters incredible biological diversity, as organisms are not tied to a thin layer of land for support. More importantly, the fluid nature of these systems allows greater areas of displacement, interconnecting millions of species (Beatley, 1991). Many marine species, such as tunas, turtles, and whales, are not only capable of migrating long distances, but require continuous habitat as essential to their lifecycle.

Globally, the most threatened habitats are coastal wetlands, shallows, sea grass beds, and coral reefs. Unfortunately, these habitats also contain some of the highest concentrations of biodiversity. They are essential to the ecological health of not just our marine habitats, but many terrestrial habitats as well. These nurseries of life are being destroyed around the world, with severe effects on economies that depend on them (Carpenter, 1983). They are the breeding grounds for many forms of marine life, and their destruction has an exponential effect on the populations of many key species (Carpenter, 1983).

The Coastal Zone

There is no standard line to separate coastal areas. Coastal zones are usually determined on a local basis, dependent on the nature of the body of water, type of coastline, topography, climate, neighboring land use, and economic and cultural factors. There are some typical, if not standard definitions of what is meant by a coastal area. The coastal zone generally includes all bays, tidelands, floodplains, immediate shorelands, and territorial waters in the segmented area. While interior land and the open oceans both effect and are affected by the coastal area, these habitats must be managed separately, though not independently.

The coastal zone provides the border between land and water. In many of the world's coasts, this is a delicate border indeed. Coasts are inherently dynamic, even compared to the rest of the biosphere. Most of the world's coastline is less than five thousand years old, due to changes in sea level. Coasts are constantly being destroyed and created. Many humans have mistakenly assumed that coastal land was somehow meant to last forever, and tried unsuccessfully to make stability where change is the norm. Coasts are always in a process of progradation (building out) or transgression (receding). Often, both processes can be acting simultaneously, resulting in a very dynamic environment. Complicating this delicate balance is background and anthropocentric global change. The rise in global temperatures, and resulting rise in sea levels, has had a significant impact on the world's coastline. Ironically, it is usually the human structures most threatened by this human caused temperature rise (Lasserre, 1991). Protected and natural coasts are beautifully adapted to handling global change (Reid and Trexler, 1991). This is because change is the only constant in the coastal zone.

Included in most discussions of coastal zone management is the marine area administered by the coastal country. Established under the Law of the Sea in 1973, the exclusive economic zone (E.E.Z.) may extend to a maximum of 200 nautical miles from the coastal baseline. Coastal states have jurisdiction over the exclusive economic zone with regard to preserving the marine environment, as well as rights to stationary natural resources within the zone. While the Law of the Sea provides for establishing areas of pollution prevention, all states enjoy freedom of navigation within the zone. Essentially, the exclusive economic zone extends the coastal zone well into marine waters.

While the coastal zone should logically include the lands with coastal watershed, this is often not feasible. Coastal protection usually only extends as far inland as what an untrained land manager interprets as the beach. In some areas, it may include critical habitat for coastal species, but this is by no means standard. Coastal wetlands are often included, as are coastal ranges (Salm, 1984). This is definitely an area where the lack of standard data makes global analysis and research more difficult.

Need to Preserve Biological Diversity

Our generation has inherited the most diverse community of living creatures to ever occupy the planet Earth (Wilson, 1988). At the same time, we also possess the most sophisticated technology to ever exist. With this technology we have pushed the rates of exploitation of natural resources past sustainable levels. This technology has brought prosperity and wealth (however unequal the distribution) to our generation while all but insuring a depleted and destroyed planet for all species to come. Nature had provided a process to allow species to adapt to a rapidly changing environment. This process of evolution and ecology is dependent of biological diversity (McNeely, et al., 1990). Biological diversity is an umbrella term to describe the degree of nature's variety. It is based on factors of the number and frequency of different habitats, species, and genes. It is under this context that the biological diversity of coastal systems will be discussed.

Biological resources have many values which warrant their preservation. There are three basic approaches to determining biological value. Biological resources may have consumptive, productive, or indirect functional values. Consumptive value is the value of nature's products that are consumed directly, such as firewood and game meat. Productive values are based on natural products sold through a market in a commercial setting, such as timber and medicinal plants. The third value is less tangible. It includes all non-consumptive values of ecosystem and species functions. Included in this category are such complex ecological functions as watershed protection, climate regulation, and soil production. Existence and option values, also included, represent the value that humans place on knowing that a species exists and will be available in the future. Clearly, these values can overlap, especially in coastal areas and habitats. Many fish have consumptive, productive, and existence or option values. They provide food for local and indigenous communities, have a commercial market value, and are appreciated simply for their existence. Entire coastal ecosystems may provide everything from driftwood for cooking and heat to commercial revenue from tourism.

Although biological conservation has many documented economic values, it is a mistake to assume that economics can fully value biological diversity. "It is certain that if we persist in this crusade to determine value where value ought to be evident, we will be left with nothing but our greed when the dust finally settles. I should make it clear that I am referring not just to the effort to put an actual price on biological diversity, but also to the attempt to rephrase the price in terms of a nebulous survival value" (Ehrenfeld, 1988). The cultural, ethical, and moral arguments are very strong, however the current status of conservation continues to be held to an economic justification (McNeely, et al., 1990).

Coastal Biodiversity

The immensity of biodiversity in coastal environments is well acknowledged (Beatley, 1991). The most impressive example of marine biodiversity is evident in coral reefs, which rival tropical rain forests in the extent of their biological productivity and diversity. While occupying only 600,000 square kilometers of the Earth's surface, they support over half a million species (Beatley, 1991). For example, the Great Barrier Reef System which spans 2000 kilometers in length supports 300 species of coral, 1500 species of fish, and more than 4,000 species of mollusks (Reid and Miller, 1989). The reefs are also important habitat for over 250 species of birds, as well as species of turtles, whales, and porpoises. Overall, coral reef systems are habitat for about one third of all fish species, and the net primary productivity of coral reefs is actually higher than for many tropical forests (Beatley, 1991).

Some of the most biologically rich dry-land terrestrial habitats, such as tropical rain forests, often occur within the coastal zone. For example, hotspots are identified vulnerable areas of tropical rain forest that are small in size but extremely rich in biodiversity. A high percentage of these hotspots are located along or near shorelines (Myers, 1988). These include the Atlantic Forest along the coast of Brazil, Peninsular Malaysia, the Philippines, and northern Borneo (Myers, 1988). Of the countries identified as "megadiversity countries", which contain especially high percentages of the world's biodiversity, many have significant amounts of shoreline. Such countries include Colombia, Mexico, Australia, and Indonesia (Beatley, 1991; Mittermeier, 1988). Another example of the importance of coastal areas in biodiversity are islands, which exhibit extremely high levels of endemism and are home to numerous rare species. Examples can be found in the unique, but threatened, biota in islands such as Hawaii and Madagascar (Beatley, 1991).

Threats to Coastal Biodiversity

Coastal areas are often threatened by the same problems as terrestrial areas. Loss of habitat, pollution, exploitation, abuse, exotic species, and global climate change all pose a serious threat to coastal biodiversity. While these dangers threaten most inland areas, they have a distinct significance when dealing with coastal habitats. Other threats are more unique to the coastal and marine environment. Loss of habitat resulting from development and agriculture continues to threaten the world's coastal zones. Because of the abuse of ocean water as a commons, pollution in the forms of dumping, leachate, and runoff poison the water.

The direct loss of habitat is an immediate threat. Coastal wetlands are often lost at a greater rate than any other habitat (Beatley, 1991). These wetlands are often destroyed in development of urban and resort areas, agriculture, and oil and gas exploitation. Beach and dune habitats, essential for coastal stability in many locations, are threatened by recreational development and construction of seawalls and shore-hardening structures. Mangrove forests are another important coastal habitat being destroyed at an alarming rate. The Philippines, Thailand, and peninsular Malaysia have seen great areas of their mangrove forests lost to agricultural uses and overharvesting of timber and fuelwood (Beatley, 1991).

Pollution is a very serious and fundamental threat to the coastal and marine environment. Because oceans are seen as a commons, their use as a pollution sink has been a global problem. The pollution comes from many mediums, including direct dumping, pipelines of effluent, agricultural runoff, and leachate. Hundreds, likely thousands, of chemical pollutants have contaminated the Earth's oceans, with measurable impacts on marine life. Examples include PCBs (polychlorinated biphenyls) which have been linked to declines of Baltic seal populations, and DDT, which is extremely dangerous to most forms of marine vertebrates (Beatley, 1991). The runoff caused by agriculture and over-logging is destroying the coral reefs ecosystem in the Philippines, and the thousands of forms of life dependent on it (Hodgson and Dixon, 1990). Oil spills, a well publicized threat to coastal areas, deserves its horrible reputation. The Exxon Valdez spill dumped 11 million gallons of oil into Alaska's pristine Prince William Sound. Conservative estimates count the loss of 1000 sea otters, 150 bald eagles, and 36,000 other marine birds. The actual impact could be much higher (Beatley, 1991).

The Role of Protected Areas in Conserving Coastal Biodiversity

Protecting coastal and marines areas as parks and preserves can be a successful solution to the loss of coastal habitats and biodiversity. Ultimately, the effectiveness of a protected area is dependent on several factors. Acceptance by local inhabitants, scientific site selection, allowable sustainable use, and quality of management all influence how well a protected area will conserve biodiversity. However, it is clear that designation of an area as a park or preserve is an important step in the sustainable conservation of the world's coasts.

An effective program of protecting coastal areas would incorporate several components. Exploitive uses must be limited or banned, such as the mining of coral reefs. Critical habitats and other vital parts of coastal environments should be targeted, based on levels of biodiversity and importance in the local ecology. Restoration to ideal conditions should be a goal, focusing on removal of damaging human developments and removal of possibly dangerous pollutants or contaminants. Also important is the availability of scientific information about the protected area, for educational and research purposes.

The IUCN (International Union for Conservation of Nature and Natural Resources) held a conference on Coastal and Marine Protected Areas in Bali, Indonesia. The role of protected areas in the conservation of coastal and marine areas was thoroughly discussed. These are: Maintaining ecological processes and life support systems; Preserving genetic diversity; Sustainable use; and Maintaining natural areas for education and research (Salm, 1984).

The most comprehensive role of protected areas is maintaining ecological processes and life support systems. They ensure ecosystem productivity, by safeguarding essential processes from disrupting or damaging activities. These processes can be physical, chemical, and biological. Lake Ichkeul in Tunisia is an example of a protected area where ecosystem processes are maintained. Declared a National Park by the Tunisian government, it is considered to have the most important wetlands in the Mediterranean region. Thousands of species of birds and fish, many of economic importance, depend on this habitat. The water balance of the lake is the result of many complex process, that allow the natural mix of fresh and salt water. The complex hydrology was of high importance in designing the protection of the area. By allowing the natural processes to continue, the delicate by very productive ecosystem was preserved (Salm, 1984).

Preserving genetic diversity is another important role of protected areas. Genetic resources are lost at two levels, extinction of an entire species and loss of populations of individuals within the species (genetic impoverishment). In conserving coastal biodiversity, genetic impoverishment is more of a problem than extinction. This is because endemism, the restricted distribution of a species to a relatively small geographic area, is much less common for marine life than terrestrial life (Salm, 1984). Coastal protected areas serve as natural gene banks, preserving genetic diversity within an entire ecosystem. In order to be effective, the selection of the protected area must be critically researched in terms of biodiversity and variability. An example can be found in the United States, in the waters of Point Reyes-Farallon Islands National Marine Sanctuary in California. There the waters provide critical feeding area for a wide range of marine birds, mammals, and fishes. It is an important migratory route for elephant seals in particular. The rich feeding areas attract many populations within the species, promoting mating and diversification of genetic resources from the widely distributed populations (Salm, 1984).

Sustainable use is popular phrase that describes the best hope for consumptive homo sapiens. It describes the level and patterns of consumption that are based on ecological limits, not consumption economics. Protected areas can be a major component of promoting sustainable use in coastal areas. Coastal areas have historically been used extremely unsustainably, with unsound modifications made in the coastal zone, severe over fishing, and extreme loss of habitat. However, protected areas can promote non-consumptive, more sustainable uses of coastal resources. They can restrict use to tourism and education and research to allow populations and the habitat to recover. Managers can allow a small sustainable fish catch that would not deplete the population. Major changes to the coastal area such as barriers to prevent transgression could be removed. Examples are abundant. Any of the coastal and marine parks that allow tourism and limited levels of fishing for the native population are bringing people one step closer to sustainable development.

Both general public education and formal research can be done in protected areas. They maintain the natural setting for many educational reasons. Simple programs such as educational nature trails or interpretive talks educate the public about coastal ecology. Buck Island National Monument in the U.S. Virgin Islands features underwater trails through coral reefs, complete with interpretive signs (Salm, 1984). Equally important is the pristine research conditions for biologists, ecologists, geologists, and oceanographers. Protected areas provide places of little or no human disturbance to develop baseline data on ecology and other sciences. They are also ideal settings for most other field work, in both educational and research settings. The "Scientific Research Zone" established on the Great Barrier Reef is an example of this role (Salm, 1984).

Social and Economic Benefits of Protected Areas

It is unfortunate that protected areas, even nature itself, must be justified in economic and social terms. However, that is the current reality. It is important to acknowledge that while these protected areas have an economic value, their value is to great to measure with money. Still, several economic benefits help increase the number of protected areas each year. Most important of these is development of recreation and tourism. In many economies, sustainable use of beautiful and diverse coastal areas is the most important industry. The strongest indicator of the economic benefits of protecting areas in action initiated by local residents to create coastal and marine parks. Examples include the Sumilon Island Marine Park in the Philippines and the Malindi/Watamu National Parks and Preserves in Kenya (Salm, 1984).

In many ways the cost of not protecting some coastal and marine habitat is outrageous. An example of this economic benefit deals with fisheries. Protected areas may be essential to continued survival of populations of many commercial fisheries. They can also protect the fisheries for local inhabitants from large industrial fishing operations as seen in the Banda Islands of Indonesia (Salm, 1984). Rehabilitation of exploited areas is extremely expensive, and thus very rare. Replanting mangrove habitats has met little success due to very high costs and long restoration times (Salm, 1984).

Beyond economics, there are many social benefits to protecting natural areas. Kalati Poai, of the Department of Agriculture and Forests in Apia, Western Samoa, gives developing country's perspective on the social role. "National Parks belong to the people. Every man, woman and child in the country has, as a heritage, these areas which are set aside forever to give pleasure to present and succeeding generations. Thus those who use parks have responsibility to themselves and to others to treat this great heritage with care and respect. Reserves are very important in the country. There are many important things in our life that could become rare. If we do not preserve or protect some of our lands and seas, these will be lost" (Salm, 1984).

Coastal and Marine Protection Policies

Protected areas were first established on land. Management programs were designed for terrestrial ecosystems. As the need to protect coastal and marine areas became apparent, the same protection policies and management plans were applied to the coastal and marine environment. While these policies often failed to address specific characteristics of coastal areas, they have been adapted in many countries with reasonable success. Some countries, such as France, Kenya, and Seychelles, make no distinctions about policies and management of coastal and marine areas from terrestrial areas. Japan's National Park Law makes a distinction in nomenclature, but little else (Salm, 1984). Other countries have more specific legislative policies. New Zealand has a Marine Reserves Act, and Trinidad and Tobago use a Marine Areas Preservation and Enhancement Act (Salm, 1984). Australia uses a very progressive and comprehensive approach to protecting their Great Barrier Marine Park, regulating or prohibiting all pollution outside the park that may have a harmful effect on the park's marine life (Salm, 1984).

There is also great variation in the specification of protected area boundaries. Some countries protect all of the waters within their Exclusive Economic Zone, while others only extend protection a kilometer off shore. Inland protection may be to the high water mark or may extend throughout the coastal ecosystem. Australia even protects the air space above the Great Barrier Reef Marine Park (Salm, 1984). Shipping may be allowed, regulated, or banned, depending on the country. There is also great variation as to the level of use allowed in the protected area. Some countries will allow limited fishing, especially for local inhabitants. Other areas may be closed to all but the least disruptive forms of tourism and research.

The irregularity of coastal and marine protection may not be such a problem, however. It allows individual countries, even local provinces and communities, to manage the protected area in the way most suitable for the local economy, culture, and ecology. Obviously, coastal protection is more likely to be enacted if management policies are flexible. Another important design aspect is incorporating buffer zones, to taper the level of disturbance and pollution near the protected area. Some countries are further ahead on this concept than others, but many local users of protected areas have been advocating buffer zones as an important component of effective protection.

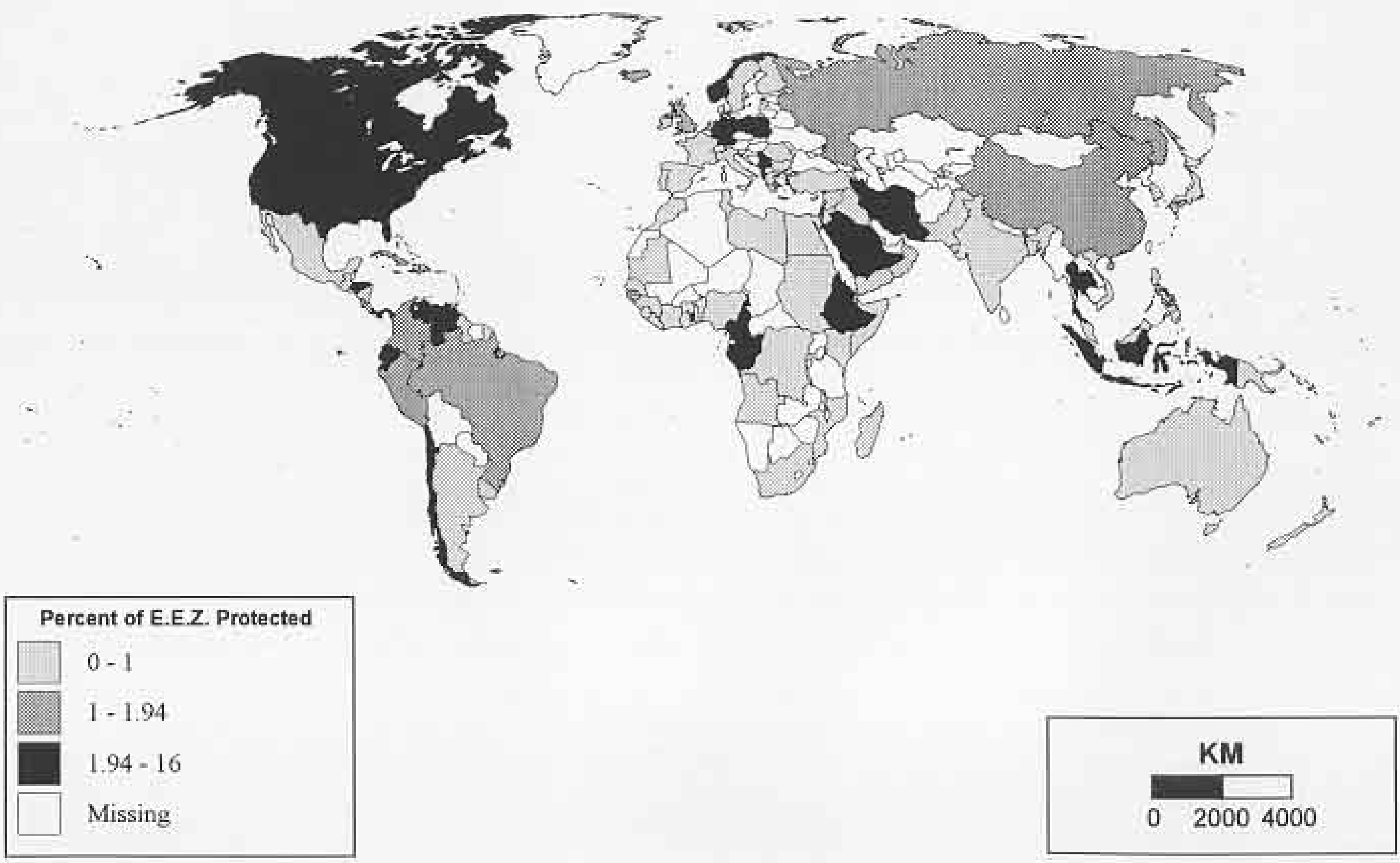
There are some consistences in coastal protection on a global scale. Hunting and harvesting of marine life is always regulated, if not banned. Industrial development is almost always not allowed, with very few exceptions. Point pollution sources are not allowed in protected areas, although illegal dumping is always a threat. Almost all protected areas incorporate concepts of sustainable use or ecotourism. The most important common concept is that they were all designed and designated in response to the threat of pollution, loss of biodiversity, or severe habitat destruction.

Building a Theory of Coastal and Marine Protection

Given the importance of coastal areas, the need to preserve coastal biological diversity under increasing threats, and the ecological and economic benefits of protected areas, the countries of the world should be protecting vast amounts of coastal and marine areas. But they are not. What are the factors that drive coastal protection? Are they economic, social, or physical? Is coastal protection only related to economic and social factors in coastal areas, or is it driven by national indicators? Is coastal and marine protection related to land protection, and to what degree? Ideally, these questions would lead to a theory of coastal protection that would point to a transition. To help in the theory building process, a geographic information system (GIS) map was produced indicating the level of coastal protection for each country analyzed. A strong geographic indicator was not present, although the Western hemisphere did show a slightly higher average of coastal protection (see map, next page).

Coastal and Marine Protection

As Indicated by Percent of Exclusive Economic Zone Protected

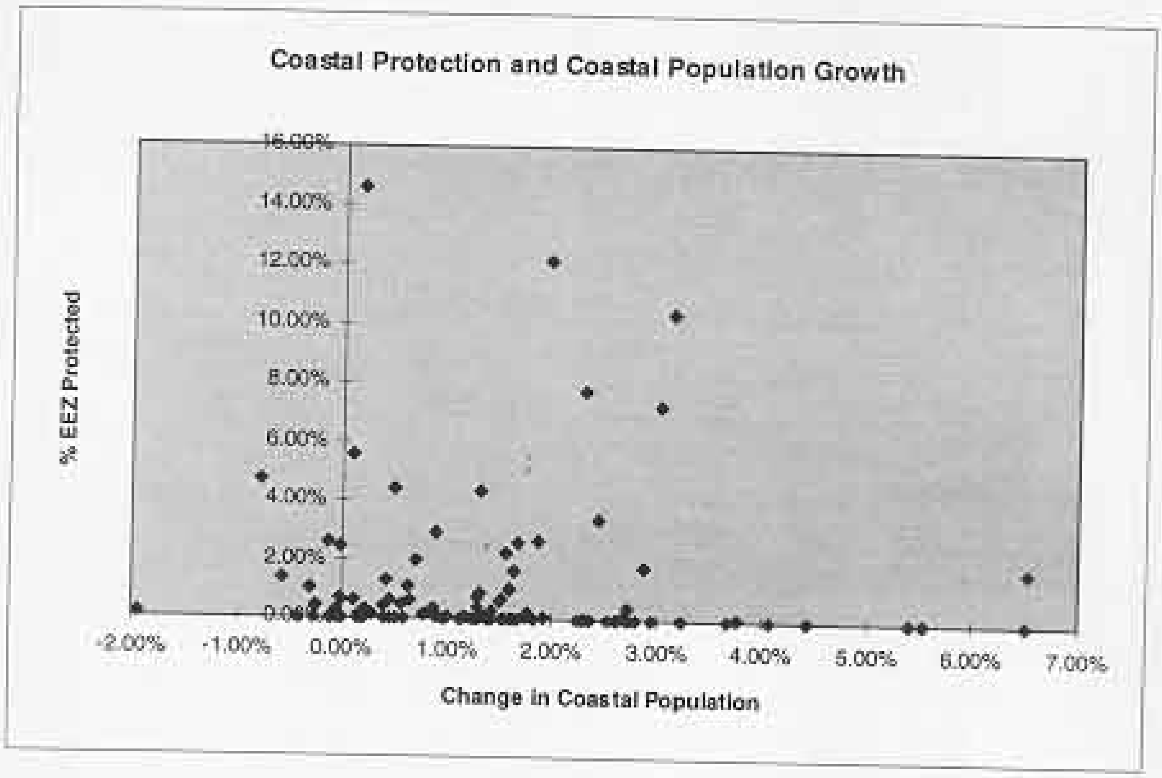


Methods

Initially, data on about a dozen coastal variables were collected for Mexico, the United States, and Canada. A hypothesis was developed that linked increasing amounts of coastal protection to an increasing coastal population. It was hypothesized that as coastal areas became more populated, their was a greater need and pressure to set aside protected areas. The level of coastal protection would be analyzed as the percent of the exclusive economic zone (EEZ) that is protected. This is a good indicator, since a country is allowed to protect any area within its exclusive economic zone, but no more. Using a percent is better than just the number of square kilometers protected, since it compensates for the great variety of coastal and marine area controlled by different countries. Coastal population was also adjusted in relation to the total population. The best indicator of coastal population growth is to calculate the change in the percent of the country's population that lives in coastal urban agglomerations from 1980 to 2000. This is preferable to a straight coastal population growth rate because it compensates for the differences in population growth rates among various countries. Rather than look at the coastal population as isolated, it is being examined as a part of a whole. For example, a coastal population growth rate of 4% in a country with an overall growth rate of 5% is quite different from the same coastal population growth rate in a country with zero population growth. For the three original countries, there appeared to be a correlation between the level of coastal protection and growth of the coastal population.

This correlation did not hold up when the rest of the countries were analyzed (see figure 1.). The growth in the coastal population as a percent of the total population was calculated for the years 1980 to 2000. This data was plotted against the percent of the exclusive economic zone protected. Data was taken for over one hundred countries. When these variables failed to produce a correlation, other measures of population dynamics were used. Growth in the coastal population, independent of the total population, was tried, but the results were similar to figure 1. A measure of coastal density, which was calculated as the coastal population per kilometer of coastline (the "C" factor) was also tried. It was hypothesized that crowding along the coastline is correlated with coastal protection, but the variables are uncorrelated. Even total population size and growth were used, with no correlation present. It should be noted that coastal population refers to the number of people living in coastal urban agglomerations, as reported by the World Resources Institute. This variable was used for two reasons. First, it is a good indicator of the population pressure on the coastal zone. Second, it was the only variable consistent available for almost all coastal countries. The original hypothesis linking coastal protection with population pressure could not be proved using these data sets.

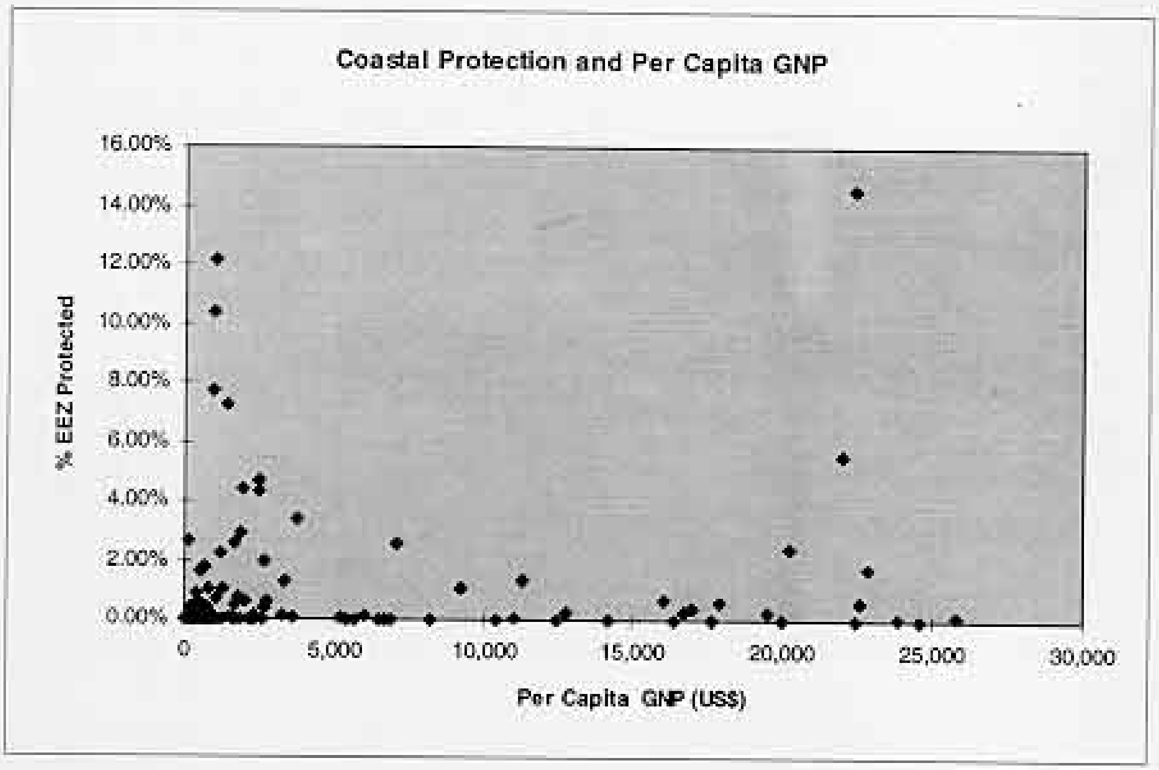
Figure 1. Coastal protection is clearly not correlated with growth of the coastal population for the countries of the world. Coastal protection is from 1989, population growth is from 1980 to 2000.



Source: World Resources Database, 1993

While a correlation could not be proven with the available data to link coastal protection and population pressure, it was still hypothesized that some social variable was driving coastal protection. Given the cost of protecting coastal and marine areas and the financial resources necessary to manage these parks and preserves, it was hypothesized that economics would have a role. After gathering data on per capita G.N.P. (Gross National Product) for every coastal country, the data was graphed against the percent of the exclusive economic zone protected (see figure 2.). Once again, a correlation did not seem present. Gross national product was used, rather than gross domestic product, because it was available for every country. Total gross national product was also calculated, but the results failed to show a correlation.

Figure 2. Even with the financial cost of protecting coastal and marine areas, per capita G.N.P. is not correlated with coastal protection. Coastal protection is from 1989, G.N.P. is from 1993.

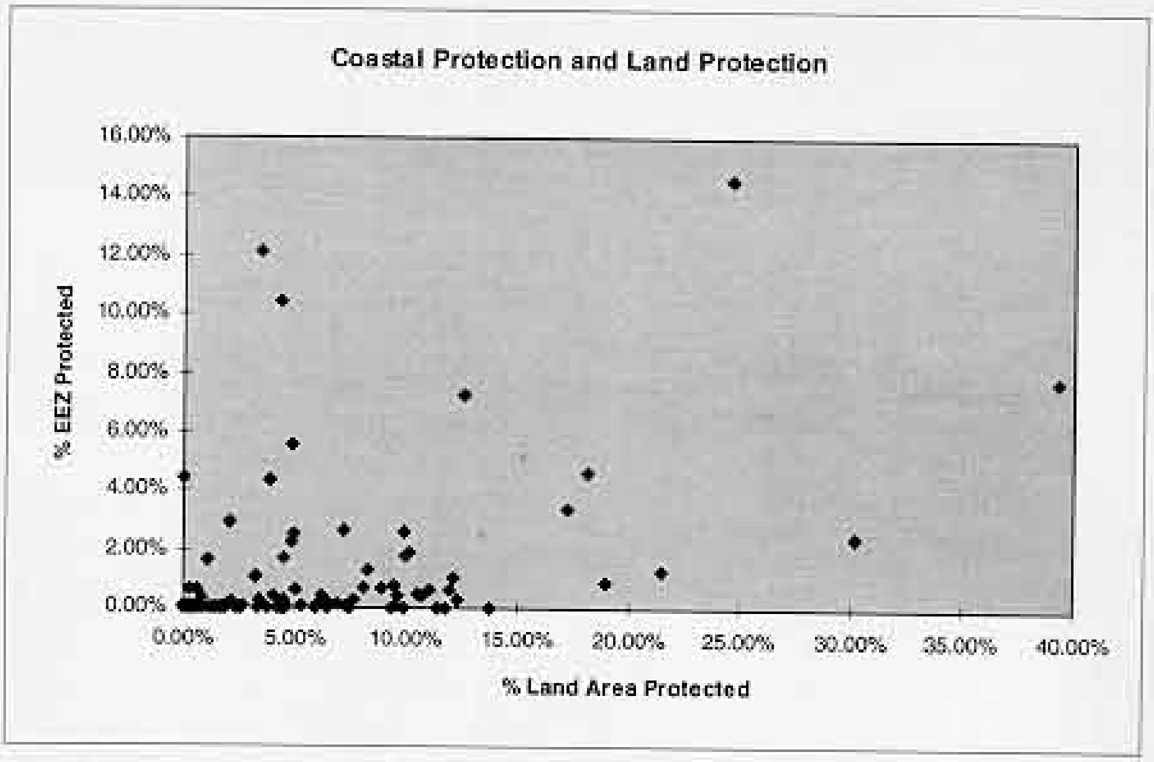


Source: World Resources Database, 1993

At this point, a correlation between coastal protection and almost a dozen social and economic variables had failed to produce a correlation. Perhaps geographical variables were the key. Coastline length was for all of the countries was identified, hypothesizing that countries with less coastline could protect a greater percent of their marine area. However, no correlation between coastline length and coastal protection was found. It should be noted that data on coastline may not be a consistent measure, since the shape of the coastline can increase the length. While coastal border would probably be a better indicator, data was not available. Other geographic variables were tested, such as area of exclusive economic zone, average width of exclusive economic zone, and area of shelf to 200 meter depth. No correlation was found between any of these variables and coastal protection, although these variables did show some correlation to each other.

A new idea came that perhaps coastal and marine protection should somehow be discussed in proportion to land protection in the country. The theory was that some countries just protected natural resources more in general, and would of course have a greater percent of their coastal and marine area protected. The idea was similar to normalizing coastal population in relation to the total population of the country. Data on percent of land area protected was collected from the IUCN (International Union for Conservation of Nature and Natural Resources) and World Resources Institute. The percent of land each country protected was graphed against percent of marine area (exclusive economic zone) protected. Once again, the variables were not correlated (see figure 3.) The level of protection of land for a country does nothing to predict its level of coastal protection. One finding did emerge: no country that protects more than 17% of its land fails to protect any coastal or marine area.

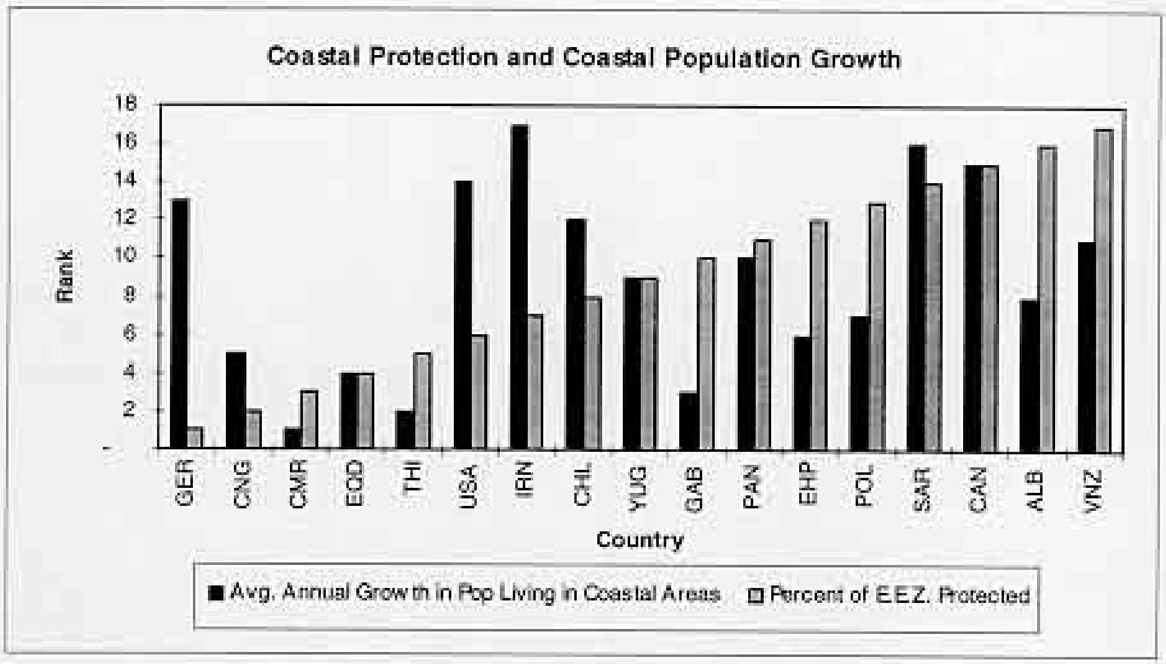
Figure 3. Even the percent of land protected by a country is not correlated with the country's coastal protection. Coastal protection is from 1989, land protection is from 1990.



Source: World Resources Database, 1993

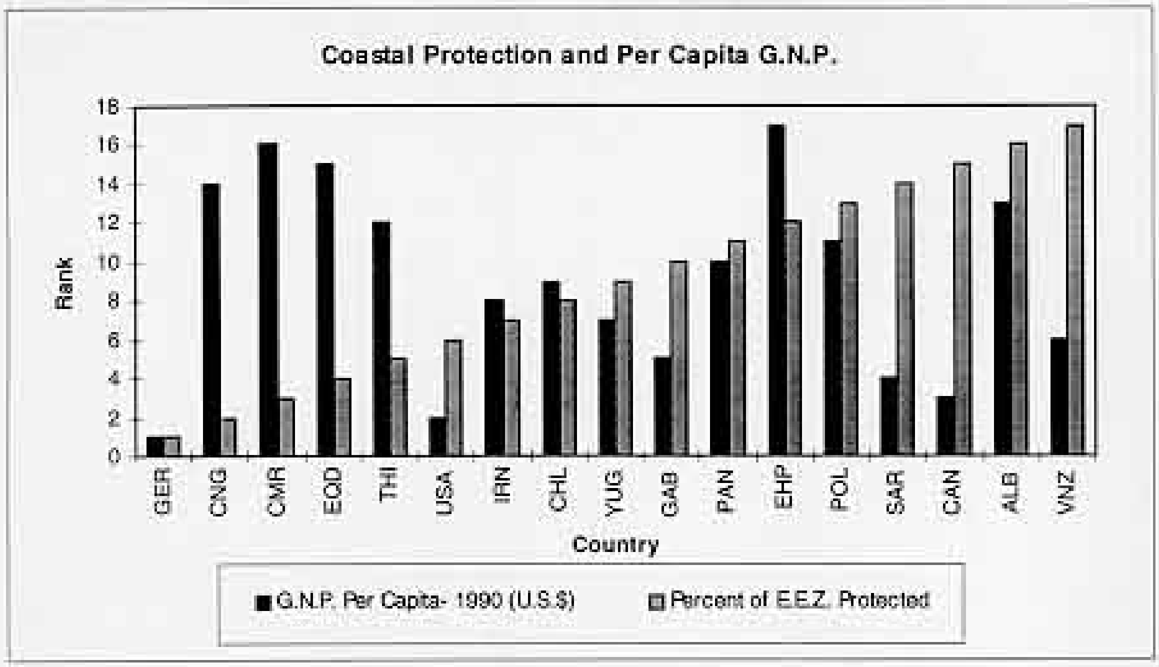
Since no correlation could be found between coastal protection and any of the twenty four social, economic, geographic, and conservationist variables attempted for all of the countries, the next step was to partition the set of countries. Since the world average of coastal and marine area protected is 1.94%, all countries above this average were analyzed as a group. These seventeen countries were (in order of the percent of the exclusive economic zone protected): Germany, Congo, Cameroon, Ecquador, Thailand, United States, Iran, Chile, Yugoslavia, Gabon, Panama, Ethiopia, Poland, Saudia Arabia, Canada, Albania, and Venezuela. A separate database of these countries was created, and they were ranked based on all of the available variables. This ranking would make visible any correlation between any of the variables for the "top" countries, by normalizing and standardizing the various data. However, coastal protection was not correlated to any of the twenty four variables used (see figures 4-6.)

Figure 4. Among the countries above the world average in coastal protection, there is still no correlation between coastal protection and population growth. Numbers 1-17 designate the rank among countries in the peer group for the variable.



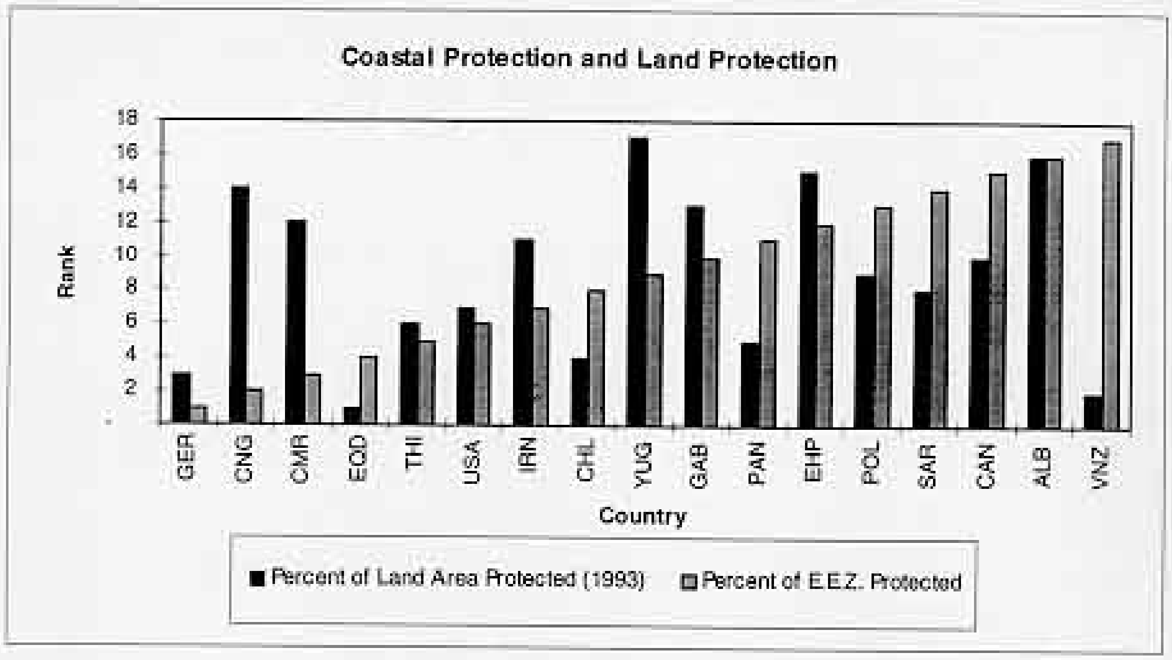
Source: World Resources Database, 1993

Figure 5. Among the countries above the world average in coastal protection, there is still no correlation between coastal protection and Per Capita G.N.P. Number 1-17 designate the rank among countries in the peer group for the variable.



Source: World Resources Database, 1993.

Figure 6. Among the countries above the world average in coastal protection, there is still no correlation between coastal protection and land protection. Numbers 1-17 designate the rank among countries in the peer group for the variable



Source: World Resources Database, 1993

Conclusions

Coastal areas are of significance importance to humans and to developing an understanding of the population-environment dynamic. There is an increasing need to preserve biological diversity, especially in coastal areas. Coastal biodiversity is threatened by resources exploitation, loss of habitat, and pollution. Protected areas can help stop these threats and preserve coastal biodiversity. They are essential in the transition to sustainable use of coastal and marine areas. In addition, protected areas have many economic and social benefits as well. To what degree these benefits are seen may be a function of the coastal and marine protection policies in place in the country. There is great variation in each county's coastal and marine protection. After examining coastal protection compared to over twenty social, economic, and geographic variables, no correlation was present. This leads to several conclusions.

It is possible that the raw data is somehow flawed. It may not have been measured consistently from country to country. Also possible is that using the variable of percent of exclusive economic zone protected is not a good indicator of coastal protection. Or, the key social or economic variable was not collected and tested, but may be out there. Another possibility is that issue defies a standard national-level analysis. The best conclusion to be drawn is that coastal protection is not dependent on or correlated to any single variable. It is most likely a factor of the physical nature of the coast, the economic benefits of protecting the coast (especially tourism), and a lack of other, more consumptive, possible uses for the coastal area. Basically, when a country sees more benefits to protecting a coastal or marine area than leaving it open for exploitation, it will, given the best political climate, protect the coastal area. Ecotourism may be the best hope for driving increasing amounts of coastal protection. The conservation attitude of the country may not even have much of a role, as seen by the lack of correlation between land and coastal protection.

Policy Recommendations

It is clear that the need to protect the world's coastline has not yet been met. Specifically, there is an alarming lack of consistency among the world's nations with regards to their level of coastal and marine protection. The current situation is essentially another tragedy of the commons. Over one hundred countries share the ocean resources. While the exclusive economic zone does a little to privatize the commons, most marine resources, namely fisheries, transcend these political boundaries. There is not enough incentive for a single sovereign to set aside coastal and marine area to protect the world's fisheries. Why should one nation's extractive marine industries limit themselves when the benefit would be shared by dozens of other nations?

The answer is global and regional agreements. Marine protection is second only to atmospheric protection in environmental problems that must be addressed on a multinational scale. Agreements must be made between nations to protect a set percentage of their exclusive economic zone. Scientific decision making should be used to identify critical areas of biodiversity, such as breeding grounds, which would receive priority in the global marine protection process. Countries sharing common oceans and seas would enter regional agreements, with a baseline level of protection mandated by a global accord.

An example of such a problem and process is seen in the protection of the Mediterranean Sea, or lack of such protection. The Mediterranean Sea provides coastline for over twenty nations, including much of Europe, the Middle East, and North Africa. Ecologically it is devastated, with many fisheries dead or dying. Only one country with Mediterranean coastline is above the world average in coastal area protected, and most countries protect nothing. The Mediterranean has seen the tragedy of the commons. Many nations have open access with little reason to limit themselves. The incentives work against individual restraint. However, if all nations agreed to protect critical habitat and coastline, as well as limit destructive marine practices, the health and productivity of the Mediterranean would likely increase. With just five percent of the coastal area protected, many fisheries could recover. The economic incentives to protect coastal areas are clear. Ecotourism, as well as research and educational benefits, would provide local revenue to local communities. A system of "Mediterranean Marine Parks" would attract a global tourism and research base, while providing life support for the sea's fisheries.

An interesting note about such a proposal is one which stands out from many other global environmental proposals in an important regard: this would not be another case of wealthy developed nations trying to impose environmental agreements on less developed nations. As seen by the data, G.N.P. is uncorrelated to coastal protection. In fact, the complete lack of any single defining characteristic among countries with high levels of protection would only increase the chance of success for such a proposal. Less developed countries would not see this as an attempt by wealthy countries to limit economic potential. The proposal would be introduced by a coalition of diverse nations, from every continent and level of development. A global coastal and marine protection conference could outline the need and benefits of coastal protection on a global scale. Countries would then target areas for protection, based on scientific data. Protection would be implemented either within existing agencies or by creating new ones. Countries that fail to comply would face import bans of any marine product.

This generation has an opportunity to implement protection during a critical transitional period. We are at a point in choosing a path of exploitation and destruction or sustainablity and conservation. No where is this choice more clear than on the beautiful coastline that has always drawn human beings. To leave this resource protected would be a major accomplishment of our generation.

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NAFTA & THE HUMAN ELEMENT, A REGION IN TRANSITION

Timothy Macdonald

Population / Environment Dynamics

Introduction

In order for the public health and the environment of Mexico to thrive following the passage of NAFTA, environmental enforcement and infrastructure development in Mexico will have to be a priority for all of the countries in the region. Both the United States and Canada have made it through many of the difficult transitions that accompany the move towards an industrialized country; Mexico, on the other hand, may be in the midst of these transitions. The transitions are created by the dynamic and complex interplay between different sectors of society. Among the most important are the bureaucratic transition, which occurs when a government begins to develop compartmentalized central control, and the power transition, which occurs as women gain economic independence in a society. These two transitions have the ability to control the movement through the demographic transition, which occurs while death rates are decreasing and birth rates are relatively high; the epidemiological transition, which occurs when the cause of death is shifting from infectious diseases to degenerative diseases; and the industrial transition, which occurs as a country moves towards greater urbanization and production. These transitions can have grave impact on a country's health and environment. When countries successfully maneuver through the transition phases, they can reach a state of relatively stable equilibrium, as the United States and Canada have reached in many of the transitions. However, Mexico is presently in the midst of many of these transitions, leaving a delicate balance to be handled by politicians on both sides of the border.

The North American Free Trade Agreement, which went into effect January 1, 1994, will undoubtedly affect Mexico's bureaucracy and its move through the transitions. NAFTA has created the largest free trade zone in the world with 370 million consumers (this is considered to be the largest "free trade zone" because it is created by an agreement between nations, as opposed to the "trade zones" within an individual country, like India or China). Reports already indicate that NAFTA has vigorously expanded trade between Mexico, Canada, and the United States. American exports to Mexico alone are expected to reach a record $50 billion in 1994. This article examines the "human" effects of the free trade agreement and measures the possible impacts of NAFTA on the population-environment dynamics and relevant transitions that are occurring in North America.

Mexico is a country currently mired in many difficult transitions, the foremost of which is that of moving rapidly from a lesser-developed country to an industrialized one. Although Mexico has environmental laws similar in many respects to those of the U.S., the lack of funding has made true enforcement a non-entity. NAFTA has the possibility of changing all aspects of the region in any number of drastically different directions: without adequate support in these times of transition, increased degradation to the environment and human health are inevitable; however, with responsible public and private action, revenue can be generated for environmental enforcement and infrastructure development. However, as we await the developments, Mexico continues its transitional phases. I will examine the interface between the increased bureaucratization of Mexico and its consequences on population, health conditions, industry, and the environment. This will include the demographic and epidemiological transitions with their corresponding effects on particulate emissions (CO_2) and energy production/consumption. A related factor that will play a key role in the transition periods will be the role and status of women in the society. Because NAFTA is going to be THE economic force in the region, these combinations and interconnected transitions make NAFTA the major influence on the direction of the current transitions.

Conditions

Most economists agree that the recently passed North American Free Trade Agreement (NAFTA) will benefit consumers in the long run. The arguments for free trade are relatively straightforward: let the "free market" determine the equilibrium price and quantity, and efficient companies will produce the cheapest/best good they can. This is opposed to trade restrictions, which keep imports limited, drive up prices due to tariffs and taxes, allow inefficient companies not to compete, and prop up prices because quantities are limited while demand is still relatively high. The proponents of NAFTA argued successfully that free trade will allow "market forces" to bring supply and demand into equilibrium, thus benefiting everyone in the long run. The primary opponents of NAFTA argued that Americans would be hurt and thousands of jobs lost due to lower wages and fewer governmental restrictions south of the border. There were also criticisms from the environmental community, who argued that the free trade agreement ignored significant environmental factors and would contribute to the degradation of an already stressed ecosystem. Today, there are few who would dispute the atrocious conditions of the border region, but the methods to change or modify existing conditions are as varied as the countries themselves.

Since the introduction of the maquiladora program in 1965, which allowed foreign-owned companies to import into Mexico, duty-free, raw materials, equipment, and machinery necessary to produce goods for export, over 1800 companies have taken up residence south of the border. This industrial explosion has led to a related population explosion, with many border cities doubling in size in the last 10 years. As Carlos de la Parra notes, "go north" has been the saying for those in Mexico seeking a more prosperous future. In addition, de la Parra explains that the de facto free trade created by the maquiladora program brought about NAFTA-like conditions in the border region. It is for this reason that I believe NAFTA may have a profound effect on the rest of Mexico. Currently, these factories, known as "maquiladoras," employ one-tenth of the country's labor force and have contributed significantly to the recent attempts to reduce the Mexican budget deficit to zero. However, the border region has seen the corresponding effect that industrialization has on air pollution, water pollution, and the general health and welfare of the population.

Reports claim that 46 million liters of raw sewage pour into the Tijuana River each day; 76 million into the New River, and 84 million into the Rio Grande. In addition, only about 16 percent of Mexico's municipal and industrial wastewater is treated before release. This has contributed to an increase in infectious disease rates for those unfortunate enough to be stuck in the border slums. Furthermore, the urbanization explosion has fueled an increase in carbon monoxide, carbon dioxide, sulfur dioxide, inhalable dust, and ozone depletion that has led to respiratory difficulties and lung failures. The lack of hazardous waste treatment facilities has only added to the problems, while the U.S. exports over 20,000 tons of hazardous waste materials per year to Mexico.

A Family of Transitions

Meadows, et al., describe the world as "a set of unfolding dynamic behavior patterns, such as growth, decline, oscillation, overshoot." This is a focus on the 'interconnections' of different sectors of society and how they change over time. Mexico, as a developing country, shows extreme growth in many different parts of society. Many products exhibit exponential growth rates because with increasing amounts of a good, there is a greater ability to produce even more of the good. A good grows exponentially when its increase is proportional to what is already there. However, things merely have the capacity for exponential growth, with adequate human oversight and responsible choices, growth rate can be managed on a sustainable basis. Technological progress, market flexibility, and responsible allocation of resources is the answer to sustainability. Although growth needs to be appreciated in a lesser developed country as a means to bring its people out of abject poverty, this cannot be done at the cost of overall human health. Currently, growth is only superficially solving, if solving at all, the problems faced in the developing world. The final limits to growth will be the limits to inputs, such as energy and raw materials, as well as the limits to outputs, such as the maximum assimilative capability of a river and the necessity of having breathable air and drinkable water.

In times of transition, systems are in tenuous relationship to one another. Problems in one sector can feed off another and lead to a shift in the delicate balance of the natural ecosystem. In Mexico, the population explosion is affecting the wealth of the nation; this, in turn, is affecting the industrial development of the country. In addition, there are serious water quality problems from a plethora of different sources that cause major health problems: the lack of wastewater treatment plants, industrial point sources of pollution, agricultural nonpoint sources, hazardous waste dumping and leaking into ground and surface water all contribute to infectious disease and child mortality. There are also significant air quality problems due to the particulates emitted by the increasing number of factories in Mexico. All of these aspects relate to a phenomenon that Meadows cautions against: that of 'overshoot.' This occurs when the human population extracts resources from the earth and emits pollution to the environment at rates which are technically insupportable; it has the possibility of leading to irreparable harm. Arguably, this is occurring in Mexico today.

North America is a fine example of the phenomena that population and economic explosions are engines of growth for pollution, waste, and resource use. Many aspects of society are driven by increases in population and urbanization. Meadows, et al., describe this as a positive feedback loop, with each growth playing off and feeding the others. The bureaucratic transition, which will play a critical role in Mexico's development, is inextricably tied to the size of the population, the wealth and industrial base of the country, and the health of the people. These factors, in turn, are also all linked to one another in complex patterns of positive and negative feedbacks.

The free trade agreement between Canada, United States, and Mexico can have dramatic effects on Mexico, due initially to the increase in commercial activity between the countries. The environmental side agreement, negotiated by President Clinton to assuage the fears of environmentalists, promised to retain existing environmental standards and provided for trade sanctions and fines up to $20 million for a country who failed to enforce their own environmental laws. In addition, there was a pledge of $8 billion for cleanup along the border, $2 billion from the Clinton administration budget, a $2 billion World Bank loan to Mexico, and $4 billion in North American Development Bank (NADBank) funds, contributed from both Mexico and the U.S. Much of this cleanup has been dedicated to the development of wastewater treatment facilities at many different cities along the border. However, there are many who believe that the border cleanup will cost at least $20 billion and that there is little funding for combating toxic chemicals and toxic dumping. Furthermore, the agencies created by the side agreement, the Border Environmental Commission on Cooperation (BECC) and NADBank, will have to work with the International Boundary Water

Commission to come up with innovative strategies for attacking long-standing border pollution problems. Later, NAFTA may have the effect of increasing the bureaucratic presence in Mexico by increasing the government's responsibility for environmental enforcement and promulgation of technical standards. This could have a residual effect on the rest of the transitions currently facing Mexico.

Bureaucratic Transition

Perhaps the most important transition for the Mexican society as a whole is the bureaucratic transition. Drake calls this transition a period where "[l]ayers of organizational structure and staff are . . . imposed upon the system, which connect more tightly the center to its periphery, thereby permitting greater control by the center." Drake cautions that this is a dangerous transition because the bureaucratic structures can take on a life of their own; this is also a phenomena with which the American people just recently registered their discontent. However, for Mexico, the bureaucracy is just beginning to develop and with the advent of NAFTA, it is likely that the government will be forced to play a greater role in the regulation of industry and the protection of the environment. The bureaucratic transition that I am describing is slightly different than the one described by Drake, it is one of expanding responsibility for government and governmental agencies. It is my contention that countries go through a transition period where government must play a more active role in protecting the environment and the health of the people (occurring often during times of rapid industrialization). A successful move through the first part of the transition occurs when a government is adequately prepared to protect the environment alongside industrial growth, and adequately prepared to protect human health during times of urbanization and population growth. The difficulty occurs in trying to establish a bureaucracy responsive to the problems at hand. It requires technical regulations and safeguards against corruption. Later, the bureaucracy may grow in size, exceed its needs, take on a life of its own, and simply add layers of structure (perhaps this is the later stages of a single transition, a position in which the U.S. may be). Currently, Mexico has just begun to increase the role of government in environmental protection and human health, while at the same time trying to privatize industries. Furthermore, there is a strong push to decentralize the government and give more control to the states, which will serve to broaden the scope of the bureaucracy, but possibly increase its responsiveness to the needs of the people.

It is the bureaucrats that must manage public development projects and who have the power to affect the entire family of transitions: they must oversee sanitation and sewage projects that will affect the epidemiological transition and all aspects of public health; they must oversee public education that will affect and control the demographic transition; they must oversee child immunization and public hospitals; and they must oversee the monumental task of protecting the environment, which will impact the industrial transition and all aspects of the ecosystem. The following charts (FIG. 1 & 2) illustrate the increases in publicly funded health programs by the Mexican government. Although they do not necessarily equate with an increase in the size or responsiveness of the bureaucracy, I believe that they demonstrate the beginning of change; a movement to increased governmental roles, and thus, increased bureaucracy.

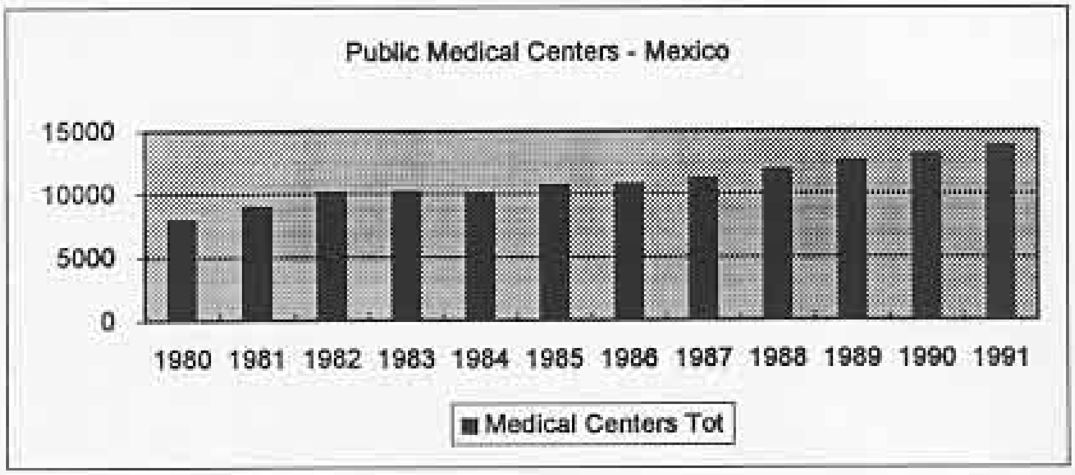

Figure 1

Total Number of Hospitals - Mexico

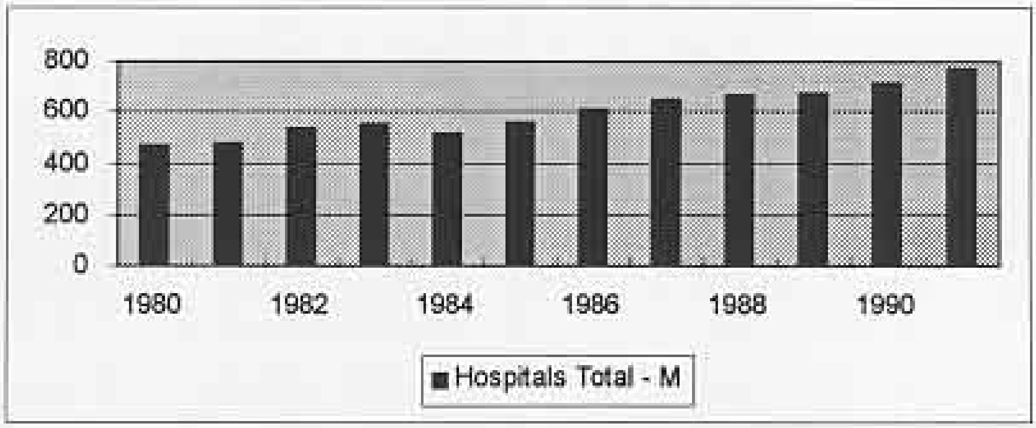

Figure 2

Source: Interinstitucional de Informacion en Salud. Informacion Estadistica, No. 11. Vol. I.

The number of medical centers and public hospitals has almost doubled since 1980. Although this does not guarantee greater healthcare for everyone, it does indicate that Mexico's government is increasing its role in serving its people. It also shows that the power and development of the bureaucracy is increasing. Another indicator for the bureaucratic transition is the number of children immunized through government programs. In order to increase the number of children immunized, the government must increase distribution methods, trained personnel, and scientific technology. Figure 3 shows that over an 11-year period, total immunizations for children (for a collection of different diseases) went from 23 million to 91 million, a dramatic increase that indicates that Mexico is moving in the right direction.

Total Number of Immunizations - Mexico

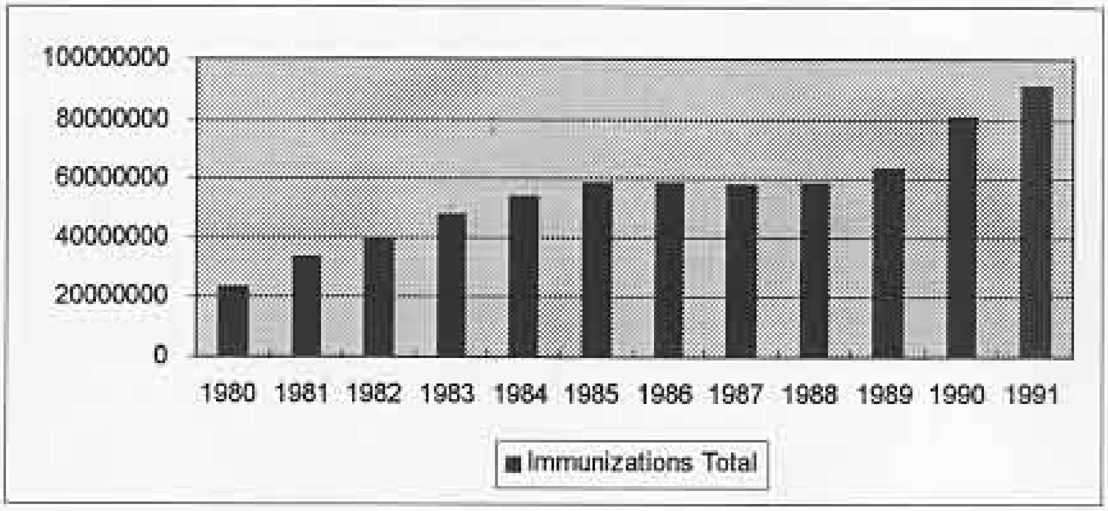

Figure 3

Source: Interinstitucional de Informacion en Salud. Informacion Estadistica, No. 11. Vol. I.

Recently, Mexico's Minister of Health combined measles vaccinations for 22 million children with a megadose of vitamin A and an antiparasitic drug. In addition, 600,000 mothers were trained in oral rehydration therapy and 7 million packages of oral rehydration salts were distributed. A successful move through the bureaucratic transition will need to see a continuation in improvements in public health and environmental protection. It can, however, leave the government in a state of responsible equilibrium, where the bureaucracy answers the concerns of the people, and allow for easier movements through all of the transitions.

One of the keys to environmental protection in Mexico is the development of an efficient governmental protection agency that has both the resources and the person-power to police already existent laws and develop new regulations as the need arises. Carlos de la Parra illustrates the level of spending broken down between the Northern and Southern states, it is apparent that the government is concentrating its expenditures in the more industrialized North even though the population of the North is less than 10 percent of Mexico's total population. However, the majority of industrial growth (and therefore tax revenue) has occurred in the border region. For environmental enforcement, the border region will be the primary focus initially. The government has already begun to dramatically increase expenditures for environmental protection. The following graph (FIG. 4) illustrates the drastic increase in resources devoted to environmental protection in Mexico in the last few years.

Government Expenditures on Environmental Enforcement (Millions $)

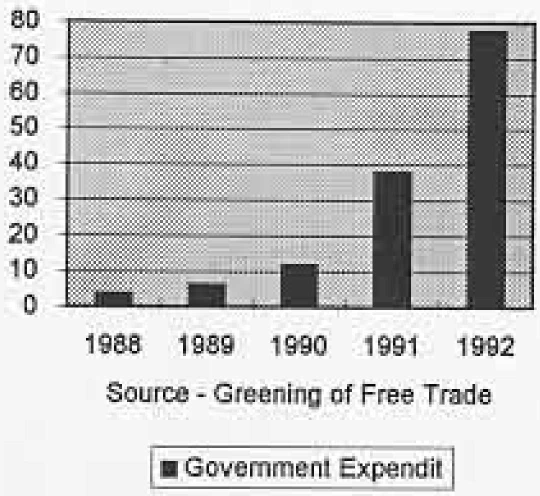

Figure 4

Until recently, the primary responsibility for environmental protection in Mexico lay in the federal environmental agency, the Secretariat of Urban Development and Ecology (SEDUE). In 1992, SEDUE was abolished and replaced with the Secretariat of Social Development (SEDESOL), which is now charged with the coordination of environmental protection between federal, state, and municipal agencies. Although environmental laws are similar to those of the U.S. and Canada, there are both budgetary and organizational constraints that have hampered enforcement. In addition, there are a multitude of other agencies that must cooperate if environmental enforcement and public health are to be taken seriously: the Secretaries of Health, Agriculture, and Water Resources, of Commerce and Industrial Growth, of

Communications and Transportation, of Education, Energy, Mining and Parastate Industries, of Naval and Fishing, of Employment and Social Work, the National commission of Nuclear Safety, as well as the governments of the states and municipios. The "General Law of Ecological Equilibrium and Environmental Protection," passed December 23, 1987, is an enormously comprehensive law that requires implementing regulations similar to those promulgated by the U.S. Environmental Protection Agency. As the move to bureaucratization occurs, Mexico will have to insure that there are safeguards against corruption and methods of oversight to avoid the bog-down of bureaucracy. There are concerns that the lack of regulations, lack of financial support, and overlapping jurisdictions will serve to increase the difficulties of the transition. Mexico's success or failure in maneuvering through the bureaucratic transition will have profound effects on the remaining transitions.

Power Transition

Another key factor that affects the demographic and epidemiological transitions is the welfare of the society, and more specifically the independence and welfare of women. Along with the bureaucratic transition, the welfare of women can act as an indicator for the success of many of the other transitions. This concept can be partially captured by the makeup of the workforce and therefore, I introduce this as the power transition. It is an attempt to measure the amount of self-determination and independence women hold in a society, which in turn will effect other transitions (including infant mortality, birth rates, urbanization, etc.). As women gain independence, both economic and personal, health can be given a priority and women will be able to make decisions regarding reproduction and family health. A more complete method of capturing this idea would be to include the level of education for women in the society, however, I leave this for another study. Historically, as societies begin industrialization, women are kept out of the 'traditional' workforce entirely. As a country develops its industrial base, there may be a realization that economic survival depends on the inclusion of women; even if there is not this realization, a fight by women for equality is likely to take place. However, there are many cultural barriers to the developments of equality in every society, and therefore, the transition takes many different forms. The transition to equality in the workforce could be unique among the transitions in that a stable state of equality may never come to be. However, as women gain economic control over their lives, both the demographic and epidemiological transitions can be brought into a steady, sustainable equilibrium.

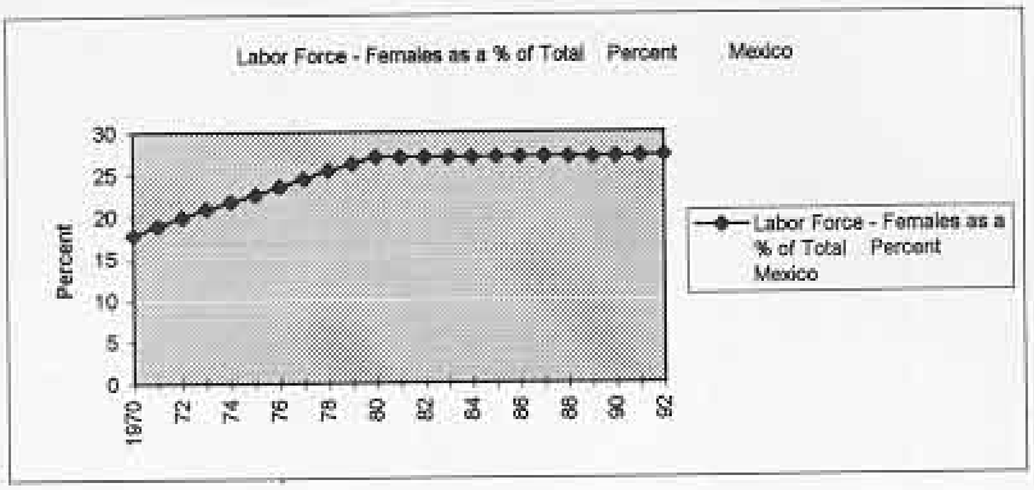

Figure 5

Source: World Resources Database, 1994 (unless otherwise noted, all remaining figures are from WRD)

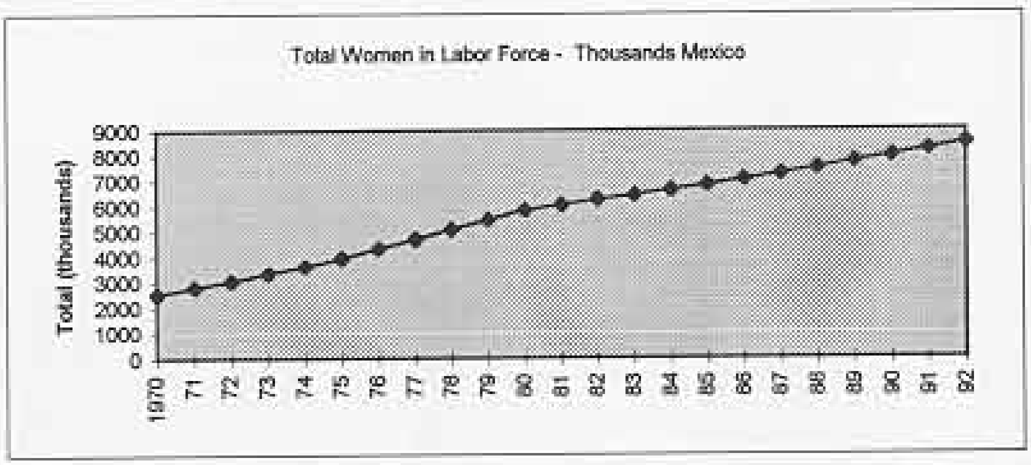

Figure 6

In Mexico, women did not even constitute 18% of the workforce in 1970. However, by 1980, they constituted almost 27% of the labor force. This may offer evidence that they had begun the transition towards a representative workforce, although the last decade has seen almost no change. The labor force itself, in Mexico, has increased rapidly since 1960, due in main part to the increase in industrialization associated with the Maquiladora program (and other programs intended to increase development: sanitation projects, and so forth), and thus, the total number of women in the labor force has risen with the total labor force (FIG. 6). The following chart shows the relationship between the prosperity of a society (measured by per capita GDP) and the independence of women (measured by % women in the workforce). Only one county in the world (the United Arab Emirates) has a per capita GDP over $7,000 and less than 25% of their workforce made up of women. This is easily explained as an outlier due to the Muslim population of the UAE. There appears to be a strong correlation between a higher GDP and a higher percent of women in the workforce, once the developing countries are eliminated from the study (the developing countries have a varying percentage of women in the workforce due to reporting differences, whether agriculture is included, and the state of economies). This makes intuitive sense, that as more people join the workforce in industrial countries, the GDP will rise. However, it is my belief that with this increased independence for women, there will be a move towards greater stability in the demographic and epidemiological transitions. Perhaps, as Mexico pushes over the 30% range, their GDP will continue to rise at an even greater rate, and they will move through the other transitions.

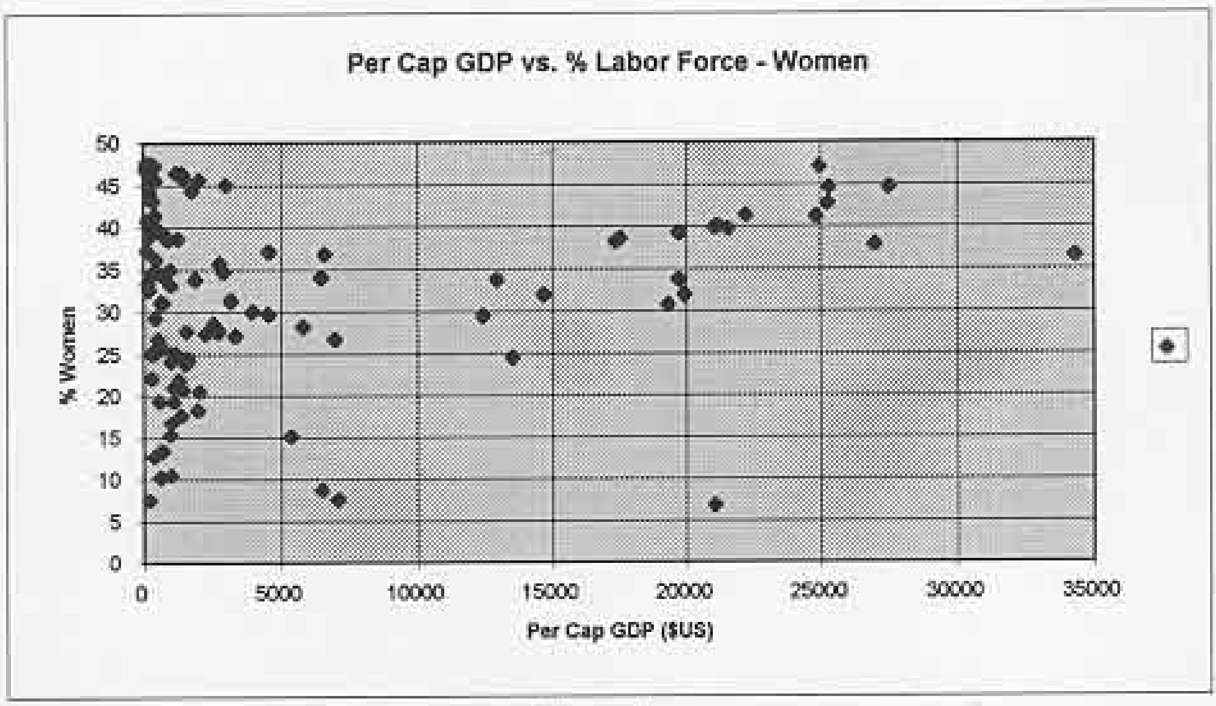

Figure 7

NAFTA's role in this transition is unclear. On one hand, increased development leads to increased demand for labor and ideally, increased representation of women in the workforce. On the other hand, there are substantial cultural differences between Mexico, Canada, and the United States which make this a difficult transition to predict. Ideas of equality cannot be successfully imposed from outside a culture. Each culture must struggle to define its own concept of equality and the role women are to play. Although NAFTA does not guarantee better standards of living for women, or anyone for that matter (in fact, there are those on the periphery - the indigenous and the rural farmer - who believe that the industrialization that comes with NAFTA will be their downfall), there is a hope that with overall economic growth and a responsible bureaucracy, people will be better equipped to face the transitions. Until they are, the vulnerable transition periods will continue to push on their limits.

Population Explosion

The role of the bureaucracy and the position of women will be particularly relevant to controlling the population explosion in Mexico. Mexico's population is currently growing at an alarming rate, and until measures are taken to slow down this population explosion, much of Mexico will continue to suffer. Although the goal of NAFTA is to increase the standard of living for all of North America's people, the increases in GNP and GDP may not keep pace with population growth in Mexico. Mexico has managed to curtail its spiraling population growth rate of the 60's and 70's, which was over 3 percent, but the future remains unclear with a growth rate of over 2 percent (FIG. 9). The growth rate of the 60's and 70's created a 'doubling time' for population of about 23 years. Growth of this magnitude is difficult for almost any economy to keep pace; this may have been one of the motivating factors for the Mexican government to agree to the Maquiladora program of the 1960's. Government officials believed that a jump-start of the economy through rapid industrialization was necessary for its survival, and decided to pursue this option at a cost to overall human health. This type of growth is not sustainable and has adverse impacts on all segments of the population.

Population of Mexico, United States, and Canada

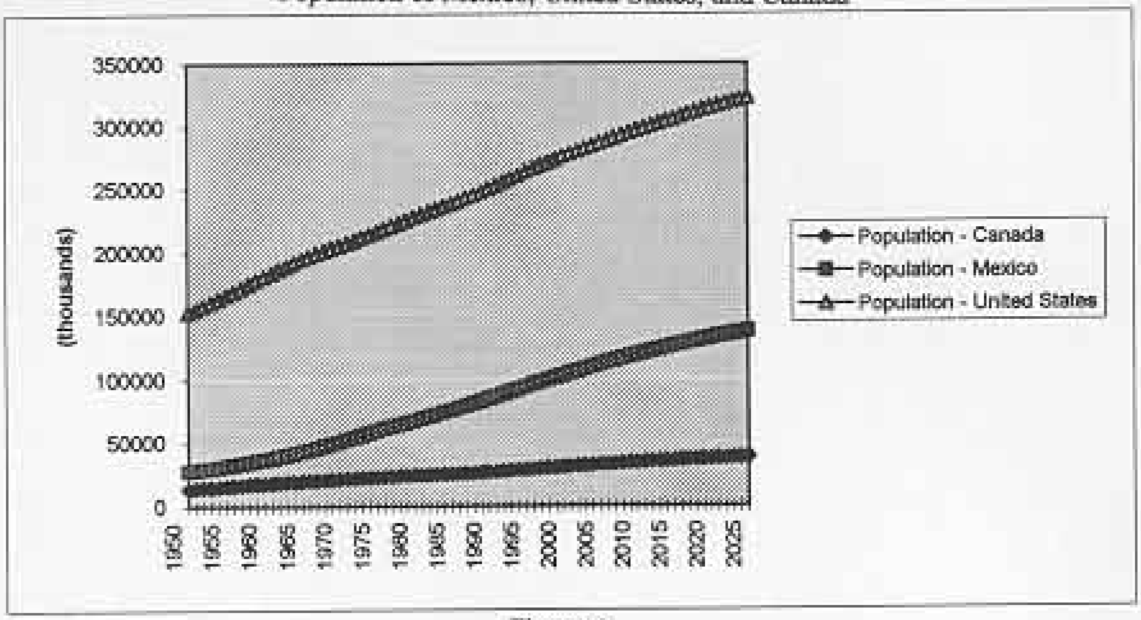

Figure 8

The Maquiladora's produced massive amounts of industrial and hazardous waste and Mexico's undeveloped infrastructure was not prepared to handle these increases. Worse yet, before the onset of the bureaucratic transition and environmental enforcement, the manufacturers were free to behave without restrictions. The delicate balance of the transitions can be upset by such a traumatic change. As Drake explains, transitions interact with one another and "[d]uring that period [of vulnerable transition], rates of change are high, societal adaptive capacity is limited . . . and there is a greater likelihood that key relationships in the dynamic will become severely imbalanced." The maquiladora program certainly had a major impact on the population in the border states. In fact, Carlos de la Parra has documented the economic differences between the border states and the rest of Mexico, and has developed a theory on the forces acting to drive the Mexican population northward.

Population Growth Rates

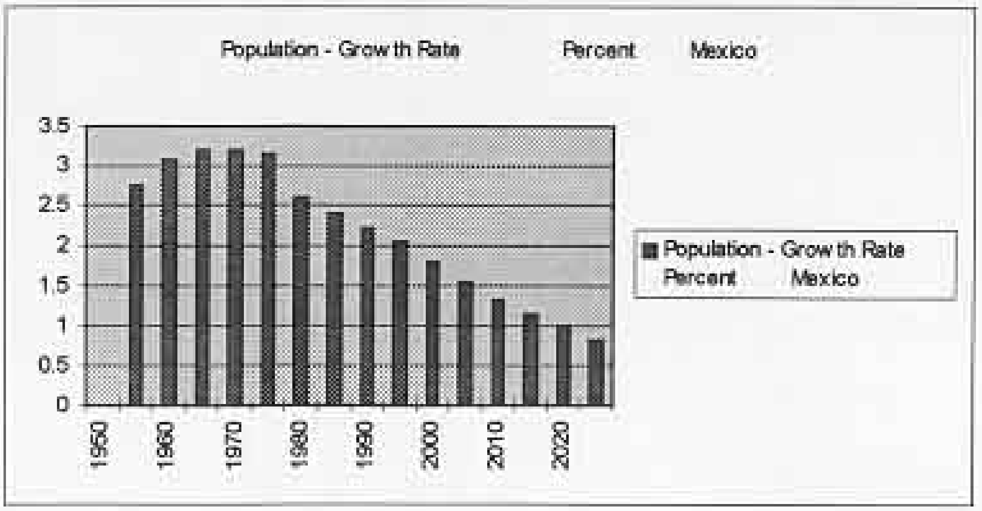

Figure 9

In the last 15 years, the population growth rate has undergone a much-needed decline. However, at over 2 percent, the growth rate still predicts a population doubling within 35 years. This growth exceeds limits inherent in a developing economy and finite resources. The World Resources Database predicts a nearly linear decline in population growth rate, to a fairly sustainable .83% in the year 2025. It is necessary to be very cautious with predictions of population growth rates, especially in light of their complexity and the lack of a clear trend in the past (three values does not insure linear decline).

At the same time, the growth rate in the United States has been relatively constant for the last 25 years. The United States moved through the transition in the first 60 years of this century, arriving at a growth rate around 1%. This creates a doubling time of about 70 years and has allowed an increasing economy to bring up the standard of living for most Americans. Furthermore, with slow rates of population growth, research, education, and technology can all take part in creating a better living environment. When population growth outpaces these factors, the negative feedback loop can be quite devastating; population grows but a limited GNP cannot support research, development, or education, which has a compounding and circular effect. We can expect that when capital grows faster than the population, there will be an increase in the standard of living or material wealth for the population. However, the converse is also true, population growth restricts the ability of capital growth because more outlays are necessary for basic consumption.

Demographic Transition

The complexity inherent in population growth rates is tied to birth and death rates, as well as infant mortality, fertility rates, and standards of living. The demographic transition begins at a period when both birth and death rates are high and in relative equilibrium. With increases in health technology, distribution, and development, the death rate begins to decline, while the birth rate remains relatively high. This creates the transition period and a volatile lag time where population growth rates are at their height. However, a successful journey through the transition sees a concomitant decrease in birth rates, ending in a stable pattern of reduced growth (or possibly even zero-growth).

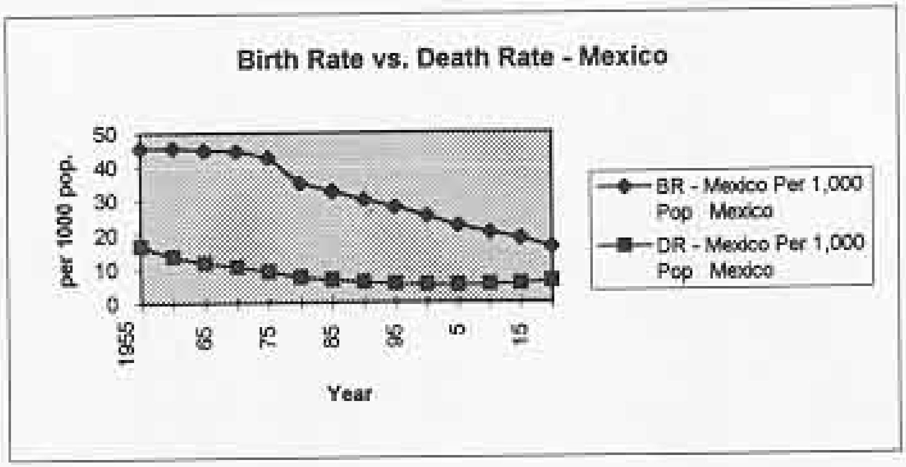

Figure 10

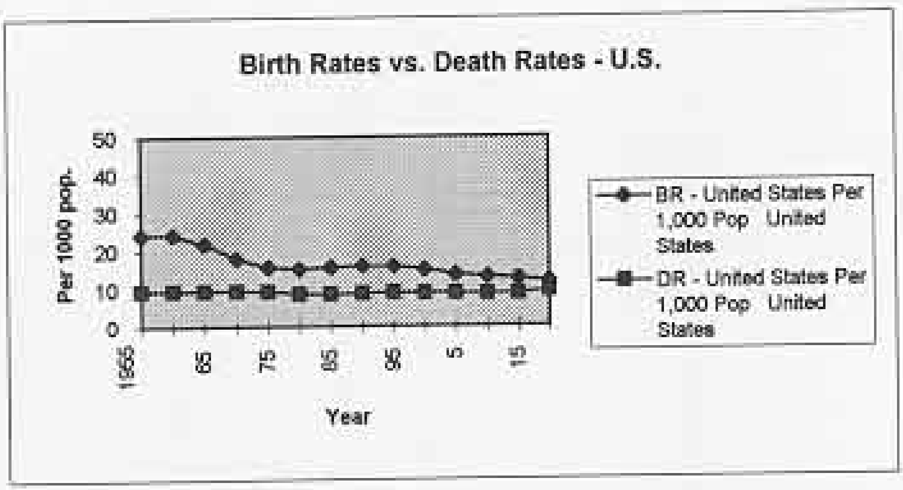

Figure 11

In the United States, both birth and death rates have been steadily declining since the 1950's. These rates have tracked one another and therefore, acted as a limit to growth. However, Mexico is currently moving through the demographic transition, due mainly to the high birth rate that exists. Mexico's death rate is exceedingly low for a lesser-developed country, and in fact, has been lower than that of the United States since 1975 (this interesting phenomenon may be due to reporting difficulties in rural areas). Their death rate has seen steady decline since the 1950's, but the birth rate has only begin to decline since the 1970's. This resulted in the exceedingly high rate of growth in Mexico until 1975 and indicates that they are still in the process of moving through the demographic transition.

Epidemiological Transition

In order to facilitate the demographic transition, it is necessary to focus on the interrelatedness of other factors. The rate at which children survive dominates much of a family's decisions, affecting both the population transition and the epidemiological transition. The epidemiological transition occurs as the cause of death shifts away from infectious diseases and to degenerative diseases. This is due in part to extensions of health care, sanitation, and immunization programs. In addition, limiting birth rates depends upon many factors, the most important of which is the extent which income actually changes the lives of families, particularly women. Education and employment for women are also key factors, along with family planning and reducing infant mortality. The effect that infant mortality can have on population illustrates much of the complexities inherent in development and growth. Until families can be confident that children will live for a relatively long period of time, they will continue to have a large number of children to insure that some survive (high fertility rates). This is the period of transition and it is when the society is in its most volatile and vulnerable state; the lag time between decreasing infant mortality and decreasing fertility and birth rates can create a population explosion. However, in the long run, when infant mortality is reduced, we may expect to see a return to a static equilibrium with corresponding decrease in birth rates and thus, a reduction in population growth.

Mexico has had an exceedingly high fertility rate since the 1950's, with a 20 year period (1950-70) of 7 births per mature woman. The World Resources Database has projected a linear decline in the fertility rate following the drastic reductions in the last 15 years (down to 3.5 children per woman). The decline can be attributed, in part, to an increase in public health programs and a decrease in child mortality.

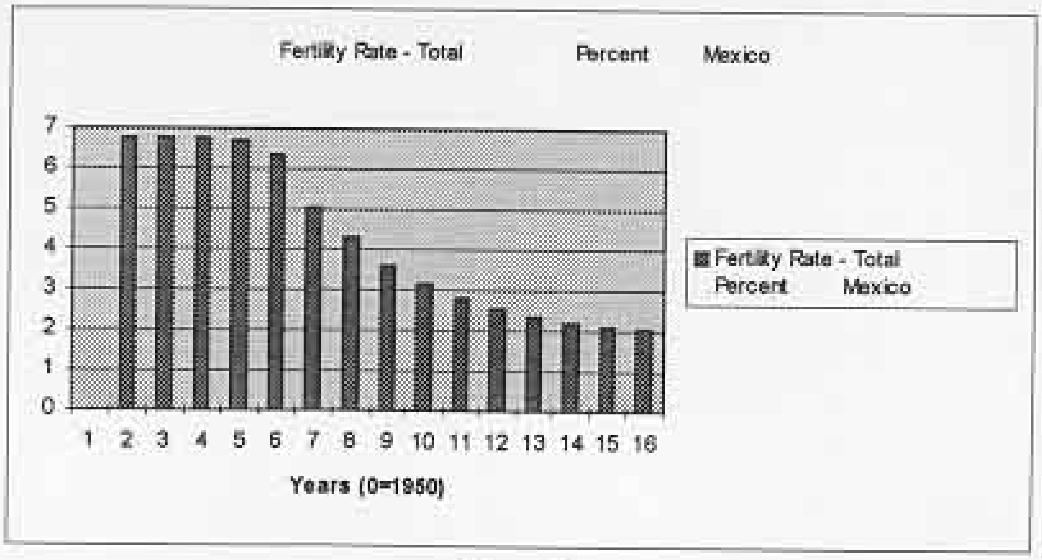

Figure 12

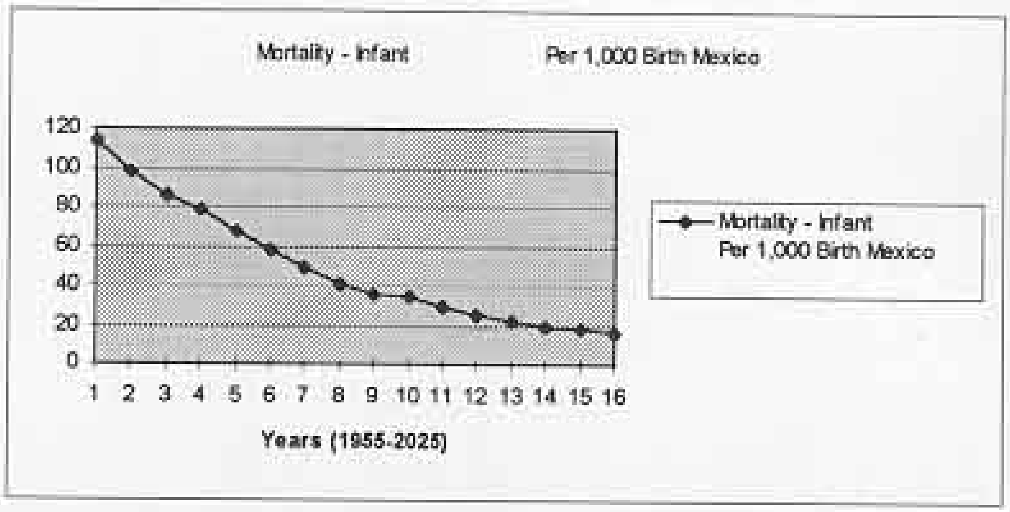

Figure 13

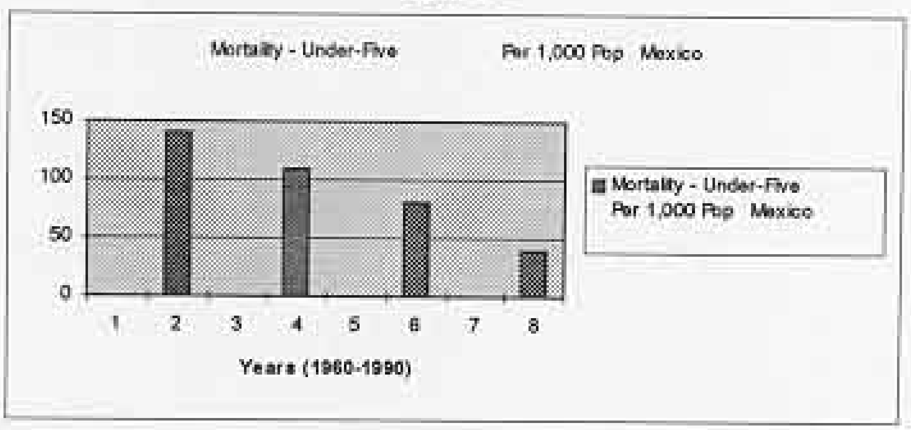

Figure 14

Looking at the total fertility rate (average number of children per mature female) of Mexico and the infant mortality rate, one can see a lag between decreases in infant mortality and decreases in the number of children (FIG. 12 & 13). Even though infant mortality has been rapidly declining since 1955, the fertility rate did not witness a substantial decline until 1975. Infant mortality fell from 120 per 1000 births in 1955 to 80 per 1000 births in 1970, but the total fertility rate remained constant at around 7 children until 1975. However, when people began to perceive these changes, the fertility rate dropped dramatically. When seen in the context of a largely agrarian economy moving to an industrial one, it is logical that families would continue having many children until it was economically inefficient to do so. Furthermore, with a gap in education and lack of information exchange, it takes time for people to see the effects of a decline in infant mortality. The importance of the bureaucratic transition may be most evident here. State-sponsored child immunizations and public health centers directly affect the lives of woman and children, and help the move through the epidemiological transition. However, until there is a focus on rural, as well as urban areas, disparate levels of health will continue.

Industrial / Energy Transition

With the largest free consumer market in the world on its doorstep (now totaling 370 million), Mexico is poised to become one of the developed countries of the world. However, it is still in the midst of the industrial transition. By looking at the Per Capita Gross National Product over the past 20 years (FIG. 15), one can get a good feeling of the instability Mexico has faced and the vulnerability inherent in the transitional phases. Mexico's export industry relies heavily on oil, and following the oil crash of the late 70's, their economy has fluctuated wildly. The Per Capita GNP was greater in 1981 ($3160 U.S.) than it was in 1991 ($3080 U.S.), prompting many to label the period the "lost decade." The fragile Mexican economy has affected all aspects of industry and makes NAFTA particularly important for the industrial transition. Based on difference set out by Carlos de la Parra between the Northern and Southern states, it is logical to assume that NAFTA may bring about even greater change in the Southern states now that companies are free to locate anywhere within Mexico (under the Maquiladora program, they were forced to locate in the border region).

Per Cap. GNP - Mexico

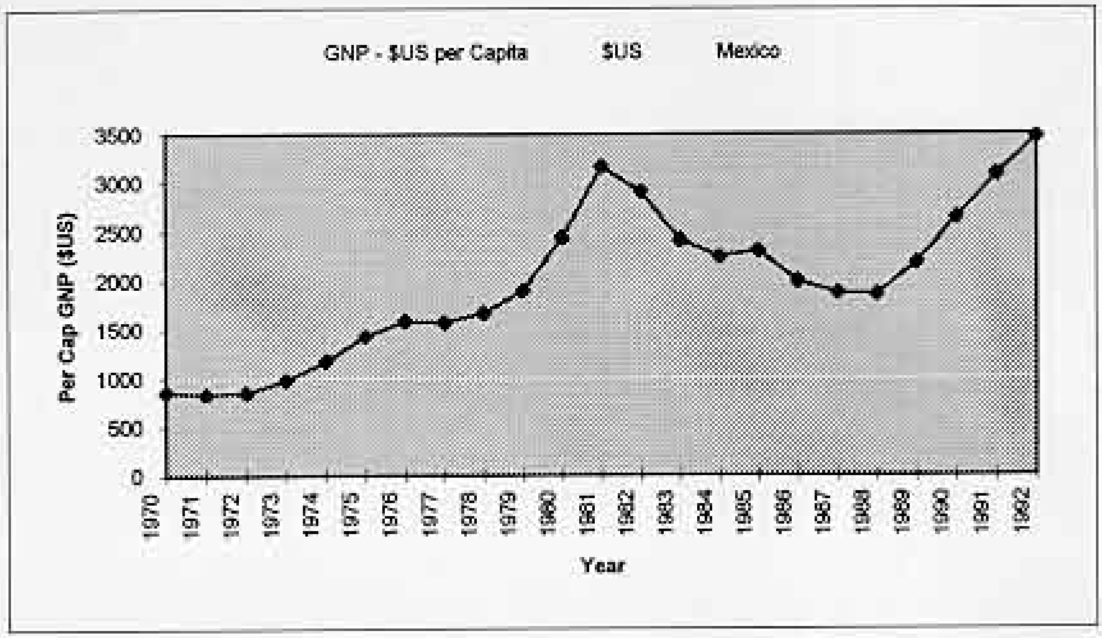

Figure 15

GNP - U.S., Canada, Mexico

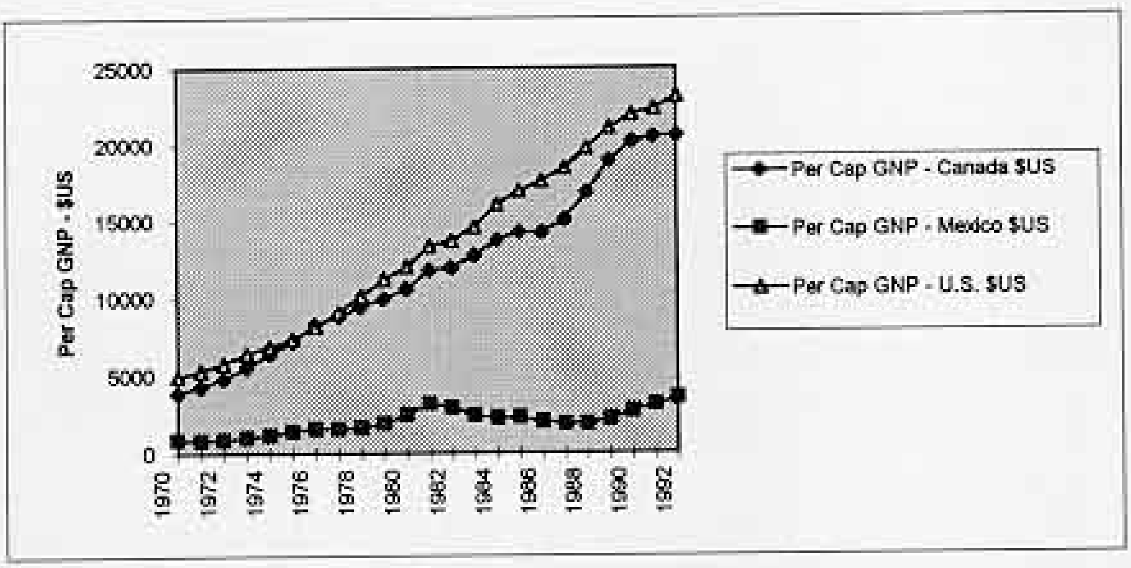

Figure 16

Figure 16 demonstrates the relative sizes of the Mexican, U.S., and Canadian economies. This is important in relation to the possible effects that NAFTA may have on the Mexican economy. The Mexican economy has tremendous room for growth and any growth will surely affect the industrial transition. With increased markets, elimination of trade barriers, and an influx of foreign capital, the industrial sector of Mexico is ripe for explosion. With this type of explosion, increased environmental pressure will be felt unless enforcement and environmental infrastructure are given a top priority. Both Industrial CO_2 emissions and Commercial Energy consumption appear to be tied to the fluctuations in GNP, and thus, if the GNP increases rapidly, a drastic increase in these factors is possible.

Looking at the CO_2 emissions, one might assume that the fear of global warming has caused a stabilization in the use of fossil fuels and other carbon producing fuels (FIG. 17). However, another explanation for the relative stabilization in emissions would be the 1981 collapse in GNP and the following economic crisis. This raises a theory in which CO_2 emissions would increase once GNP had regained its former level. Because of the possibilities of the 'greenhouse' effect, this would not bode well for the world in general. However, from the standpoint of North American free trade, Mexico is far and away the smallest emitter of CO_2 (FIG. 18). Because they do no want to be put at a competitive disadvantage, Mexican industries do not have an incentive to self-restrict CO_2 emissions or develop 'cleaner' alternatives. Furthermore, the United States currently emits over 10 times the CO_2 levels of Mexican industries and 21 percent of the 'greenhouse' gasses worldwide. It is worth noting that 35% of all chlorofluorocarbons (CFCs) in the world are consumed in the United States and Canada, while only one percent is consumed in Mexico. One only needs to view the CO_2 emissions to understand why a developing country like Mexico does not want to limit growth because of CO_2 emissions. Furthermore, the current ability to take action against climate change is in the industrial countries who have contributed the major portion of emissions during their industrialization.

CO_2 Emissions - Mexico

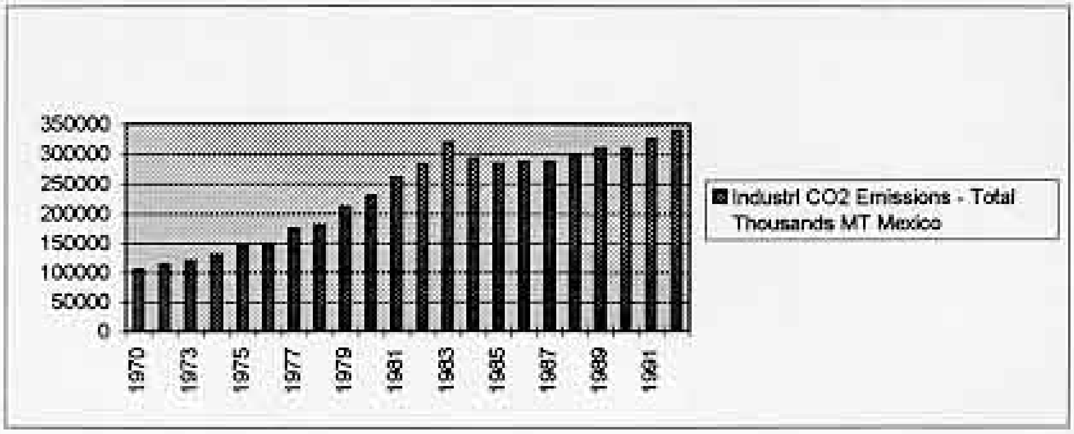

Figure 17

CO_2 Emissions - U.S., Mexico

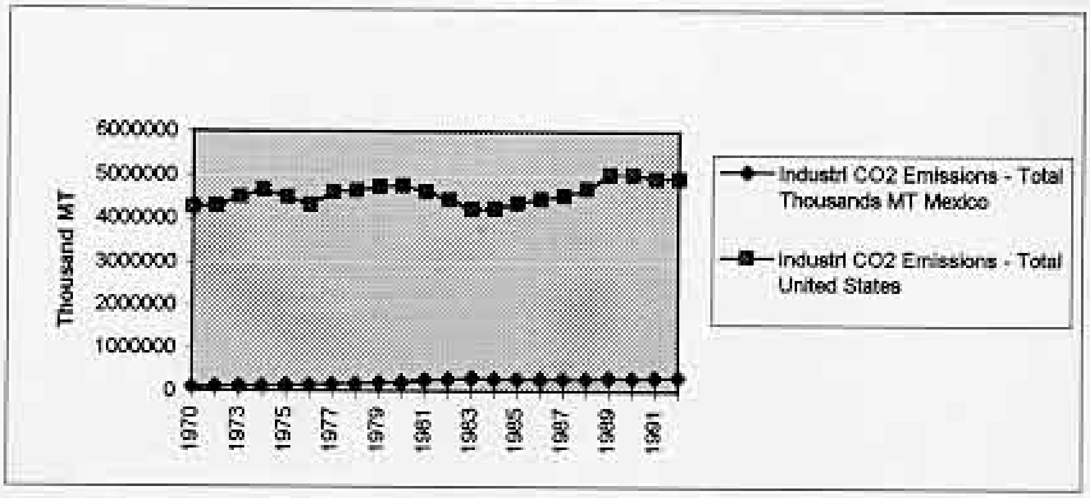

Figure 18

One commentators has explained that, "[p]roductive modernization of rural resources has been part of social policy in Latin America on the premise that high rates of resource exploitation are necessary to modernize and develop the countryside." Furthermore, commercial energy consumption is growing fast in order to meet growing development requirements. What is necessary on a global scale is to promote a rapid transfer of technologies to developing countries to help monitor, limit, or adapt to different means of energy production. NAFTA certainly allows for technological transfer on the market but until transfers are done on a preferential, non-competitive basis, developing economies will be unable to concentrate their resources on research and development. However, Mexico has developed specific programs to combat their move through the energy transition. They have enacted a 'Program for Energy Saving' to reduce energy consumption through demand management; a reforestation policy to prioritize the goal of biodiversity preservation; and, they have given a commitment to scientific and research activities. One major concern is that 80% of Mexico's power generation is based on petroleum consumption, and there is a need to develop alternative energy options.

Per Capita Commercial Energy Consumption

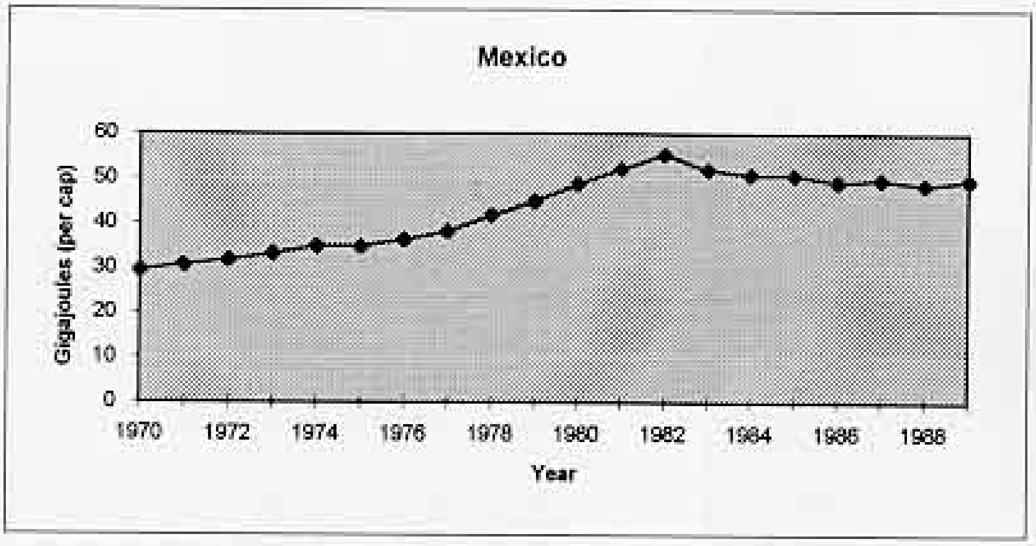

Figure 19

Commercial energy consumption exhibits a pulse that may also be linked to the GNP of Mexico (FIG 19). There were steady increases in commercial energy consumption from 1970 until 1982, since then however, per capita consumption has fallen and total consumption has remained almost constant. This is important only in attempting to predict how commercial energy consumption will behave in the future. If commercial energy consumption follows an exponential growth pattern, the current ten year pause is not indicative of future consumptive use. In fact, fitting an exponential curve with the ten year pause may better predict the future commercial energy consumption (FIG. 20). From 1970 to 1982, the exponential curve slightly overpredicts the actual energy consumption, but the actual level does appear to exhibit exponential growth. This would not bode well for Mexico because it predicts an energy consumption of more than double current levels in the year 2000. With the boost that NAFTA may have on the Mexican economy, the transition could even be more severe than predicted.

Exponential Growth for Energy Consumption

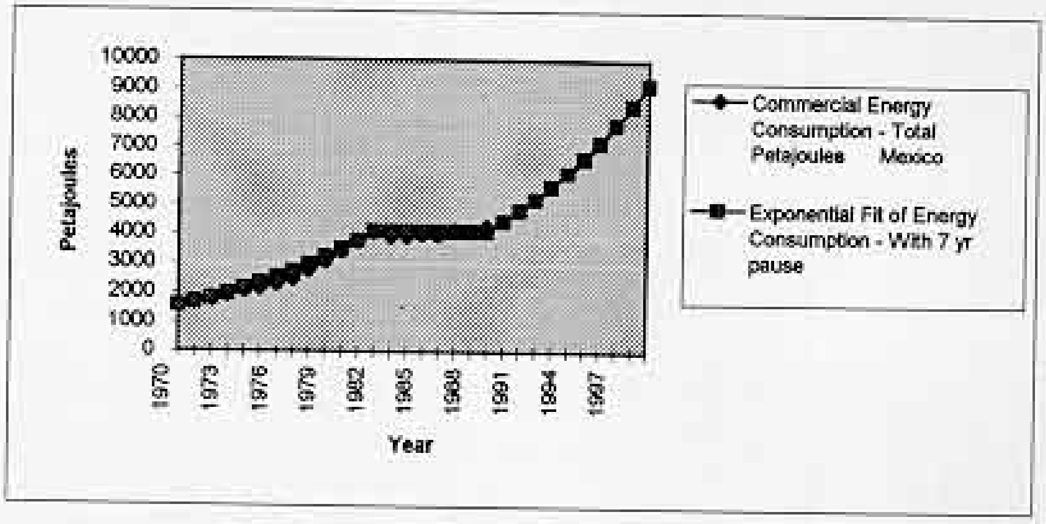

Figure 20

Commercial fuel production is another important aspect of the industrial transition. The commercial fuel production shows a stabilization around 1982, experiencing the same effects as fuel consumption and again tied to the collapse in GNP (FIG 21). Fitting a logistic curve to this data might show that the limits to fuel production have been reached and that production will stabilize at 9 million terajoules. This could also help explain why the consumption of energy has remained constant since the early 1980's. However, this curve does not show a good fit to the data and may indicate that there were other factors to the stabilization. Assuming a logistic curve would be a narrow view on the circumstances and ignore other significant variables affecting fuel production, including declining world fuel prices and a plummeting Mexican GNP. A better explanation would be similar to the one given for the consumption charts. Again, this could mean that with the economic surge of NAFTA, commercial fuel production will take off once GNP regains its strength.

Commercial Fuel Production

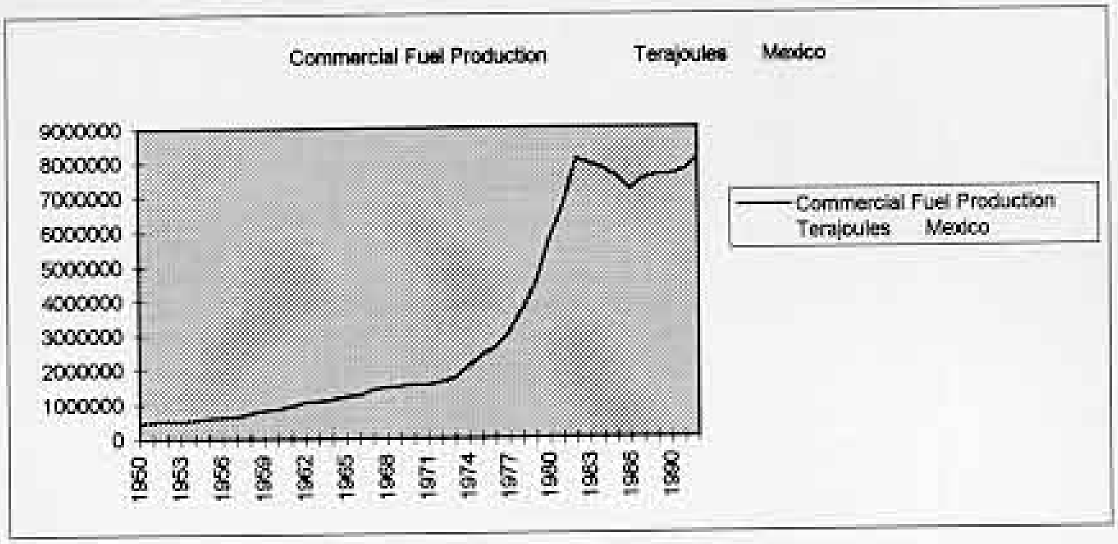

Figure 21

Logistic Curve for Fuel Production

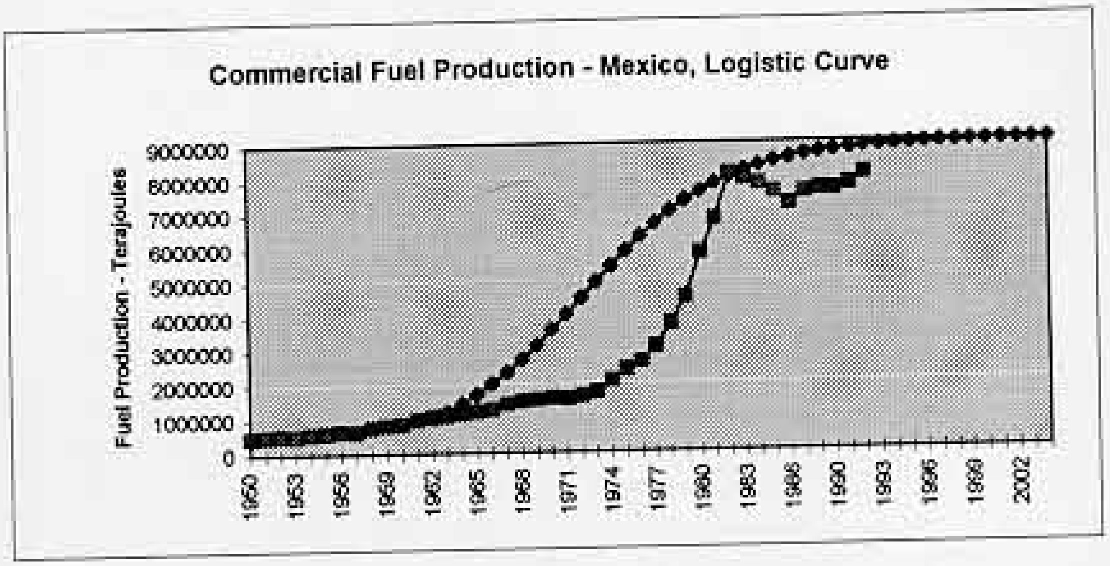

Figure 22

Policy Implications

Although there is no guaranteed protection of resources through NAFTA, there is a hope that with increased economic growth, Mexico can devote more resources to environmental protection and development. The development of stringent environmental standards and effective methods of policing these standards will be a necessity for the responsible bureaucratic structures, namely SEDESOL. There are incentives to protect environmental quality and public health through economic stability and shared scientific technology, but there must be actual implementation to affect Mexico's move through the transitions. In addition, there is a joint effort between Mexican and U.S. environmental agencies for the protection of the border region through agreements, International Boundary Waters Commission (IBWC) negotiations, and wastewater treatment facilities. An innovative solution would be to use U.S. law to sanction polluters on both sides of the border. Section 310(a) of the Clean Water Act (CWA) gives U.S. courts jurisdiction (through the EPA) to award damages to non-U.S. nations injured due to pollution originating in the U.S. This would have to be done in conjunction with a Mexican agreement to award damages to U.S. citizens injured due to pollution originating in Mexico (a "reciprocity finding"). This type of cooperation could be incredibly effective at pollution abatement, especially if private citizen suits, under 505(a) of CWA, are encouraged and protected in both country's jurisdictions. However, it is worth noting that no claims have been brought under section 310(a) due to obstacles in bringing a lawsuit against a non-U.S. nation (Mexico) in U.S. courts (namely the Foreign Sovereign Immunities Act which grants immunity to other nations in many cases).

Another option for better enforcement of environmental standards in the border region is to give the IBWC and the Boundary Environmental Commission on Cooperation (BECC) enforcement powers (in the same vein as the U.N., International Court of Justice, or the recently passed World Trade Organization has the ability to sanction). Developing theories in international law indicate that countries have a right to a 'reasonable and equitable share' of transboundary resources and that the best administrator of these is a neutral body. The IBWC and BECC require greater authority to enforce and promulgate regulations to preserve and prevent pollution of transboundary resources. Currently, the IBWC has no authority to enforce standards under Mexican or U.S. jurisdiction and is relegated to environmental infrastructure development. The joint Integrated Environmental Plan directly addresses pollution in the border region and dictates that the EPA and SEDESOL work together to protect natural resources. This plan could be extended to create unified standards and give enforcement authority to the IBWC and the BECC. Some problems with such a plan are which country's technical standards to apply and whether either county would agree to cede authority to a relatively independent body. The state of the border region on both sides make this idea a reasonable possibility.

Mexican environmental infrastructure development has played a leading role in recent attempts at protecting both health and the environment. This approach must continue, particularly in the border region, if the economic increases of NAFTA are to be managed. The Mexican government has 52 sewage treatment facility construction projects planned and will need all the capital they can get for development and enforcement. NAFTA holds great promise for the prospects of the future, but also many concerns for the present.

Conclusion

The Mexican society is obviously in the process of moving through many of the typical transitions that are faced by developing countries. Because NAFTA will have such a major impact on the Mexican economy, it is sure to be a major influence on the transitions. Particular importance will placed on the success or failure with the movement through the bureaucratic transition and the power transition, both of which can have far reaching implications for all of the other transitions. In order for Mexico to be most successful in moving through the transitions, the bureaucracy will have to be designed in such a way that it is responsive to the people. Perhaps if greater control is given to the states to implement specific programs, the bureaucracy can be an effective promoter of human and environmental health.

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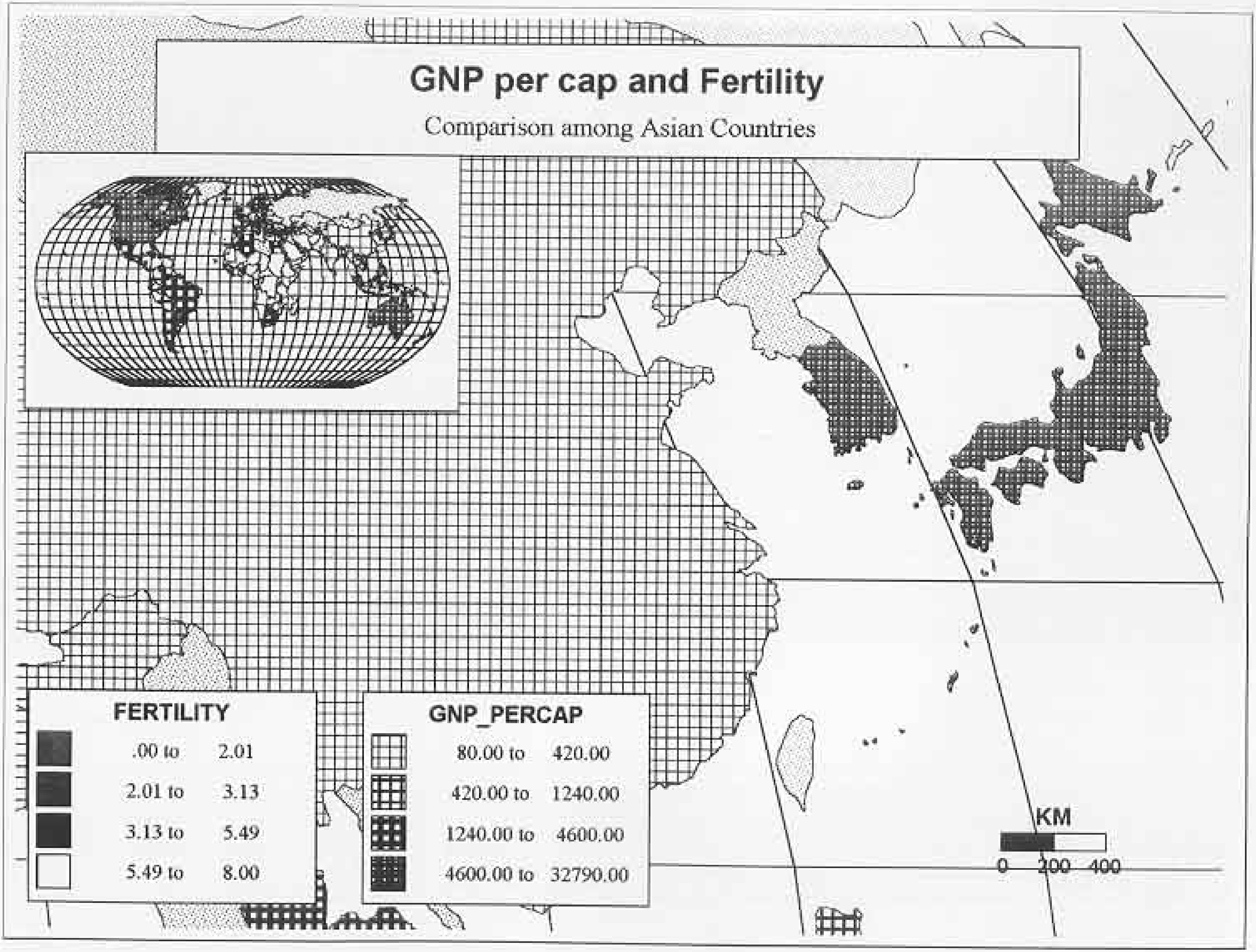
DEMOGRAPHIC TRANSITION AND ECONOMIC GROWTH IN KOREA: COMPARISONS BETWEEN ASIAN COUNTRIES

Soonae Park


GNP per cap and Fertility
Comparison among Asian Countries
FERTILITY
.00 to 2.01
2.01 to 3.13
3.13 to 5.49
5.49 to 8.00
GNP_PERCAP
80.00 to 420.00
420.00 to 1240.00
1240.00 to 4600.00
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I. Introduction

Demographic phenomena, such as the long term changes in births and deaths, are closely related to economic development. This relationship, however, is by no means uniform in different periods in history and in different countries. During the past three decades, the economic dynamism of Asia has been a focus of world attention. Annual growth rates of Asia's GNP have been higher than in any other part of the world. Commensurate with this rapid growth, the region's international trade has grown, and by the early 1980s the volume of U.S.- Asian trade had surpassed trade between U.S. and Europe (WRD, 1994). This dynamism exists chiefly in the free market economies of Asia. Three major factors have contributed to 1) demographic diversity and the different stages of industrial development of Asian countries, 2) the common cultural background of Asia, and 3) the geographical proximity of these countries with one another (Cho and Fujioka, 1985).

Asian countries have also experienced two kinds of major change: a demographic transition and an industrial transition. The former is characterized by the transition from high to low birth rates and from high to low death rates. The latter can be defined as the transition from an economy in which the agricultural sector predominates in gross domestic product (GDP) to one in which the share of industry, manufacturing, and services is predominant. Interaction between Asian countries in different stages of demographic transition and different stages of industrial development, generates an economic dynamism by facilitating the transfer of capital and technology from countries that are at a more economically advanced stage (e.g., Japan) to those that are less economically advanced (e.g., China).

Among Asian countries, Korea provides a good illustration. With an initial population growth rate at three percent, the economy has grown at an annual rate of nine percent during the last three decades. During the same period, fertility has declined greatly. Also, the rate of economic growth is high and demographic transition is fast. This level of sustained economic growth and this pace of demographic transition are in sharp contrast to the recent historical performance of the European countries.

This paper will offer an interpretation of the structural changes in Korea's economy, within the broader context of Asian economic and demographic trends as outlined above, and with consideration of behavior factors not traditionally incorporated in this kind of analysis such as educational level, particularly for women, and cultural norms and values. It will then provide some cross-country comparisons with Japan and other East Asian countries, which share a similar cultural and geographic background, but an dissimilar with respect to initial demographic conditions and phase of economic development. Finally, I will suggest several policy implications that stem from this analysis of the Asian economic community.

II. Distinction of Demographic and Economic Transitions in Asian Countries

The relation between demographic and economic changes has long been studied by demographers and economists. The most prominent characteristic of the classical theory of demographic transition is the argument that the demographic transition of Western Europe, and in particular the changes in fertility, are dependent on the level of economic development. In other words, the decrease in fertility is a by-product resulting from economic growth. However the idea of demographic transition brought about primarily through economic development and in particular the drop in fertility is now losing support. The quickest way to reduce fertility is by implementing policies for improving health and education, supported by family planning programs rather than pure economic indices (Caldwell, 1982). Also it has been criticized because it largely ignores the role of cultural differences in hastening fertility decline (Coale, 1973). Considering the relationship between population and development, discussed above, two-way interaction between demographic and industrial transition is more acceptable idea than the notion of a uni-directional influence of socio-economic development on demographic behavior (Asian Population and Development Association, 1989).

In Asia, demographic transition has been associated with the attainment of full employment rising wages, the quick spread of mechanization, the growth of family income and savings, and substantial structural changes (Oshima, 1987). According to Oshima, as per capita income increases, aggregate demand for industrial products rises. Then urban employment opportunities open up, and soon full employment is reached. The progress in mechanization leads to an increase in the demand for more skilled and educated labor. This calls for an increase in secondary education. Thus, this sequence leads to a more rapid fertility decline and subsequent completion of the demographic transition.

As the labor force moves from agriculture to industry, there is a parallel shift from rural to urban society, with all the attendant implications of social, cultural, and political life. In addition, the shift away from agriculture reduces the number of peasants and landless workers, who have the largest family size and the lowest incomes. In addition, each major sector of the economy shifts from proprietary to corporate enterprises, from smaller farms to larger farms and firms, and from less skilled to more skilled occupations. All of this tend to reduce the desired family size.

III. Research Methodologies

There is no general theory on socio-economic phenomena that applies universally to all periods of history and all countries. However Drake's transition theory aims at universality (Drake 1993). He describes the complex dynamics of demographic and environmental relationship in a family structure discussed next.

1. Transition Analysis

Transition theory has been developed for studying population-environmental dynamics. William Drake in his "Toward Building a Theory of Population-Environmental Dynamics: a Family of Transition" provides a summary of transition theory. Drake defines transition as "a time-dependent sector's passage that involves the environment and population and the sectoral shift from slow to rapid change within a specific time span, as well as the sector eventually reaching a relative stability." Because Drake proposes sector transition as part of the family of population-environmental dynamics, some general characteristics of sector transitions are very important for transition analysis.

Five common attributes of transitions are proposed by Drake. The first common attribute of all transitions is the similarity of their trajectories. All sector transitions begin their transitions in relative stability, then move from small change to rapid change within a specific time span, and finally reach to a comparative balance. Because this similarity exists in many sectors, special mathematical functions may apply to these transitions.

The second one is the applicability of transitions across scales. Transitions not only occur in many sectors in a society, but also at many different geographic scales, both temporal, and spatial. Moreover, because the national- or regional -level transitions are almost always the consequence of local transition , sector transitions interact with each other -not only inter-sectoral but intra-sectoral.

The third common attribute of transitions is the timing of transitions. The time span may be one of the most important dimensions of a transition because it also determines the duration of the interactions among sector transitions. The public policy thus may apply as a tool to facilitate the trend of transition during socially vulnerable times.

The fourth common attribute of transitions is societal vulnerability. Transitions frequently affect all parts of society in a similar way. During the critical periods, the rate of change is high; consequently, the society is especially vulnerable to damage. The short time for a society to adjust and the limited feedback mechanisms for a society to re-adjust are two reasons that societal vulnerability occurs. In addition, the sector relationships become imbalanced.

The fifth is the societal opportunities. Although transitions have their special setting and pattern for different geographic scales, the transition period can be better managed by transferring some examples which have already been experienced by other countries or local areas. In this respect, comparison across different geographic scales provides a meaningful role for societal opportunities during transitions. This common attribute of transferring transition experiences among different geographic scales also makes transition analysis powerful in terms of policy implementation.

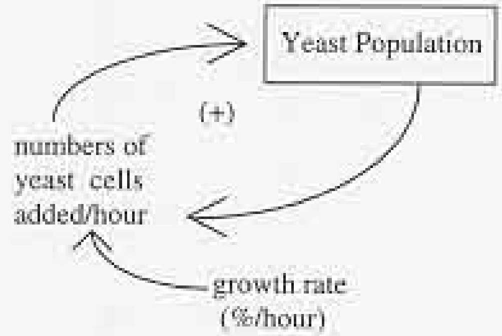
As a result, the application of policy implications might be the most significant role for transition theories. Human intervention in terms of public policy might be a key factor that instructs the direction and rate of transition.

2. System Analysis

Meadow explained that exponential growth happens for one or two reasons: because a growing entity reproduces itself out of itself, or because a growing entity is driven by something that reproduces itself out of itself.

Meadows illustrate the system structure of self-reproducing population with a diagram as shown **figure 1**. The box around the yeast population indicates a stock that accumulation of yeast resulted from past multiplications. The (+)sign in the middle of the loop means that the two arrows together make up a positive feedback loop. A positive feedback loop is a chain of cause and effect relationship that closes on itself so that a change in any one element in the loop will change the original element even more in the same direction (Meadows, 1992)

Figure 1



Like population, capital has the system structure (a positive feedback loop) to produce the behavior called exponential growth. But capital has also other feedback loops influencing it, and other possible behaviors. Everyone knows that economies do not always grow. But they have a strong tendency to grow, and most of them do grow, whenever possible.

Meadows (1992) treats the world as a closed system. A system, according this book, is stated as:

> .....An interconnected set of elements that is coherently organized around some purpose. A system is more than the sum of its parts. It can exhibit dynamic, adaptive, goal-seeking, self-preserving, and evolutionary behavior.

We may use a system concept and see environment and economic activity as a system. The interconnections may be dynamic or static versions. Inflows, outflows, stocks, feedback loop, equilibrium are main terminology of system analysis.

In system analysis, the mathematical constructions are of central importance. They are employed as a tool that defines all the interconnections and elements of a system. In addition to the system of linear equations that construct the relationship between the economic activities and population growth, a regression model can also be employed for forecasting purposes.

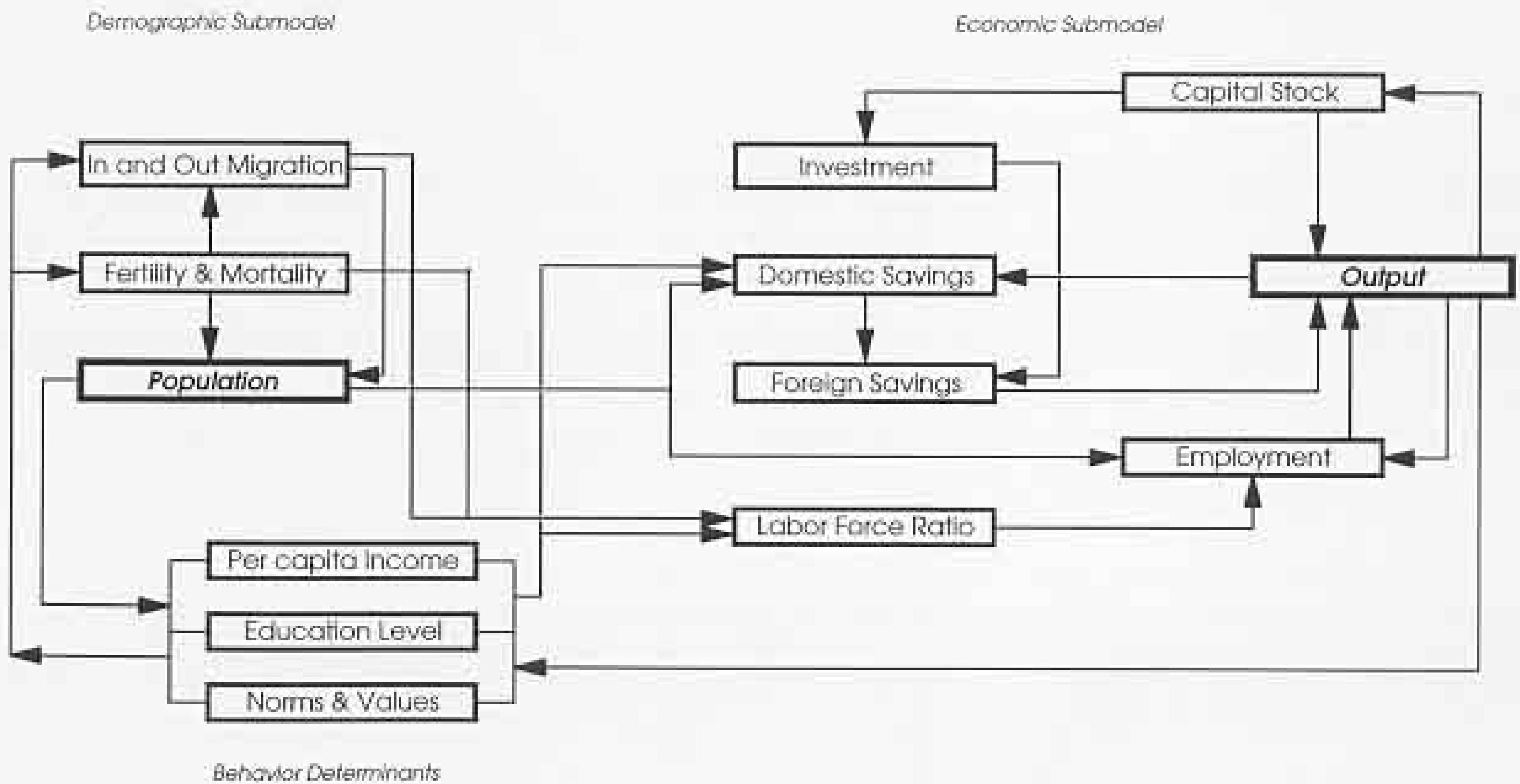
3. Evaluation and Choices of Methodologies

From the above description, similarities may be found when we use transition analysis and systems analysis to do research for a specified social system. The first is the system view of defined social system. Two methodologies emphasize all the elements that involve behavior changes of the system. In other words, to understand a sector transition it is impossible to exclude related sectoral behavior that must be considered as inside the whole system. Thus, as proposed by Drake, the complex dynamic system of environment-population relationships needs to be treated as a family of transitions. The second is the interactions among elements in a system. Those interactions not only process inflows but have some properties such as a feedback mechanism among some elements. Moreover the interconnections are dynamic. As a consequence, the whole system is constructed under the concept of dynamic frame.

4. A Conceptual Model

The model comprises three blocs: the economic submodel, the demographic submodel and behavioral determinants set. **Figure 2** provides the overall framework of the model.

Figure 2. A Conceptual Model



The economic submodel determines sectoral and total output using the usual production factors such as capital stock and labor employment in the output market. The economy undergoes structural changes in the course of economic growth which will be captured in the labor and capital market. The demographic submodel provide a sex and age specific-population, and thus demographic variables such as child dependency ratio and working age population. The demographic-behavior determinant set provides a link between growth rates of population and economic factors. All three submodels are also affected by public policy.

IV. Demographic Transition and Economic Growth in Korea

In this part I will discuss the relationship between demographic phenomena and economic growth which has been noted in developing countries, that is, rapid population growth prior to their modern economic growth.

1. Historical Overview

1) Korea

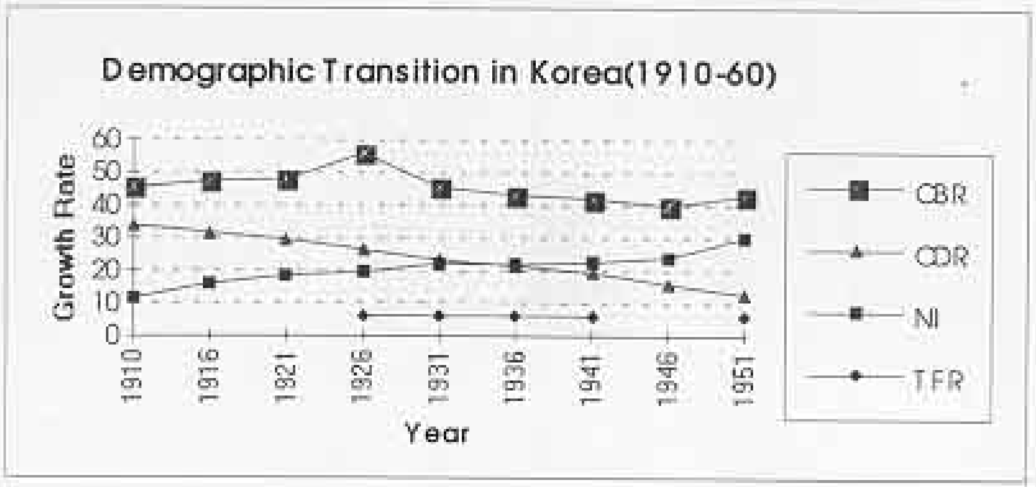
In order to identify the period of recent economic growth and the initial demographic condition, Korea' colonial period must be examined. For the colonial period from 1910 to 1945, no systematic national income data is available. Industrial output is estimated to have grown at three percent and per capita industrial output around 1.5 percent per annum (Kim and Roemer, 1979). Demographic indicators during the period are shown in **Table 1**. The crude birth rate(CBR) remained as high as 45, with some increases, while the crude death rate(CDR) gradually declined. This decline in the CDR occurred during a period when the country was open and had access to some technology and public health care. The total fertility rate(TFR), however, showed no changes.

Table 1. Trends in Major Demographic Indicators in Korea, 1910-1960

YEAR	CBR	CDR	NI	TFR
1910-1915	45.3	33.7	11.6	
1916-1920	47.5	31.6	15.9	
1921-1925	48.0	29.5	18.5	
1926-1930	55.9	26.4	19.5	6.2
1931-1935	45.5	23.3	22.2	6.1
1936-1940	43.3	21.4	21.9	6.2
1941-1945	42.1	19.5	22.6	6.1
1946-1950	39.9	15.8	24.1	
1951-1960	43.0	12.8	30.1	6.2

Source: The data for CBR, CDR, and NI are from Cho(1973), and for TFR from Kwon at al.(1975)

Figure 3



After Korea was liberated from colonial rule at the end of World War II, more calamities awaited. The withdrawal of Japanese, who had played dominant roles as entrepreneurs, managers and technicians, plus the division between the North and South led to a paralyzed and disorganized economy. The Korean War, however, which lasted three years, was the most severe disaster (Kim and Roemer, 1979). These two raging waves were accompanied by great reshuffling of the Korean population. Approximately 2.6 million people moved from abroad and from North Korea into South Korea between 1945 and 1949(Repetto et al., 1981). This equaled about 10 percent of South Korea's population. Most of the immigrants settled in urban areas. Population resettlement also occurred during the war.

After the war ended, Korea launched a post-war recovery program with the help of foreign aid. The latter half of the 1950s may be considered as a period of recovery from the war. Entering the 1960s, more precisely from 1963, Korea maintained sustained economic growth, as is shown in **Figure 4.** The rate of economic growth was, on average, approximately nine percent per annum for the next three decades. This made the size of the economy thirteen times larger. As for demography, the fertility rate began to decline from its traditionally high level. It reached a very low level(below replacement) during the same period, as shown in **Figure 5.**

Therefore, two conclusions may be drawn about the initial demographic conditions (1910-1960). First, demographic transition had already begun during this period with an accelerated population growth. Second, the resource endowment and capital were very limited relative to population size. These conditions indicate that the rate of labor absorption should have been sufficiently high for the economy to begin modern economic growth.

Figure 4 (Data from WRD)

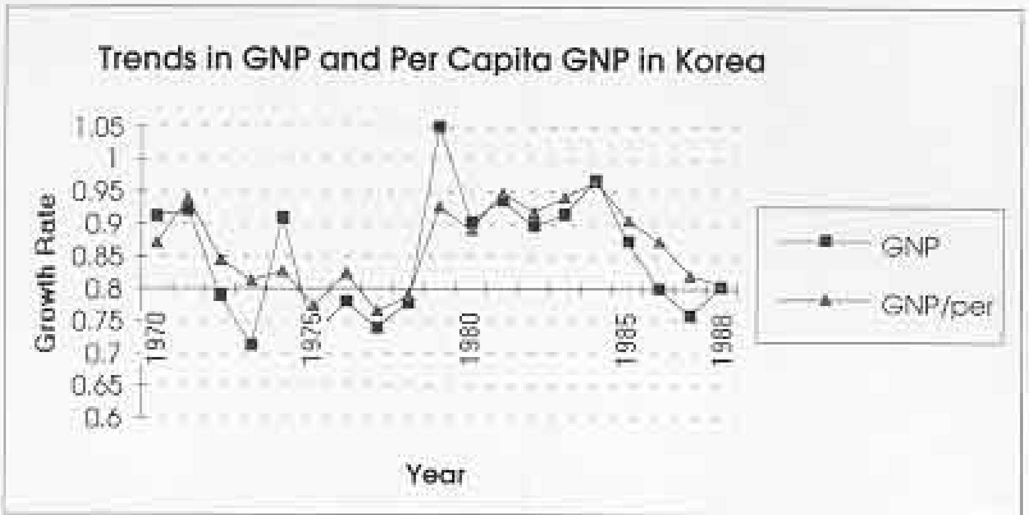
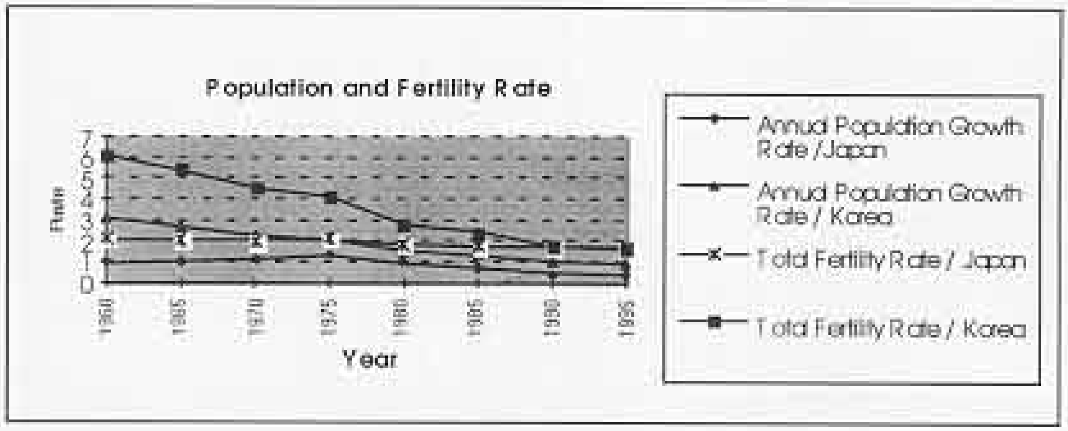


Figure 5 Population Growth Comparison between Korea and Japan (Data from WRD)



2) Comparison with Japan

The difference in the initial demographic conditions between Korea and Japan must be examined to pave the way for the following comparison(see Figure 5 and Table 2). Modern economic growth in Japan starts in the middle of the 1880s after a transitional period of some 20 years from the Meiji revitalization, beginning in 1868 (Minami, 1986). The Japanese economy had grown at an average of 3.15 percent for the pre-war period of 1889-1938, and 8.81 for the post-war period of 1955-76 (Minami, 1986). The spread of modern technology and economic growth occurred at the same time. At the takeoff stage of economic development, population was growing at 0.6 to 0.9 percent per annum, which is much lower than that of such developing countries as Korea. Throughout the whole period, the annual rate of population growth remained, on average at one percent, the population density was 100 persons per sq. km and the dependency ratio was estimated at 60 to 63 (Ohbuchi, 1980).

Table 2. Some Demographic Indicators at the takeoff Stage in Korea and Japan

	Population	Population Density	Dependency ratio
	growth rate	ths psns/sq km	ratio
Korea	2.8	274.6	82.6
Japan	0.6-0.9	100	60-63

Source: The data for Japan are from Ohbuchi(1980), Korea from Kim and Roemer(1979)

This comparison shows that the two countries contrast sharply in demographic conditions at the initial phase of modern economic growth. Korea entered modern economic growth with ongoing demographic transition, i.e., an accelerated population growth, while Japan did not. The disparity in initial demographic conditions may have caused some differences in the patterns of economic growth between the two countries.

2. Modern Demographic and Economic Transition

1) Fertility Rates and Population Growth

The drastic fall in population growth is primarily accounted for by the equivalent change in fertility rates. In the early 1960s, at the onset of modern economic growth, total fertility rate was at three percent due to an early decline in mortality rates. During the modern economic growth period, TFR has fallen from 6.02 to 1.62, having passed through the replacement level in the mean time. A steady decline in mortality was also witnessed. Female life expectancy at birth has risen from 53.7 to 75.3 during the same period. Reflecting these conspicuous changes in vital rates, the growth rate and age structure of population were greatly altered. The dependency ratio, temporally increasing at an earlier period, also has shown a steady decline. The phases of demographic transition in Korea may be seen in **Figure 6**. Between the 1920s and the 1950s, there was a gradual decline in mortality, but no significant change in fertility from a traditionally high level. This period is equivalent to the early expansion stage in demographic transition. With the beginning of modern economic growth in 1960s, a decline in fertility as well as in mortality is observed. Therefore, the period from the 1960s to the mid-1980s is equivalent to the late expansion stage. Since the mid-1980s Korea has shown a sustained, drastic fall in the fertility rate, and a further decline in mortality rates. Thus, it took only 60 years from the beginning of a mortality decline in the colonial period to reach the phase at which the fertility rate reached its lowest level. Here again Korea showed a much quicker demographic transition compared to the European industrialized countries of the past.

Figure 6 Demographic Transition in Korea (Data from WRD)

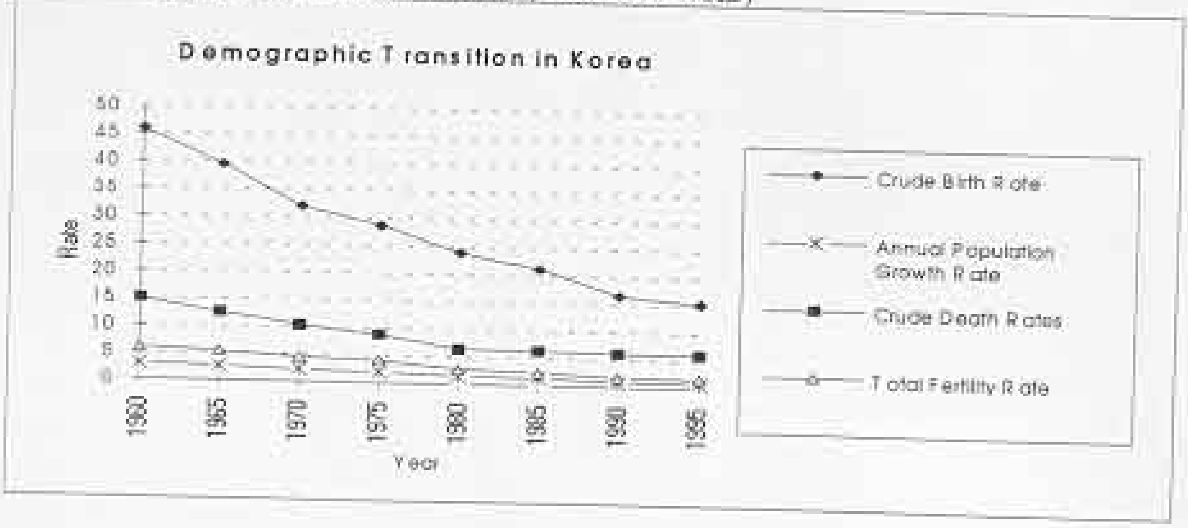
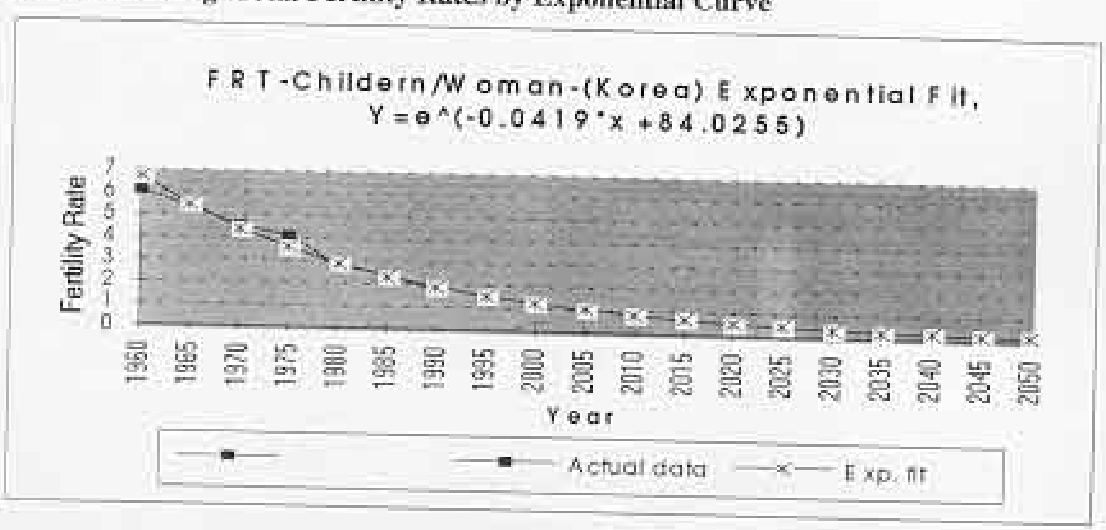


Figure 7 Forecasting Total Fertility Rates by Exponential Curve



2)Interaction between Demographic and Economic Transition

The first response to high population growth was to increase non-primary employment enough to obtain labor surplus, for further economic growth. The Korean labor market in the early 1960s may be characterized as that of a typical labor surplus economy. Over 60% of the economically active population were living in farm areas, and approximately 65% of the employed population were engaged in the primary industries of agriculture and fishery. (see Figure 10)

Figure 8 Total Population and Economically Active Population Growth Rates in Korea

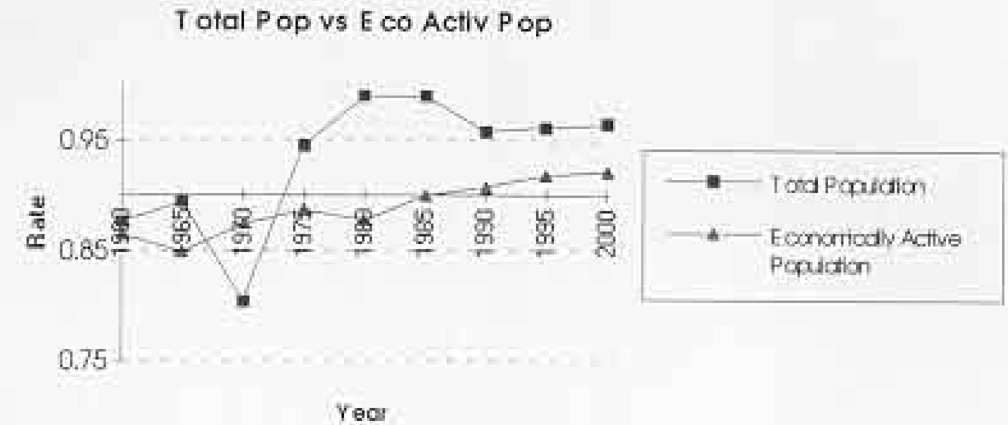


Figure 9 Distribution of GDP in Asian Countries (1965-1990)

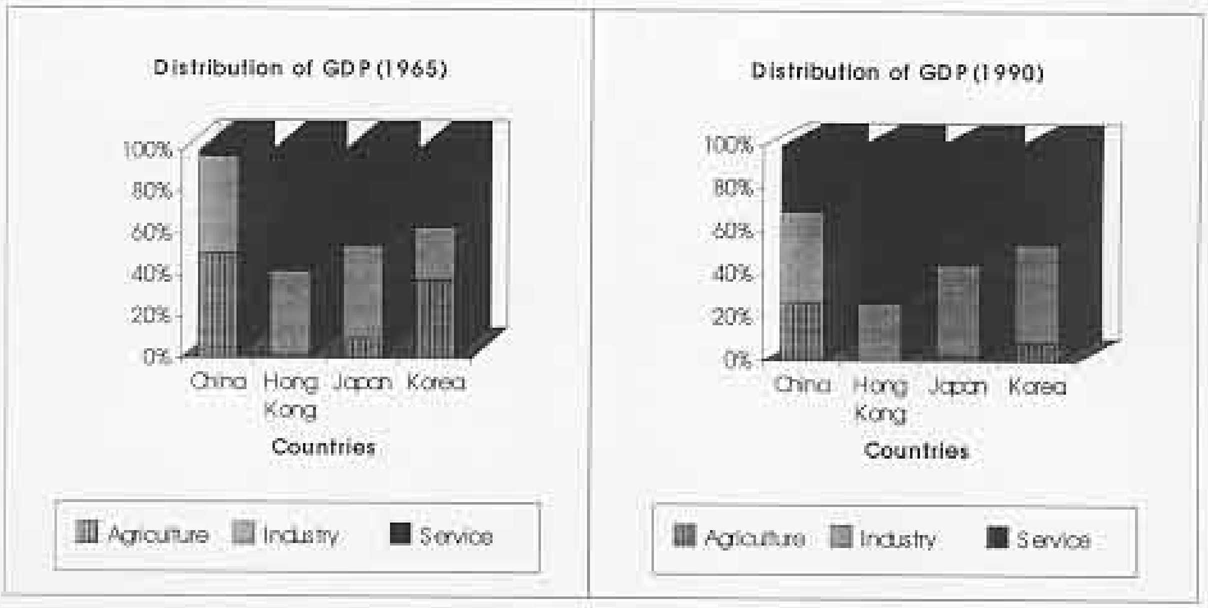
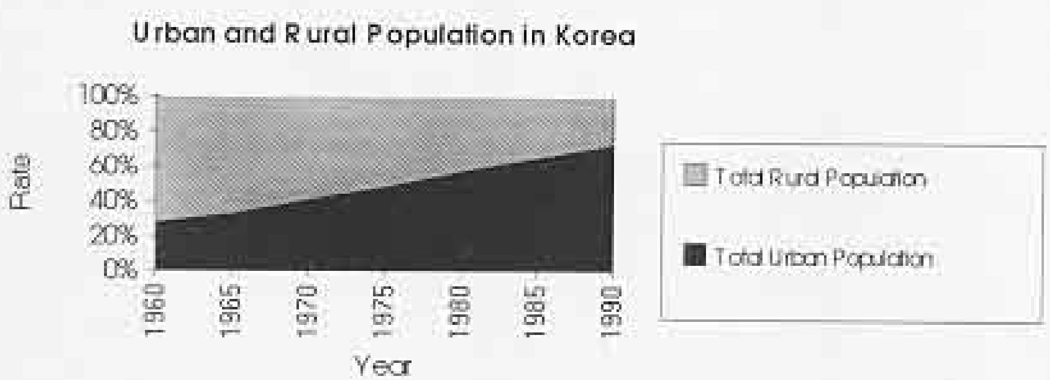


Figure 10 Urban Population Growth (1960-1990)



Under these circumstances, heavy emphasis was given to labor absorption from the non-primary sector. Since the rate of population growth was very high, the rate of labor absorption by the non-primary sector had to be very high. The rapid increase in non-primary employment resulted in a significant change in the structure of employment (Bai: 1982, Kim: 1987). With respect to demographic factors, the .rapid changes have provided favorable circumstances for high economic growth in the labor market, as the cohorts born during the high birth period of the 1950s and 1960s reach working age, the supply of young labor will continue at a high rate, and rapid decline in fertility has led to a steady decline in dependency rates. This will help push the saving rate upward.

Another response to high population growth was the structural changes in Korea's economy. As seen in Figure 9, Korea has experienced rapid industrial transition from an economy in which the agricultural sector predominates in GDP to one which the share of industry, manufacturing, and services is predominant during 30 years. Mechanized agriculture also contributed to these rapid changes.

3) Educational Attainments

The Quality of the labor force needs to be examined, since human capital is considered to be one of the most important factors of economic development. Due to traditional high aspiration for education, Korea has had a relatively high educational level compared to countries at a similar income level(Amsden, 1989).

Figure 11 Enrollment Rates in Secondary School and Higher Education In Asia

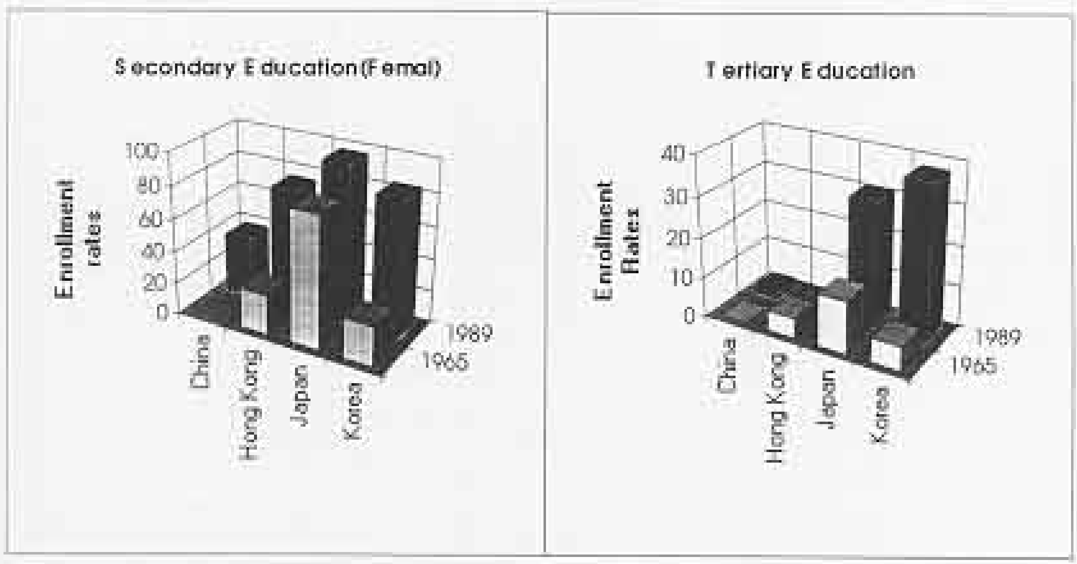
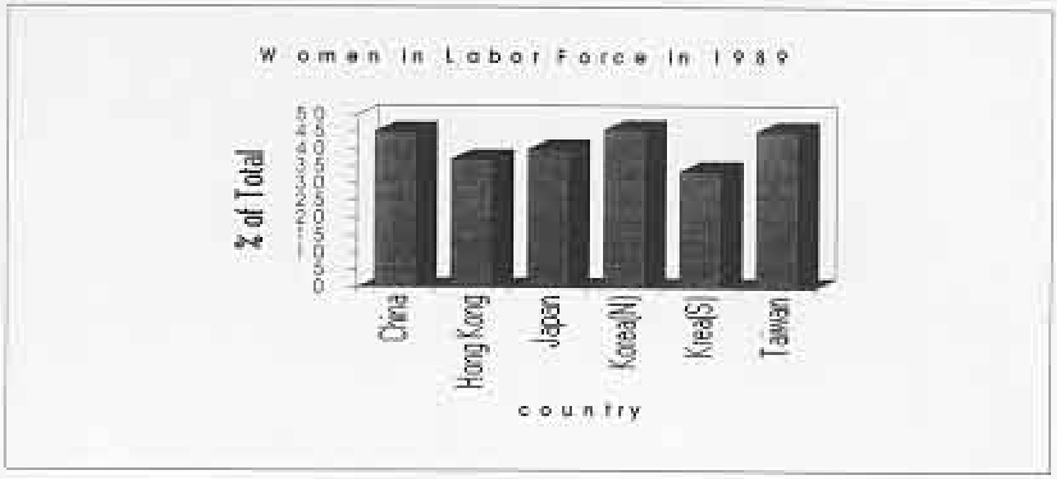


Figure 12



As employment and income grow in the developing country, female labor force participation and women's wages will tend to increase. Increased wages and employment opportunities for women outside the home lead to an increase in the opportunity cost of bearing and raising children and, consequently, to a decline in fertility. As incomes increase and as health and life expectancy improve, parents will also invest more in quality factors such as higher education, more nutrition for a small family rather than having a lot of children. Figure 10 shows rapid increases in secondary and tertiary education enrollments. Especially remarkable growth rates in education can be found in Korea. As education level rises and fertility rates will fall.

V. Economic and Demographic Interactions within Asian Countries

1. Economic Growth based on Cultural Affinity

The concept of regional economic cooperation and development in Asian countries is receiving increasing attention among the countries involved, for a number of reasons. From a historical perspective, East Asia during the past few centuries has seen the rise and fall of national groups based on ethnic identifications. The population of East Asia is divided by international boundaries into separate national economies, some of which have been arbitrarily isolated from the others. Despite this artificial division, the people of the region share in common a rich cultural heritage, including traditional East Asian values. Considered collectively, the East Asian countries have a number of ethnic and cultural affinities that can potentially strengthen economic relationship within the region. The commonalties include material culture, such as clothing and food, and the values of Shamanism, Buddhism, and Confucian education based on the use of Chinese characters. In addition to geographic proximity, East Asia offers a great potential for intra-regional economic cooperation to stimulate regional development, based on the highly complementary factor endowments in terms of natural resources, abundant labor supply, technology and capital. This affinity contributed to rapid economic growth of Asia, furthermore it aroused international migration within Asian countries.

2. International Migration within Asian Countries

Manpower flows in Asia today is changing greatly. These phenomena can be seen as another demographic transition. Mutual exchanges of labor have increased along with the rise in exchanges of goods and direct investments within the Asian region. Up until about 1981, Korea was a labor supply country, and had sent more than 150, 000 workers to the middle Eastern region alone. However, today the number of Korean workers in the Middle East has dropped to approximately 20,000 (Funkoo Park). This is due to such factors as the need to replace Korean workers, who came to require higher salaries, with Philippines and Thai workers.

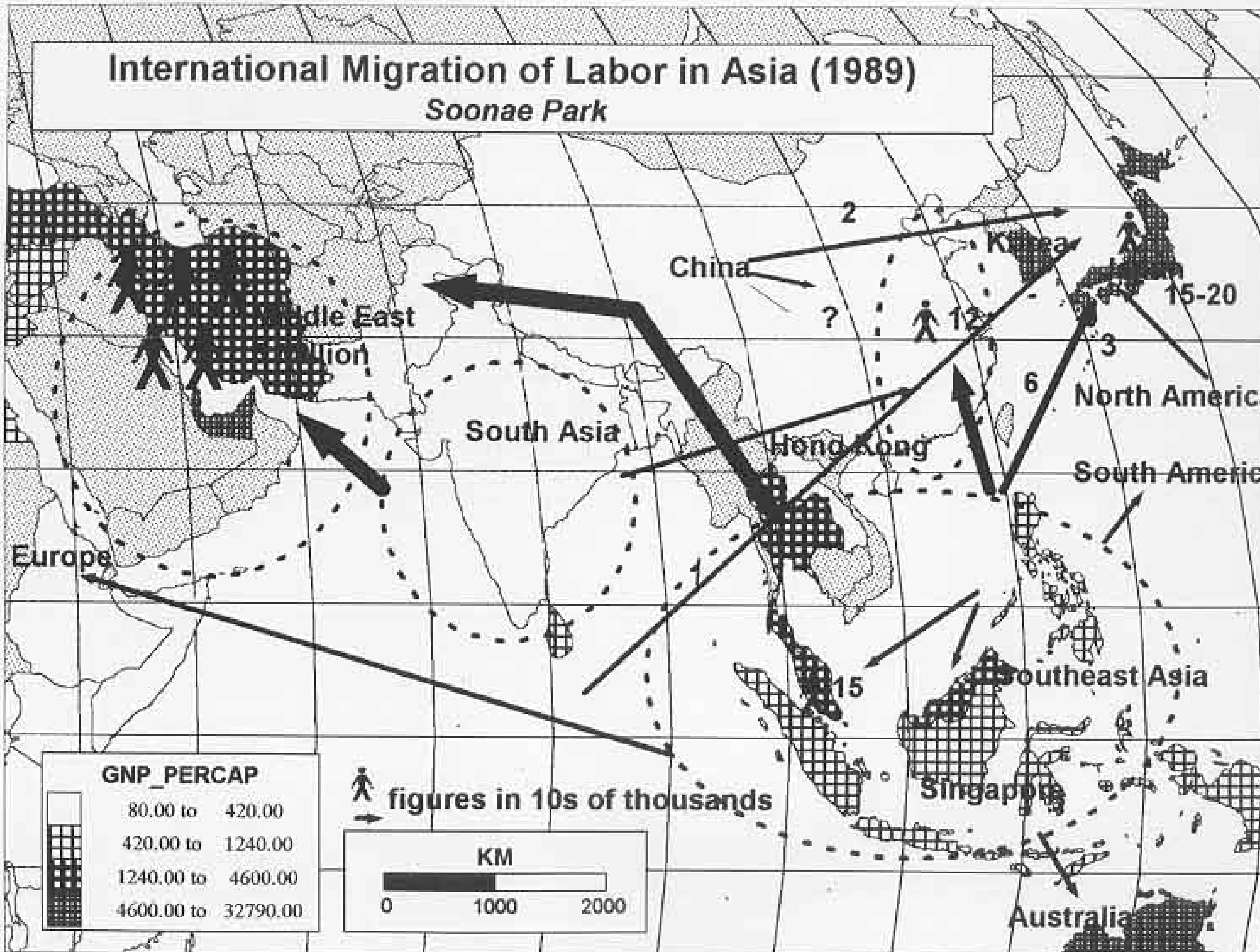
Triggered by the growth of the Korean economy in the last half year of the 1980s, and in particular the growth of export processing industries, illegal workers began entering Korea from Asian regions. In 1991, of the approximately 3 million foreigners who entered Korea, 42,000 remained in Korea illegally. Of course, Chinese were the most numerous with about 18,000, followed by Filipinos(16,000) and Nepalese(2000). These illegal workers are employed in the so-called "3D professions"--Dirty, Difficult and Dangerous jobs, in construction and manufacturing(Hong Kim, 1992).

In addition, another phenomenon deserving attention in Korea is the fact that with the growth of the Korean economy in the 1980s, workers who left Korea in the past are returning, including the construction workers from the Middle East mentioned above. At the beginning of the 1980s, there was an annual average of some 1000 returnees, but in 1991 this number had reached 7000 (Hong Kim, 1992).Though Korea had exported large number of workers through the middle of the 1980s, have now begun to accept foreign workers while at the same time sending workers to other countries.

This new transition has just begun, and much of the migration is illegal. However, despite its illegality, if we consider that 1) this transition consists of only a portion of the major current of migration, 2) it is mutually related at its root to the movement of goods and capital, and 3) there is political movement towards the legalization of foreign workers, it seems valid to say that this is the beginning stage of an international structure of labor migration within the Asian economic sphere.

VI. Findings and Conclusion

The purpose of this paper has been interpret the changes in Korea's economy related to population growth, to generate ideas for public policy initiatives. The most striking characteristics of Korea's structure can be summarized as the speed of economic development and the sharp decline in


International Migration of Labor in Asia (1989)
Soonae Park
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15-20
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North America
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South Asia
Hong Kong
Europe
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Southeast Asia
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GNP_PERCAP
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4600.00 to 32790.00
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fertility rates. Indeed it took only 60 years from the beginning of a mortality decline in the colonial period to reach the phase in which the fertility rate reached its lowest level. During this period, Per capita income has increased eight times; and the size of the economy has increased thirteen times. Thus, the rapid fertility decline and demographic transition took place in association with rapid economic growth. Furthermore, continued economic growth has been is accompanied by great changes in factors affecting human demographic behavior. Thus, great changes in the demographic behavior and vital rates of the population have occurred in association with the modern economy in Korea.

With respect to demographic factors, the .rapid changes have provided favorable circumstances for high economic growth in the labor market. This compatibility, however will not last forever. When the large population born in the high fertility years of the early-1960s reaches old age, the aging of the population will begin. From then on, the supply of working population will decelerate, and the dependency burden will increase. Moreover, Korea has a growing labor shortage with higher wages, thus stimulating international migration. Slower labor force growth and rapid industrialization will begin to shift the comparative advantage of the more demographically advanced countries. Therefore government and industry should prepare the way, especially through education, to grasp the comparative advantage that will take place. Korean industry needs to upgrade its technological ability rather than compete through low production costs. In this way Korea can be demonstrate the truth of Meadows assertion:

> With enough investment sustained for a long enough time, with fair pricing for products and fair market conditions, with the increased output allocated to the poor and especially to the education and employment of woman, a population can lift itself out of poverty (Meadows, 1992).

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POPULATION POLICY AND ENVIRONMENTAL QUALITY

By Brent Plater

Introduction

Throughout industrial times, environmentalists and economists alike have been concerned about the ramifications of population growth. During this period, population growth was cited as the ultimate cause of many economic, social and environmental problems. However, few countries opted to enact policy limiting population growth in order to control these problems.

The one notable exception is China. Unable to attain economic growth rates that could outpace its population growth, China implemented a population control regime in order to increase the standard of living. Since the implementation of the policy the standard of living continuously increased while the country as a whole produced record economic growth rates.

Although originally mandated to alleviate economic problems specifically, the positive consequences of the population policy may have extended into other arenas, including environmental quality. One of China's major environmental problems which may have been affected is industrial air pollution; in particular, the amount of Sulfur dioxide (SO_2) emitted by China's burgeoning economy. Although not the exclusive culprit, SO_2 has caused a significant portion of China's environmental pollution. A major byproduct of coal combustion, SO_2 acidifies lakes and streams, is a major component of acid rain, and causes respiratory illnesses. China has recently labeled SO_2 as an industrial pollutant of major concern (Geping and Jinchang, 1994), an indication of the severity of the problems caused by the pollutant.

The purpose of this paper is to show how the population policy has reduced environmental stress in China. Specifically, I will analyze the effect of the policy on reducing industrial Sulfur dioxide emissions. Furthermore, I will compare China's population policy to the Clean Air Act (C.A.A.) of the United States to contrast the effectiveness of each policy at improving environmental quality.

Population Policy

On the eve of his victory in 1949 over the Chinese nationalists, Mao proclaimed that "Of all things in the world, people are most precious." Under Marxist economic assumptions, Mao envisioned a China where the main source of wealth, the labor force, produced an abundant supply of goods and services under a socialist regime (Stycos, 1991). Yet less than three decades later, China implemented the most restrictive population policy the world had ever seen. The path toward this remarkable change in population theory reveals the complexities of policy formation in China.

Mao was forced to re-evaluate his Marxist position on population growth in 1953. A census taken that year revealed that there were 100,000,000 more people than predicted by agricultural planners, causing a severe food shortage. This crisis propelled Mao to permit public discussion about population control issues, and to force local hospitals to open and operate family planning clinics. However, birth control technologies were crude and in short supply, leaving little impact on national birth rates.

In 1958, the focus on family planning ended with the implementation of the "Great Leap Forward". The Great Leap was an attempt to surpass the western nations in economic production. A key tenet of the Leap was that a large population would only serve to propel China's economic engine faster than a small one. The plan encouraged people to leave agrarian lifestyles and begin careers in the industrial work force. Mao predicted China would surpass the western world in economic prosperity within three years as a result of the Leap. With emphasis on birth control reduced, the family planning institutions created just a few years before no longer received promotional funding.

By shifting a large percentage of the Chinese labor force to public work efforts, agricultural production during the Leap plummeted. Famine followed, causing an estimated 30 million more deaths than normal (Coale, 1984). Stunned by the unqualified failure of the Great Leap, Mao began once again to promote birth control in 1962.

Efficient organization characterized China's second campaign of population policy. Propaganda in newspapers presented child bearing as "not altogether a personal matter" due to the huge social costs of children which the state had to bear (Aird, 1990). Postponing marriage was encouraged, and prominent officials described the optimal family size as "no more than two children with a three to five year interval between them" (Chen, 1979). In addition, safer, more convenient birth control devices were introduced. These combined efforts lead to a decline in birth rates that continued throughout the late 60's.

The second campaign ended with the beginning of the Cultural Revolution. Instigated by Mao to purge the communist party of supposed corruptors, the Revolution brought militant youth groups to power, charged with extracting revenge on Mao's enemies. Eventually the youth groups began to war among themselves, displacing the civil order in China with a kind of mob rule. Mao used military intervention to settle the turmoil. Once order was established in 1969, the third campaign of population policy began.

The third campaign marked the beginning of China's modern population policy. It began with an assertion by officials that a socialist state should control production, including the most important component of production: people. This ironic twist on Mao's original sentiment towards population size was justified by the assumed economic and military benefits of a small population. Information seminars were held throughout the republic to emphasize the importance of limiting the number of children per couple to no more than two. Supplemented by an increase in availability of IUD's, population growth rates declined from 2.6% in 1970 to 2.2% in 1975 (WRD, 1994).

The immediate success of the population policy lead to an optimistic prediction that China would halve its growth rate by 1981. However, growth rate decline leveled off in 1978, alarming population planners. Moreover, population projections indicated that population growth would continue as long as couples were allowed to have two children. Faced with these facts, China implemented a one-child per family policy. As early as 1981, couples were encouraged to sign "one child certificates", committing the couples to have only one child (Tien, 1983). By 1982, China became the first nation in the world to amend its constitution to include population planning.

The State implemented the one-child policy through several coercive tactics. Heavy taxes were levied on second and third births. When the taxes proved inadequate, women underwent forced sterilization. However, the stringent policy clashed with the strong desire among the Chinese to have a son, leading to infanticide of female newborns. The resistance of the Chinese to accept this policy coupled with pressure from the United States and other western countries encouraged china to relax the policy in 1984. Under the new amendments, a second child would be allowed in some instances, as long as the births were spaced far apart.

The population policy in China has been quite successful at reducing population growth. The crude birth rate, the total fertility rate and the population growth rate have all declined during its implementation (see Figure 1 and Table 1.). The effect of the decrease in population growth rate on environmental quality is developed in the next section.

Figure 1.
Crude Birth Rate in China (vertical lines represent phases in population policy)

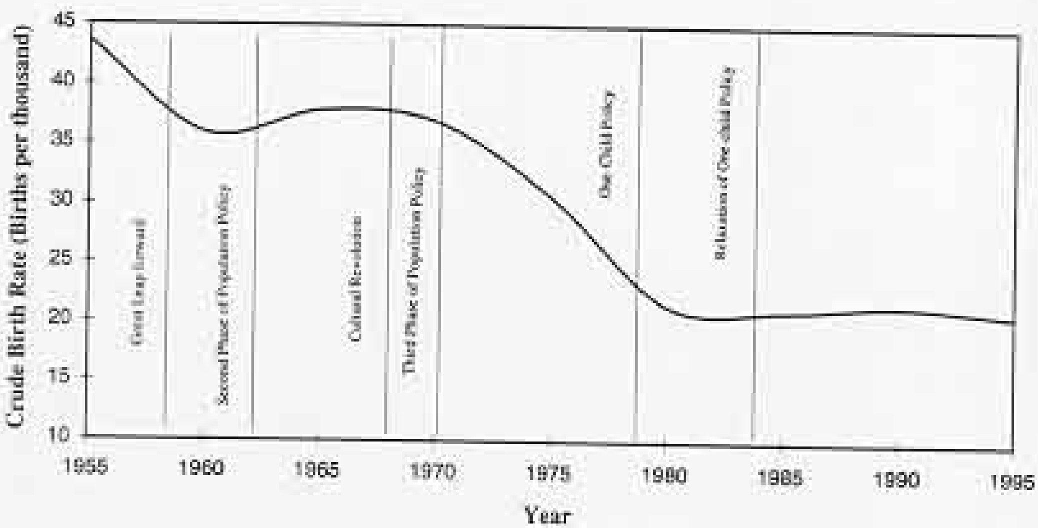


Table 1. Changes in population growth indicators in China over time

	Pop. Growth Rate (%)	Crude Birth Rate	Total Fertility Rate
1965	2.07	37.8	5.93
1970	2.61	36.9	5.99
1975	2.20	30.6	4.76
1980	1.43	21.5	2.90
1985	1.44	21.1	2.52
1990	1.49	21.6	2.38
1995 (projected)	1.42	20.8	2.20

(Source: World Resources Database, 1994)

Environmental Quality

China is blessed with an abundance of natural resources. Home to over 30% of the world's species (Geping, 1982), it is one of the world's most biologically diverse countries. In addition, China has an extensive coal reserve, which is used to meet 70% of the country's energy demand (Geping and Jinchang, 1994). Unfortunately, a historically inept wildlife management program has brought many of China's endemic species to the brink of extinction, while an accelerated push for economic growth has left a trail of industrial pollution. This decrease in environmental quality was exacerbated in 1949, when Mao revolutionized the Chinese government into a socialist state. The centrally planed economic strategies stressed economic growth, giving little consideration to environmental quality. Coupled with increasing growth rates of an already large population, environmental stresses have increased dramatically, potentially affecting global environmental quality. China's environmental problems are broad, and include issues of both wildlife conservation and human health.

Wildlife Conservation

Many of the China's endemic species are in danger of extinction. Habitat destruction is the main vector of extinction, although poaching has had a major impact on the population size of many larger mammals, such as the snow leopard and the Siberian tiger (Hair, 1987). Although policies to preserve wildlife have been in existence since the 1960's, they were rarely enforced, and in many instances were subordinated by government directives to extract resources (Geping, 1982).

China began to revamp it's wildlife conservation programs in the early 80's. Working with conservation organizations such as the World Wildlife Fund, China implemented a three-pronged conservation program: creating wildlife reserves, improving scientific research, and adopting conservation legislation. Although results are still inconclusive, there have been some positive outgrowths from the program. China has increased the amount of land in its conservation system from a 1982 total of 1.7 million hectares to 40 million hectares in 1990, with plans for adding another 10 million hectares by the end of this century (Livernash, 1994). Knowledge of endangered species has increased with the help of research scientists from the United States, and some legislation has been passed dealing with conservation issues.

The ultimate fate of China's wildlife will depend on how well China can implement its population policy. As population grows and the per capita arable land goes down, there will be increased pressure to remove the development restrictions on many of the conservation parks, leaving only those parks which have little human utility for China's vast diversity of wildlife. Although conservation issues are not developed here, it is yet another area where the population policy may have positive consequences. By reducing population growth rates, the amount of land needed for human endeavors is reduced, leaving more land available for wildlife protection.

Human Health

China's leap in economic activity has centered on its ability to exploit energy reserves. Since such a large portion of China's energy comes from coal, the energy exploitation has been followed by more severe pollution problems than an economy based on other forms of fuel.

For instance, China's energy consumption doubled over the past two decades (Duderstadt, 1992), while air and water quality have decreased substantially. Heavy metals have been found to exceed national standards in 7.7% of rivers flowing through industrial centers, and atmospheric pollution is comparable to that of the United States during the 1950's- well before environmental regulation was in place (Geping and Jinchang, 1994).

Acid rain has become increasingly prevalent in the past decade. Recent studies show that over 44.5% of rainfall throughout the provinces is acidic (Geping and Jinchang, 1994), becoming more prevalent in areas with high levels of coal combustion.

With only 40% of the population with access to potable water and other sanitation services, the degradation of the natural environment has had a large impact on human health. The estimated cost in human life and welfare is around 880 million dollars, in addition to the indirect costs of crop damage and land degradation (Livernash, 1994). In addition, fish stocks have seen consistent declines since the 1970's, and outbreaks of water born diseases have re-emerged.

Once again, the population policy may have impacted this environmental problem. By reducing population growth rates, total pollution will be at a lower rate than otherwise expected, buying time for pollution policy to control the industrial output.

Air Pollution Policy

In 1972, China drafted its first statement of environmental policy for the United Nations conference on the Human Environment (Livernash, 1994). This statement brought environmental regulation into the realm of socialist planning, and ultimately lead to the creation of the National Environmental Protection Agency (NEPA), China's principle environmental organization (Glaesser, 1987).

NEPA administers most environmental regulation in China. However, environmental issues affect many agencies within the government, all of which must be consulted about potential regulation. Furthermore, a substantial portion of the agencies must support the regulation for it to gain enough political momentum to become law. NEPA itself has over 100,000 employees working on various environmental issues (Livernash, 1994), yet is unable to meet the environmental demands of the country (NEPA, 1991). This has become particularly evident in NEPA's attempt to regulate SO_2, China's principle air pollutant. Daily means of SO_2 in urban areas often reach 400 ug/m^3, eight times greater than the World Health Organization's acceptable limit for SO_2 emissions (Smil, 1993).

The primary reason that SO_2 levels in China are so high is its dependence on coal for energy. China derives 76% of its energy from coal; twice the world average (Table 2). Although China recognizes coal dependency as a significant factor in its environmental degradation, there is no indication that the republic will switch to a cleaner form of energy in the near future (NEPA, 1991).

China has made some progress in drafting air-quality legislation (Hsu, 1992). New industrial facilities are required to incorporate environmental protection into the design, construction, and operation of facilities, with a recommended expenditure of 7% of the facilities capital budget for environmental protection. In addition, local environmental protection bureaus have the authority to demand environmental impact assessments (EIA) on all major construction projects. The EIA's must be approved by the bureaus before construction can commence. Also, NEPA's power to enforce environmental legislation has been consistentlystrengthened over the past decade.

Figure 2.
Total Sulfur Dioxide Emissions in China (1982-1990)

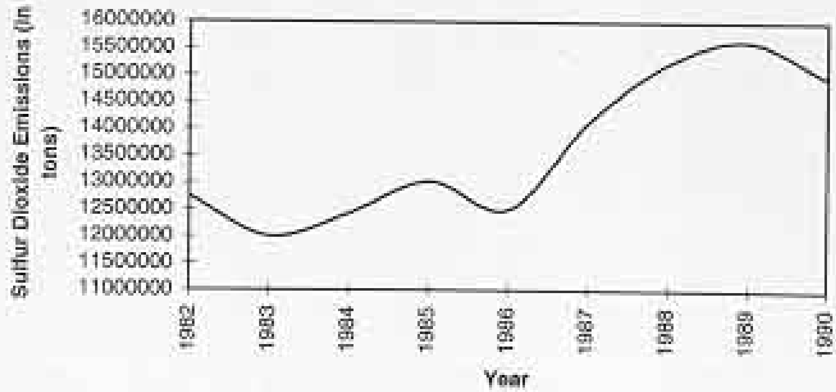


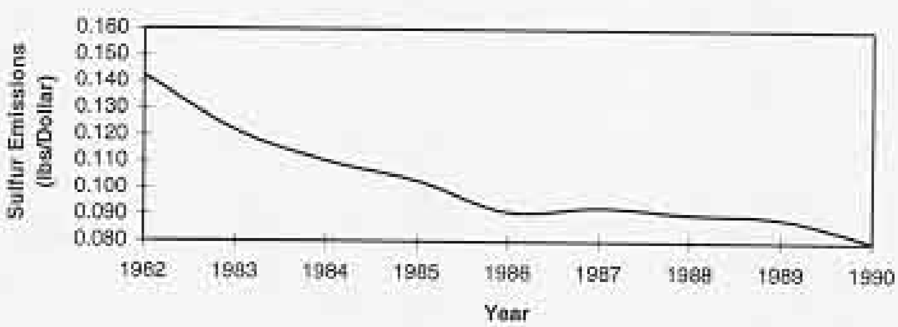
Table 2. Coal consumption as a percentage of total energy consumption

World	China	United States	Japan	France
30.0%	76.0%	23.3%	18.8%	10.0%

(Source: Geping and Jinchang, 1994)

Preliminary results of the policies effect on reducing SO_2 show mixed results. The amount of SO_2 emitted per dollar in the Chinese economy has been reduced dramatically, indicating an increased efficiency to deal with the byproducts of coal combustion. However, the reduction may be due to the construction of taller smokestacks instead of increased efficiency of coal combustion. If this is the case, the decrease in SO_2 per dollar would merely indicate a dispersion of SO_2 outside of China's boundaries, without any increase in coal combustion efficiency.

Figure 3.
Sulfur Dioxide Emissions per Constant U.S. Dollar in China (1982-1990)



China's most comprehensive environmental management plans deal with pollutants of global concern, such as Carbon dioxide (NEPA, 1991). An obvious reason for this is that China's funding for many of its environmental programs comes from the World Bank and other first world organizations. By focusing on global problems which may impact first world nations, China has been able to secure funding for a budding environmental program.

Projecting Population

As shown earlier, the population policy phases in China have made a considerable impact on population growth. In order to find out how this change in population affected SO_2 emissions, I first needed to estimate what China's population trajectory would be without the population policy; i.e. what China's population would be today if it would not have enacted population control policies. This was done by fitting a curve to China's population data up to 1970; 1970 was the first year of modern population policy in China, thus it is the year in which the population trajectory was first affected. A linear as well as an exponential curve was fit to the population data, according to the following formulas:

$$\text{EXPONENTIAL: } Y=e^{(.023703*X+13.36337)}$$

$$\text{LINEAR: } Y=13009.78*X+526557$$

For both formulas, Y equals the projected population size, and X equals the year of the projection in standardized form.

Results of the curve fit are shown in Figure 4. Although neither curve is an exact fit of the actual data, the exponential curve is a better fit than the linear curve. Using the data from the exponential fit, I calculated the difference in population size between the actual population and the exponential projection, indicating the change in population size which has occurred due to China's population policy.

Figure 4.
Comparison of China's Actual Population to the Exponential and Linear Curve Fit

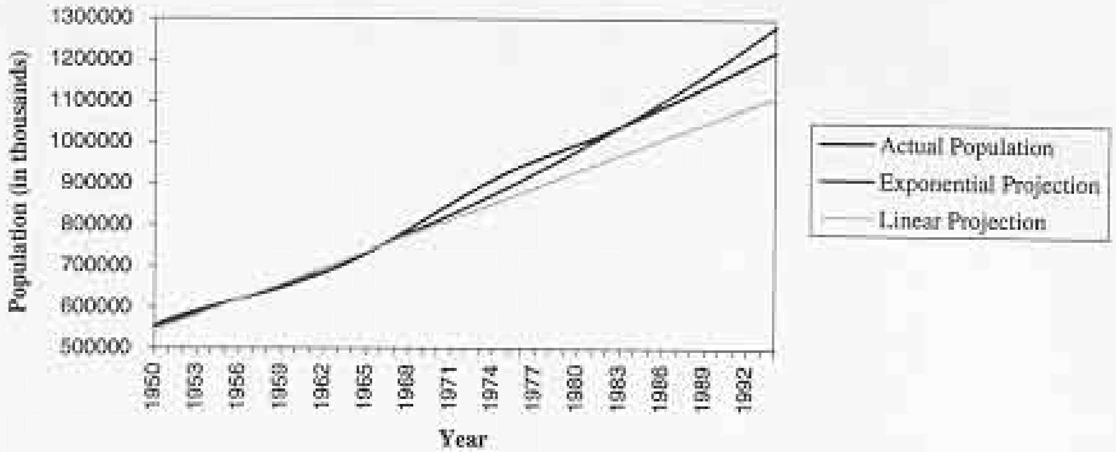


Table 3. Actual, projected and the change in population due to population policy in thousands for selected years.

	1984	1985	1986	1987	1988	1989	1990
Actual	1.05E+6	1.07E+6	1.08E+6	1.10E+6	1.11E+6	1.13E+6	1.15E+6
Projected	1.05E+6	1.07E+6	1.10E+6	1.12E+6	1.14E+6	1.16E+6	1.18E+6
Change	3735	85484	13519	18510	23606	28869	34376

Estimating Sulfur Dioxide Emissions

Estimating SO_2 emissions under the exponential population projection is considerably more difficult (and possibly less accurate) than creating an exponential population projection, because there is no historical data on SO_2 emissions in China. However, predictions can be made using economic analysis, based on the assumption that SO_2 emissions are directly related to economic activity.

As noted earlier, most SO_2 emissions in China are a result of burning coal for fuel (Geping, 1991). The fuel is in turn used to fulfill the energy demands of China's industrial development. Based on this set of circumstances, I assumed that a strong relationship existed between economic development and the amount of SO_2 emitted. Although this assumption is very simplistic, due to the fact that China has not implemented a strong pollution control regimen and it's high dependence on coal as a fuel source, it seems to have enough circumstantial evidence to be held as fact.

With SO_2 related to an economic variable, I could make a second assumption based on economic analysis. I assumed that China's Standard of Living (economic production per person) would be identical for each year of the actual population data and the exponential population projection. Since

Standard of Living and SO_2 production per person are related, I could then state that the per person SO_2 emissions would not change with a change in population size.

This assumption does not seem to make intuitive sense at first glance. However, it is supported by basic macroeconomic theories (Denison, 1974). The key rationalization component of this assumption is the concept of worker productivity; particularly how it affects the macroeconomy and thus SO_2 emissions.

Worker productivity is simply the amount of economic output a given worker produces in a specific time frame. When the time frame is one year, productivity is called the standard of living. In general, productivity can be defined by the following formula:

Economic Output/ Population

Although population size is a factor in the productivity equation, an increase in population does not directly translate into a decrease in productivity. In fact, working under a set amount of industrial capital and level of technology, population and economic output will increase at the same rate. This occurs because as a person is added to the population, the person is also adding to the economic output at a level defined by the capital and technology in the current economic state. Therefore, an increase in population would change only the total amount of output, not the per capita output.

Although worker productivity is not affected by population size, it is not destined to remain at a constant level. Rather, there are two main vectors in which worker productivity may increase. The first is known as capital deepening; increasing the amount of industrial capital available per worker. The second factor is technological progress. This generally means not more capital per worker so much as better capital per worker, which in turn makes the worker able to produce more output.

In China, the amount of capital and technology available for economic uses has been controlled almost exclusively by its international trade policies. As more nations began to trade with China, there was an enormous influx of capital and technology, which rapidly increased their capacity to grow economically. There is no reason to believe that the changes in trade policy is related to a change in population size, so it is easy to conclude that the amount of capital and technology available to produce economic goods (and SO_2) would be the same under the actual and projected population sizes.

The effect of changes in productivity and population size on the macroeconomy can be looked at jointly under one equation:

$$\% \Delta \text{ GDP} \approx \% \Delta \text{ productivity} + \% \Delta \text{ population}$$

Therefore, a change in population size while the other variables remain constant will be matched by an equal change in GDP, keeping the standard of living at the same level, even though the overall GDP would increase. Furthermore, since there is a relationship in China between SO_2 emissions, the per capita SO_2 emission would also be constant. Thus, the SO_2 emitted per person is regulated by the amount of capital and economic infrastructure in place, while the total SO_2 is a function of the population size and the per capita production.

Results

By multiplying the change in population obtained from the exponential curve fit by the per capita SO_2 emissions for each year, I calculated the amount of SO_2 which would have been emitted if the population policies had never been implemented.

Table 4. Amount of Sulfur dioxide emitted under exponential population projection (population in thousands, total Sulfur dioxide in tons)

Year	Projected Population	SO2 lbs/person	Total SO2 Projected
1982	1,018,780	24.9	1.27E+7
1983	1,038,521	23.1	1.20E+7
1984	1,058,645	23.6	1.25E+7
1985	1,079,158	24.3	1.32E+7
1986	1,100,070	23.0	1.27E+7
1987	1,121,386	25.6	1.44E+7
1988	1,143,116	27.2	1.56E+7
1989	1,165,266	27.5	1.61E+7
1990	1,187,846	25.9	1.54E+7

Compared to the actual amount of SO_2 emitted, the population policy seems to have had a moderate impact on the levels of SO_2 in the air (see graph).

Figure 5.
Actual Compared to Projected Sulfur Dioxide Emissions in China

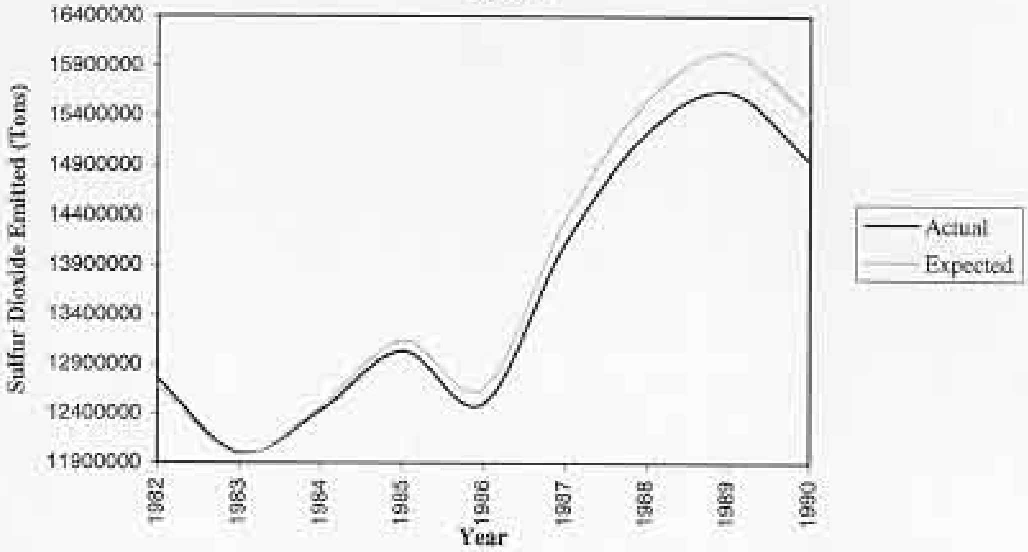


Table 5. Difference between actual and projected SO_2 emissions (in tons of SO_2)

Year	Actual Emissions	Projected Emissions	Difference (Proj.-Actual)	% Decrease in Emissions
1982	1.28E+7	1.27E+7	-144,386	-1.1%
1983	1.20E+7	1.20E+7	-23,806	-.2%
1984	1.25E+7	1.25E+7	88,010	7%
1985	1.31E+7	1.32E+7	208,961	1.6%
1986	1.25E+7	1.27E+7	311,044	2.5%
1987	1.41E+7	1.44E+7	473,964	3.3%
1988	1.53E+7	1.56E+7	642,267	4.1%
1989	1.57E+7	1.61E+7	794,638	4.9%
1990	1.50E+7	1.54E+7	891,083	5.6%

The average decrease in emissions per year from 1982-1990 is 2.6%, or approximately 3,239,600 tons of Sulfur dioxide.

Comparison of Effectiveness to C.A.A.

To compare the effectiveness of the population policy on improving environmental quality, it is necessary to discover how effective other policy strategies have been in reducing environmental stress in this particular pollution medium. A notable example can be found in the United States. The United

States regulates air pollution at its source with stringent standards on emissions of particular pollutants. Although the effectiveness of this type of policy varies from pollutant to pollutant, the key distinction here is that the United States has implemented a policy directly regulating air quality, while the population policy indirectly affects air pollution.

The United States began regulating air quality over 20 years ago with the passage of the Clean Air Act, becoming the first industrialized nation to pass such a law (Hammond, 1992). The act creates standards of air quality for major pollutants (through the Environmental Protection Agency), which the States assume responsibility for implementing. Both the Federal and State governments share enforcement responsibilities.

Since the passage of the C.A.A., Sulfur emissions have consistently decreased. Through the twenty years of its implementation, Sulfur levels have decreased over 30% (Rosenbaum, 1990), from 33 million tons to 22 million tons. A similar picture can be seen when looking at the amount of Sulfur emitted per dollar of the U.S. economy. In contrast to China, it appears that not only are companies more efficient than they were 20 years ago, but they are also producing less of the pollutant overall.

Figure 6.
Sulfur Emissions per Person in the United States (1970-1991)

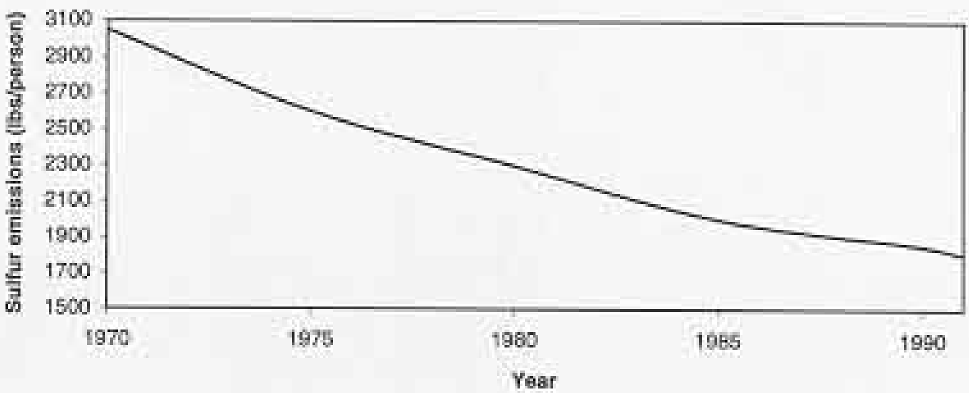
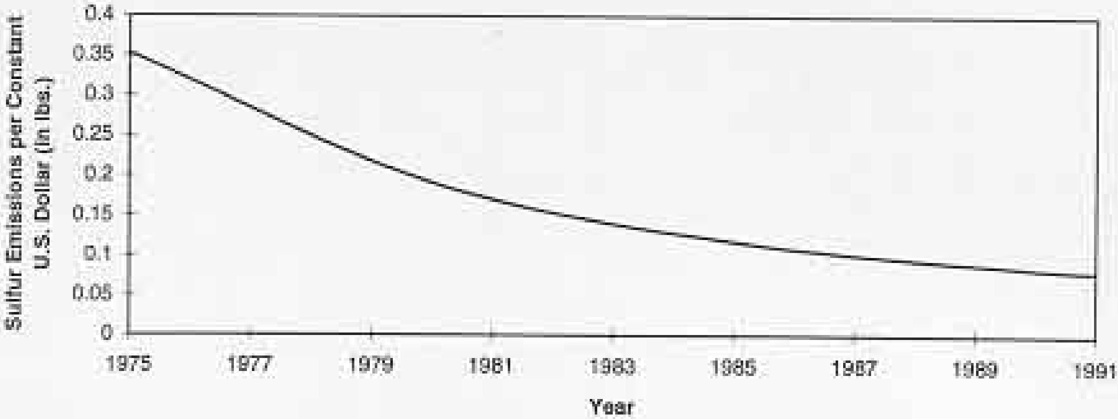


Figure 7.
Sulfur Emissions per Constant Dollar in the United States (1975-1991)



However, the same caveat which applied to the results of the Chinese data showing an increased efficiency at reducing Sulfur emissions applies to the United States. Increasing the height of smokestacks in order to spread the Sulfur into other states and countries that are regulated separately has become commonplace among Sulfur emitters. This phenomenon is most visible in the Midwest, where Sulfur emitting factories send their pollution "air mail" to Canada via smokestacks over 200 feet tall (Rosenbaum, 1991).

Despite this potential bias, the distinction between the effectiveness of the C.A.A. and the population policy is quite clear; the C.A.A. has been over 12 times as effective at reducing Sulfur emissions than the population policy. The most interesting difference between the Sulfur emissions is that the United States has been able to consistently reduce emissions during the past twenty years, while the total emissions in China have fluctuated haphazardly. This is a derivative of the type of policy each country has put in place. The C.A.A. has specifically mandated a change in consumption and production behaviors to alleviate the sulfur dioxide problem, leading to the consistent reduction in total emissions. On the other hand, the population policy reduces the total amount of pollution by reducing the number of polluters. Since the population policy does not mandate a continual reduction in pollution over time the total amount of emissions will fluctuate depending on the quality of industrial capital and the production levels of the pollutant. The population policy merely insures that the pollution levels will be less than they would have been.

Another important note about the population policy is that its ramifications are not limited to air quality. Thus, it will have a slight impact on many social ills. Although it may be possible to have a greater impact on a particular problem with a more directed policy, the total costs of the numerous policies needed to impact the same amount of problems as the population policy may prove this political strategy economically inefficient.

These results have important policy implication for less developed countries. Less developed countries are often fraught with a slew of social problems demanding their respective governments attention. However, at the same time they are restricted from addressing all of these problems to due a lack of funding. By investing the monetary equivalent of one directed policy, a country could impact many of its problems in one policy blow.

Conclusions

The population policy in China has had broad effects throughout society, reaching far beyond the economic objectives it was originally intended for. However, standing alone it does not seem to be the most effective means of achieving a social goal. Particularly in the case of Sulfur emissions, a policy with a more directed focus on reducing emissions has been much more effective.

However, this does not discredit the population policy entirely. Rather, it indicates that the two policy forms should be used in conjunction for maximum effectiveness. For instance, if China had a rigorous air pollution policy in addition to the population policy, the emissions would have decreased over time (due to pollution policy) as well as a decrease when compared to the alternative population trajectory. The combined effect would be synergistic, decreasing pollution beyond what either policy can do alone.

Although there are indications that China is beginning to integrate pollution control into its socialist planning, the prospect of nations with strong pollution prevention programs implementing population policy is bleak. This is particularly true in the United States, which has a large per capita resource base. Although there are several reasons for this, an overriding issue is the lack of connectivity between population and social ills in the minds of many people. Until the benefits of population planning are presented to the United States in a thorough and directed manner, population policy will be stuck in academia.

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World Resources Database, 1994

A FRAMEWORK OF POLLUTION PREVENTION AND LIFE-CYCLE DESIGN: AIDING DEVELOPING NATIONS THROUGH TRANSITION TO INDUSTRIALIZATION

Shelley Price

Introduction

Arguably, the United States experienced the beginnings of its transition from an agricultural society to one heavily laden in industry around the turn of the century with the creation of the steam engine and the automobile. Both creations not only changed the way we traveled, but the way we worked and the fuel we used. Steam and internal combustion engines facilitated the energy transition from the renewable resource of timber to the not renewable, more environment polluting fossil fuel of coal, oil and gasoline. With this new source of power came the ability to do more work in less time and with less man power, thus more efficient agricultural processes and an increase in industrialization; the freedom to relocate, thus changes in demographics - from rural to urban settings; the ability to move large amount of goods quickly over vast distances, thus the building of interstate commerce: a transportation network; and much more. The United States boomed. Its economy and population expanded. Industrial and technological advances hastened to a frenzied speed. After World War II and for 30 years the U.S. was undoubtedly the World leader in everything: agricultural production, education, invention, and technology. We were both a economic and political superpower. Then in the beginning of the 1970's the country realized at what expense: the environment.

The United States had depleted much of its known natural resources, razed the forests, polluted the air and killed its streams. Both the environment and citizen groups called out for help. 1970 saw this nation's first collective awareness of the environment, Earth Day, and the first tangible solution, the National Environmental Protection Act (NEPA), as well as the beginning of environmental regulation. Damage to the environment was dealt with by medium by medium regulations. The Clean Air Act (CAA) was designed to identify and control pollutants and sources of emissions that may reduce the quality of the nation's air. The Clean Water Act (CWA) was designed to address the quality needs of the nation's waterbodies with regards to both human and environmental concerns and with the objective of restoring and maintaining the chemical, physical, and biological integrity of the water source. The

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) were designed around the issue of hazardous and toxic substances; the former to govern the clean-up sites containing hazardous substances, and the later to control the waste management of such substances (EPA, February 1993). These so-called "end-of-the-pipe" regulations all had several commonalities: they dealt with environmental problems medium by medium, after they occurred, and governed their clean-up by using inflexible sets of control methods (ex. "Best Available Control Technology" or BACT). These regulations have had some effect, but there still exists little incentive for polluters not to pollute, or to overuse resources.

With developing nations beginning to enter the transition from an agricultural culture to an industrial economy, they face the same problems of environmental degradation and resource depletion as the U.S. faced 90 years ago. They do, however, exist two main differences: by the nature of the area, natural resources tend to be less abundant in these countries and their ecosystems are more frail and more susceptible to irreversible environmental damage. As global awareness of the importance of these lands to the well being of not only the country in which they lay, but to the Earth as a whole increases, the need for preventive measures becomes more evident. However the traditional means of conservation to save the environment means stemming the growth of that nation. The question now becomes: how can environmental protection and economic growth occur simultaneously? I hypothesize that sustainable development with substantial environmental protection can be attained by following a model of Pollution Prevention and Life-Cycle Design just recently created by the U.S. By using the U.S. model, developing nations, specifically Central and South America, can hope to bypass some of the environment disasters already experienced by the developed world. Table 1. illustrates human-induced land degradation. Notice that South American is below the World average, and well below that of Europe. I would argue that the statistic for North and Central America is unnaturally low due to the vast untouched land mass of most of Canada which would offset the higher levels of deforestation and overgrazing of Central America. Even if Central America has a higher rate of land degradation, it is still crucial to prevent developing nations from reaching levels attained by developed nations.

TABLE 1.

Human-Induced Land Degradation Worldwide, 1945-Present

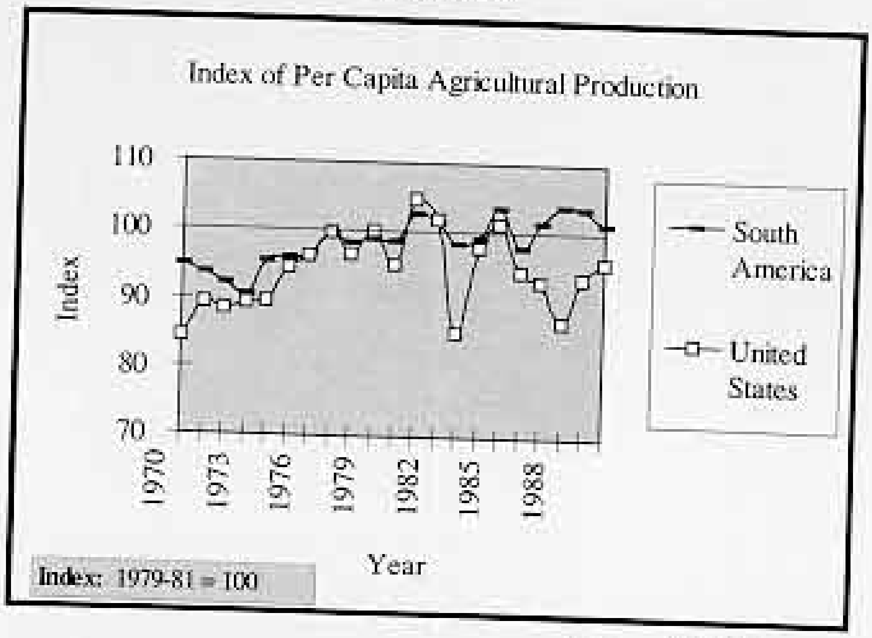
Region	Overgrazing	Deforestation	Agricultural Mismanagement	Other	Total	Degraded Area as Share of Total Vegetated Land
		(million	hectares)			(percent)
Europe	50	84	64	22	220	23
South America	68	100	64	12	244	14
North & Central America	38	18	91	11	158	8
World	679	579	552	155	1965	17

Source: Worldwatch Institute, 1991

The South In Change: the Agricultural Transition

Transition from an agricultural based society to an industrial based economy cannot occur unless agricultural productivity increases. As more people leave the farms to find employment among the industrial sector, fewer people must be able to raise enough food to support the growing population. This can be accomplished in two ways: 1) increased mechanization of agricultural practices, and 2) increased use of fertilizers and pesticides to increase yield per acre. Both of these trends are supported by data from the World Resources Institute (1994) for many developing South and Central American countries: Brazil, Columbia, and Panama, to name a few, and by the U.S. Bureau of the Census (1994) for the U.S. Overall, fewer farmers are producing more food on larger farms than has been previously experienced. Increased agricultural productivity thus is a valuable support mechanism in the agricultural transition. Figure 1. illustrates increased agricultural productivity as measured in per capita agricultural production. The U.S. does not match south's increase in productivity throughout the 80's probably due to two main reason: 1) government policies to suppress farm production in the midst of a food surplus in attempt to support farm prices (1983) and 2) a disastrous year of drought leading to low crop yield (1988). So, not only does increase land productivity support the transition from agriculture to industry but also increases the level of water pollution from soil erosion and pesticide and fertilizer runoff as a result of increased mechanization of agricultural practices and increased use of fertilizers and pesticides to increase per acre yield results.

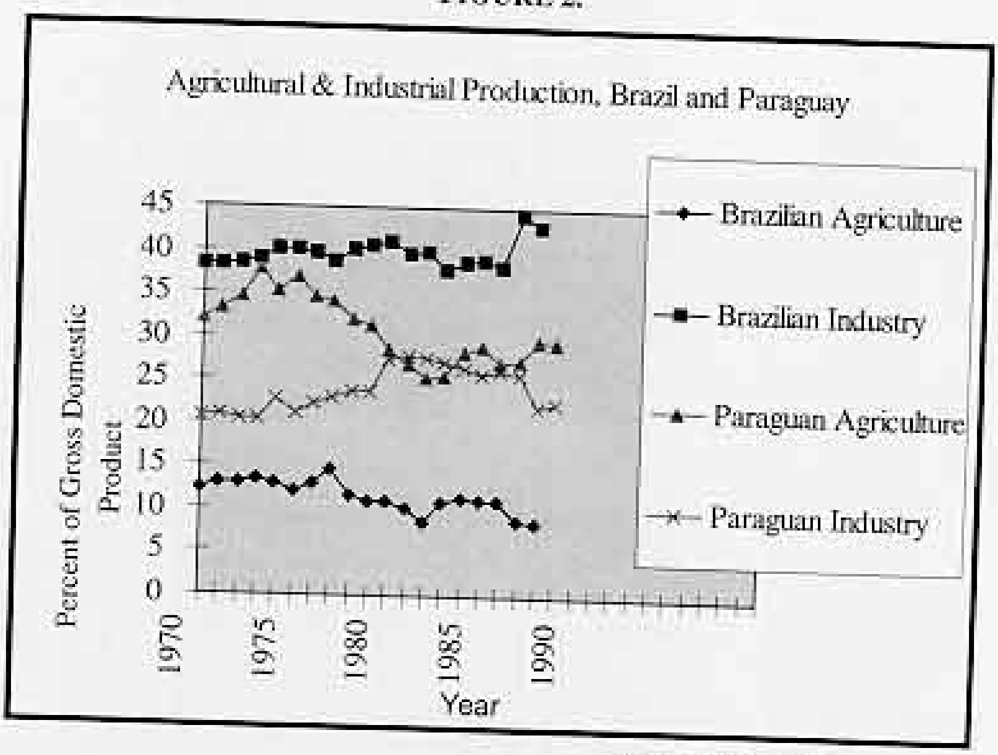
FIGURE 1.



Source: World Resources Institute, 1994

Again, as the agricultural sector increases its ability to support larger populations, more labor is free to migrate to the industrial sector. Figure 2. shows trends of relative levels of agricultural and industrial activity within two select southern countries.

FIGURE 2.



Source: World Resources Institute, 1994

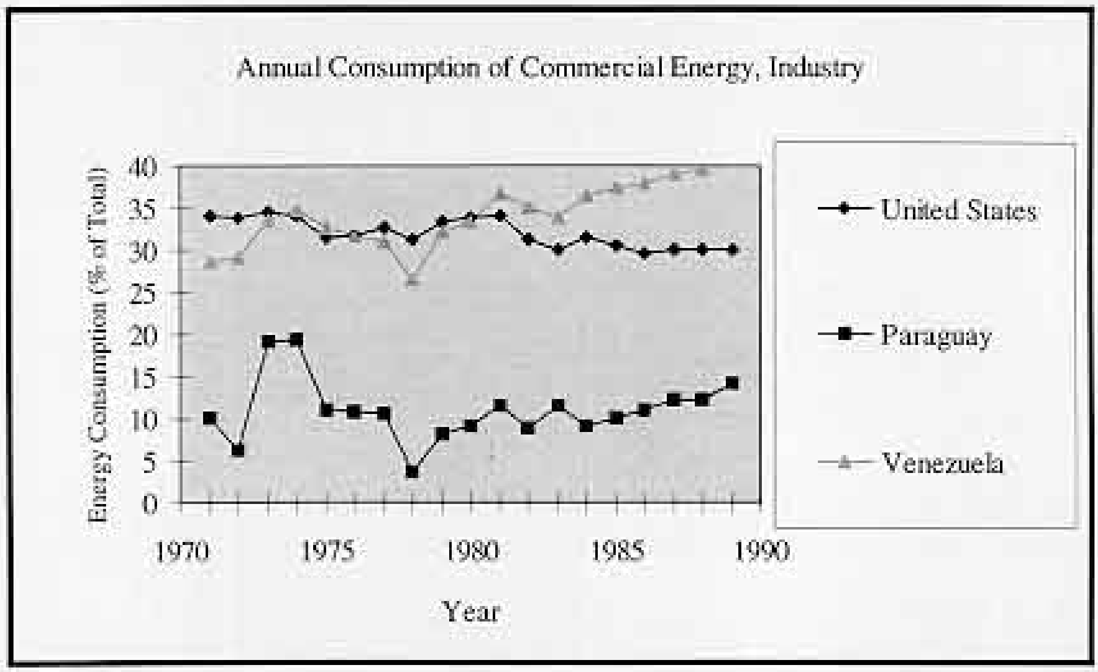
Because it has not been determined which sector change occurred first - decrease in agriculture or an increase in industry - it can only be said that these two sectors have an inverse relationship to one and another. This, however, is characteristic of a dynamic relationship. Relationships are not always linear, nor is there always a one way flow of influence. Two or more factor can work simultaneously on each other in opposing manners: trends in agriculture influences industry as trends in industry influences agriculture.

The South in Change: the Industrialization, Energy Consumption, and Pollution Connection

The development of the Colonial South is not much unlike the development of the American South around the turn of the century. The American South, eager to experience the wonders of wealth, heavily exploited it raw natural resources. They exported those resources to the North, who, in turn, used those materials in their manufacturing processes, and produced value-added goods, which where subsequently sold back to the South at a substantial profit. A few of the merchant commercialists, who monopolized this trade pattern, became rich off the relationship, but most Southerners were adversely affected. With resources beginning to deplete, the South, who had nearly 30% of the country's population had only 10% of its nonagricultural wealth (Cobb, 1984). Today, the old Colonial South of Central and South America is following much the same pattern. As a result of rapid industrialization in this region, countries are encouraging export-industries to make use of their cheap natural resources and generate economic growth by providing low level, unskilled labor jobs (Leonard, 1988). This only serves to improve the balance-of-payment outlook and deplete valuable natural resource reserves prior to the development of the country's own self-sustainable industrial sector.

Like the turn of the century American South, the Colonial South not only requires vast new sources of energy, but usually acquires - through transfers from the North - old, outdated environmentally dirty technologies and capital to accommodate its increased need for energy (Cobb, 1984, Leonard, 1988). So, as the South develops, it does so in an energy and pollution intensive manner. Figure 3. illustrates increases in a few representative Southern countries. The U.S. appears to be fairly constant in its energy consumption, whereas Venezuela and Paraguay experience an upward trend in commercial energy consumption by industry. The three downward trends in energy consumption in and around 1978 points out a global energy crisis. This one event would have the effect of suppressing economic growth by immediately limiting available energy. Venezuela hovers around the same level of industrial energy consumption as does the United States, with an increase in the late 80's. Arguably, the decrease in U.S. energy consumption may be occurring due to an increase in use of more energy efficient equipment, or from a shift from a high-energy demanding, industrially based economy to one that is more focused on a less-energy demanding: a technology based economy.

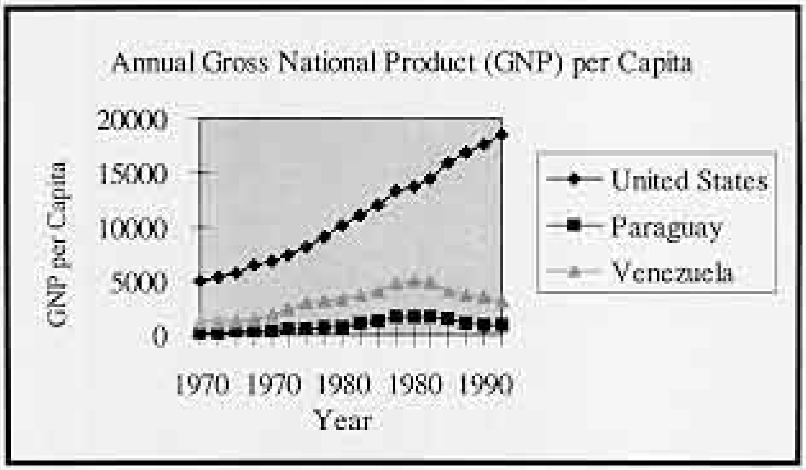
FIGURE 3.



Source: World Resources Institute, 1994

Energy consumption, as a percent of the total, might indicate the development of the economy. Annual Gross National Product per capita is also a good indicator of economic strength (Figure 4.).

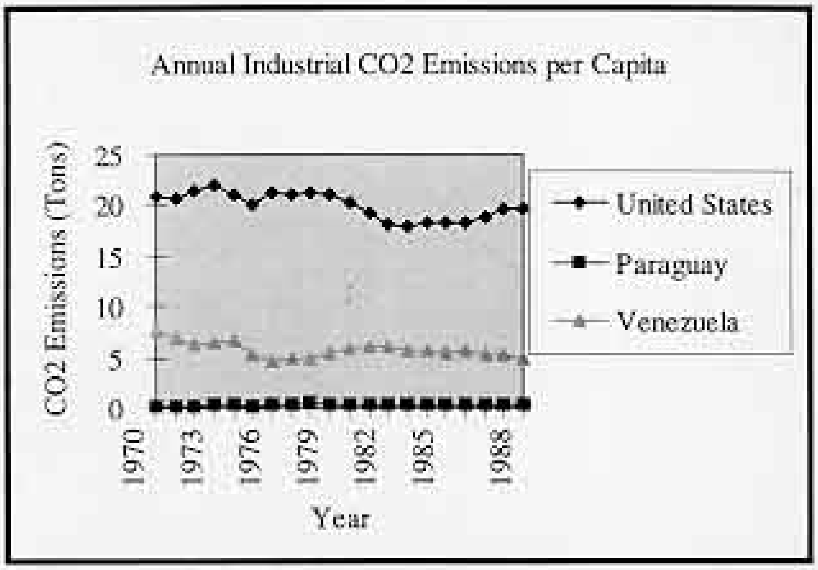
FIGURE 4.



Source: World Resources Institute, 1994

Thus Venezuela's higher ranking above Paraguay in both categories in Figures 3. and 4. strongly suggests that Venezuela has attained a higher level of economic development as compared to Paraguay. Figure 5. looks at annual industrial CO_2 emissions per capita. Comparing the magnitudes of per capita pollution reiterates the premise that as a country industrializes, level of pollution and environmental degradation increases.

FIGURE 5.



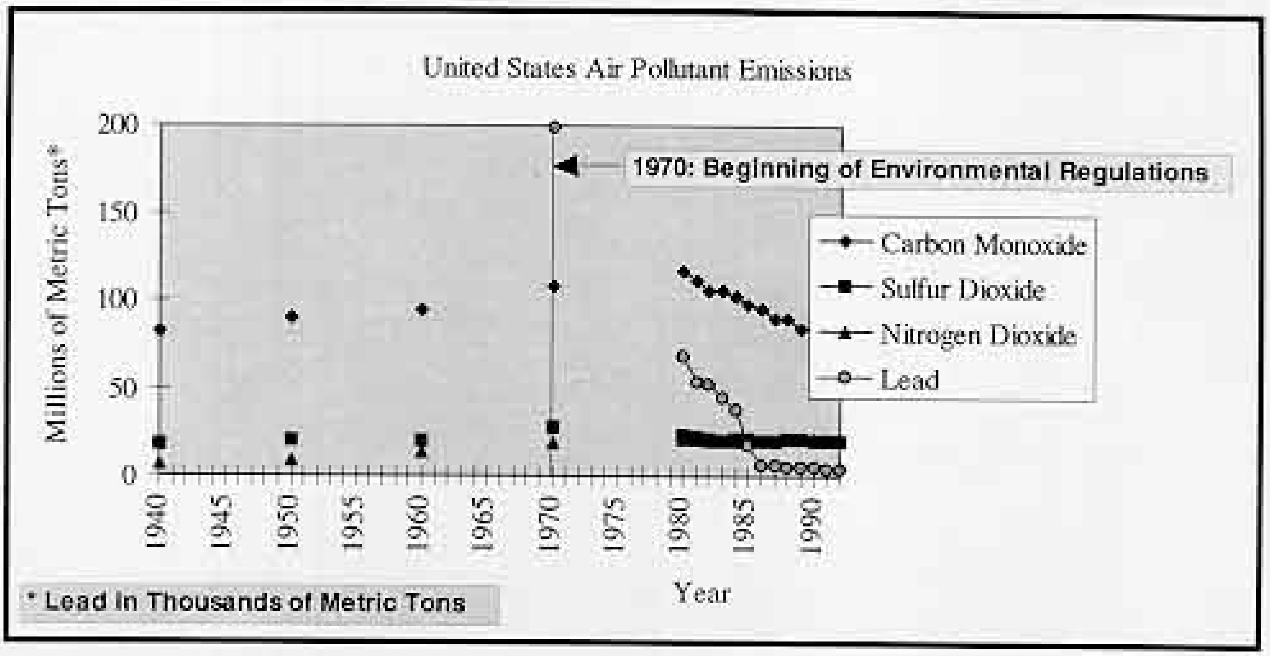
Source: World Resources Institute, 1994

Drake (1993) further describes this relationship as being part of the *Toxicity Transition*. This transition spans the sectors of local surface and ground waters, solid wastes, local air pollution and the global atmosphere, among others. It is characterized by changes in population, a transition from agriculture to industry as the focus of the economy, and a corresponding change in the levels of pollution. The transition begins with low levels of agricultural and industrial production and correspondingly low levels of toxics. As population increases and production shifts from agriculture to industry, levels of toxic by-products increases. Eventually, at a fairly high level of economic development, levels of environmental degradation becomes such that the public begins to demand action to control the pollution. Such was the case with the United States.

The United States: Environmental Regulations

Post World War II was a time for economic and industrial expansion for the U.S. Industrial development increased the standard of living, creating a greater demand for manufactured goods. Such a demand increased the pressures on the environment for additional resources to support further expansion. The environment suffered from not only the extraction of raw resources, but from the generation of wastes and toxic by-products from the manufacturing, use, and end of life stages of the product's life-cycle. The point at which the public demanded environmental remediation is evidenced by the creation of the National Environmental Protection Act (NEPA) in 1970. Throughout the subsequent 20 years came the creation of medium specific environmental regulations focused on air (the Clean Air Act - CAA), water (the Clean Water Act - CWA), and solid and toxic waste (the Resource Conservation and Recovery Act - RCRA, and the Comprehensive Environmental Response, Compensation and Liability Act - CERCLA, respectively). Figure 6. looks at trends of a few emissions covered under the CAA.

FIGURE 6.



Source: U.S. Bureau of the Census, 1994

Clearly, the creation of abatement regulations has had an effect on the output of pollution. Because data is lacking in the 1970's it is difficult to determine how quickly and to what extent the regulations had on effecting change. The 1970 and 1980 data on Carbon Monoxide indicates that a higher peak was reached before levels began to fall. It would be interesting to discover the year of that peak, because that data would allude to the amount of time (time lag) between creation of pollution regulation and visible results. Change is slow, but understanding the scale of change better enables policy makers in determining the correct level of control to deal with the problem. The unavailability of data concerning levels of lead from 1940 to 1980 presents difficulties in determining the high and low levels. Without the baseline of earlier data, it is difficult to determine the extent to which the decrease of lead levels is significant. Again, it is crucial to understand the problem when creating and analyzing a regulatory program.

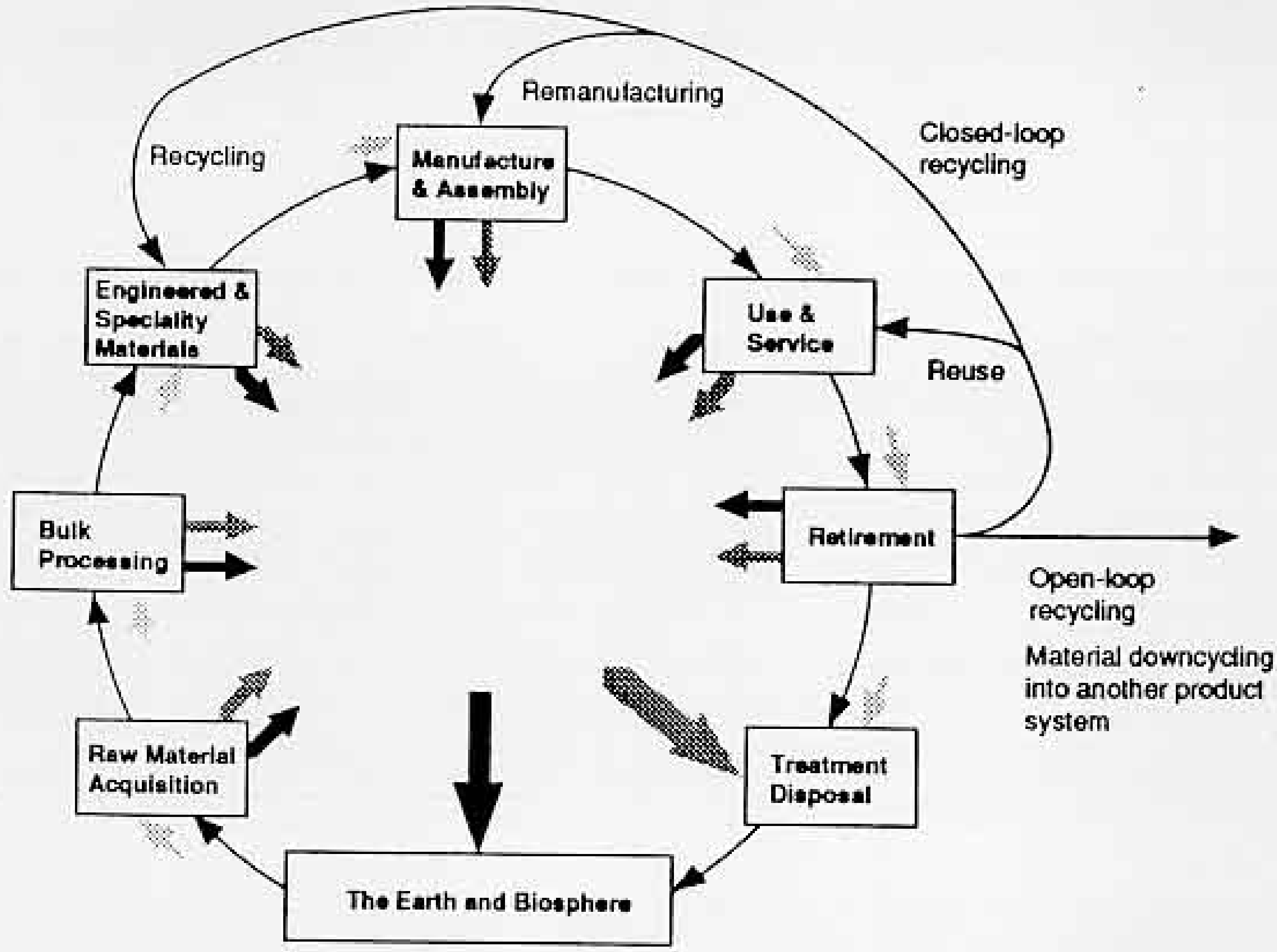
All of the environmental regulations previously mentioned fall under the command-and-control approach where an authoritative body determines policy, procedure, and results. Here, the government determines which substances are to be controlled, by what method, and to what extent or level. Industry has always argued that government regulation is costly and interferes with growth. Indeed, those arguments have been quantified. Tietenberg (1990) finds that the ratio of the cost of command-and-control approaches to those of market-based approaches in the United States is high, which means that command-and-control is significantly more expensive. Out of eleven cases, four had ratios of between 1 and 2, five had ratios between 2 and 10, and two had ratios in excess of 10. Work done by Jorgensen and Wilcoxen (1990) estimates that the rate of growth in the United States of the GNP (1973-1985) would have been .19 percentage points higher without environmental controls. This does not, however, take into consideration the benefits from a cleaner environment: improved long-term health effects, gains in psychological welfare, improvements in amenities and biodiversity, and so on (Pearce and Warford, 1993).

A Framework for Environmental Protection: Pollution Prevention and Design for Environment

A hint of the next generation of environmental regulation came with the passage of the 1990 Pollution Prevention Act (PPA). Although the premise of the act is one of prevention as the best medicine, it did also introduce several new concepts. The first is the idea of Design for Environment. Simply put, this construct considers all aspects of a product, its inputs and outputs, through its life cycle. The stages of a product's life cycle can be organized into the following stages: 1) raw material acquisition, 2) bulk material processing, 3) engineered and specialty materials production, 4) manufacturing and assembly, 5) use and service, 6) retirement, and 7) disposal (Figure 7.) There are also goals which the life cycle concept seeks to promote at each of these stages. These goals are (EPA, January, 1993):

- Conserve Resources
- Prevent Pollution
- Support Environmental Equity
- Preserve Diverse, Sustainable Ecosystems
- Maintain long-term, Viable Economic Systems

FIGURE 7. The Product Life Cycle



- Fugitive and untreated residuals
- Airborne, waterborne, and solid residuals
- Material, energy, and labor inputs for *Process* and *Management*
- Transfer of materials between stages for *Product*; includes transportation and packaging (*Distribution*)

Source: Life Cycle Design Guidance Manual, EPA

The second main concept is the larger umbrella of an Industrial Ecosystem. Jelinski, et al, (1992) defines it as "a concept in which an industrial system is viewed not in isolation from its surrounding systems but in concert with them. Industrial ecology seeks to optimize the total materials cycle from virgin material to finished material, to component, to product, to waste product, and ultimate disposal." He also goes on to describe three models of material flows through ecosystems. Type I is a linear materials flow where unlimited resources enter into an ecosystem component, and exit as unlimited waste. Type II has energy and limited resources entering into a cycle of ecosystem components, and exiting as limited waste. Type III has energy as the only input, entering into a cycle of ecosystem components, resulting in no outputs, or wastes. Under the idea of an industrial ecosystem, current processes could be represented as somewhere along the spectrum between a Type I and Type II system. Design for Environment and Life Cycle Design seek to push the product process towards a Type III system where the is no waste and sustainability is boundless. Again, Figure 7. illustrates the life cycle stages along with pathways towards Type II and III systems. This as a whole can be taken as one ecosystem component. Ecosystem components can be linked together through material downcycling into other product systems.

This concept, if used to its fullest extent in the product production process, can lower the costs of extracting raw materials by using material outputs from other stages of its or other product's life cycle, eliminate the abatement costs of reducing pollution occurring at the end of a life cycle, and can increase the benefits garnished from a cleaner environment, such as the aforementioned improved long-term health effects, gains in psychological welfare, improvements in amenities and biodiversity, and so on. Much can be saved in the reduction of abatement costs, considering that most industrial nations are spending 1-2 percent of their GNP on pollution control (Goodland, et al., 1992).

Barriers to the Framework

Although there can be substantial savings by using this framework, there are certain barriers and limitations to its success. This construct is technology intensive. Environmental protection and life cycle design is based on high levels of technology. The access to and the availability of such technology is usually highly limited in developing countries. Information is critical to this program and the scope of the function of the information is vast. It includes information of available technologies, the problems, the solutions, costs, benefits, available capital, as well as communication and access to information. Analytical information and information dissemination is extremely difficult in low-tech countries who have little in the way of communication networks. Because this framework relies heavily on newer technologies, it often is capital extensive - that is, high levels of capital are needed to afford the technology that can be cost saving in the long run. Again, costs can be prohibitive in developing nations. A stable infrastructure is needed to organize, coordinate, facilitate, and even enforce such a program. Although this is largely a market-based environmental protection program, some oversight is needed. In developed countries, this usually falls to the hands of the government, specifically, the environmental oversight branch of the government. But in countries where civil wars and political unrest are common place, this could pose another problem. One limitation to this approach: it does not encourage the designation of lands, waters, or areas for the purpose of preservation. This is a framework for *sustainable development*, for conservation of resources, not for preservation. Also, it does not address consumption issues or trends in population. Another way to promote sustainable development is to address the underlying issues in resource depletion and environmental degradation: population and consumption patterns.

Solutions to Weaknesses of the Framework

Intraregional cooperation and coordination is probably the single most comprehensive solution to the barriers to the framework. The intraregional group - a block of countries working together for a similar purpose, such as the North American Free Trade Agreement (NAFTA) block - must have a stable, economically and technologically well-developed country as a member. This member must be willing to provide technical and informational support to the other cooperative members. The more developed nation acts as a facilitator and a clearinghouse. Non-governmental Organizations (NGOs), who specialized in environmental issues and world development, such as the World Bank and or some working groups of the United Nations, can provide capital for start up costs, some environmental enforcement, and analytical support to evaluate results of new technologies and programs. If the program can not be analyzed then it can not be successfully run. Analytical support is crucial. NGOs and supporting developed countries will provide the stability needed to maintain the program.

Area preservation programs and programs to address underlining issues of population and consumption patterns must compliment this framework. Again, pollution prevention and life cycle analysis is not intended as a stand alone, cure-all model. It must work in harmony with other models in order to fully address the complexity of transitional changes and environmental degradation.

Conclusion

As the South continues to develop, environmental degradation will excel at alarming rates. Due to the nature of the resource base and the quality of the land, this stress will not be easily handled. The ramifications of such environmental stress could be felt for centuries. If developing worlds follow the path taken be the current developed worlds towards environmental abatement through medium by medium, end-of-pipe regulation, the damage already incurred may be too significant to correct. Alternative solutions must be sought. A framework of pollution prevention and life cycle design would be appropriate in this case. This framework works within the market, not against it. As a result, economic growth is not ebbed as it is by more traditional regulations. There are some significant barriers to implementing a program such as this successfully in developing worlds. But alone with intraregional cooperation, following a set of guidelines can increase the successs of the program (Tolba and Biswas, 1991):

- Strengthening policies and institutions
- Expanding technical training
- Improving information dissemination and awareness building at the producer level
- Integrating traditional production systems with advanced technologies
- Research and development
- Technical assistance which meets the need of the individual

With these policy goals in place, pollution prevention and life cycle design can be integrated with other frameworks to cover the multi-faceted nature of transition to an industrial state, while maintaining the integrity of the environment.

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Back issues of Solstice are available on the WebSite of the Institute of Mathematical Geography, http://www-personal.umich.edu/~sarhaus/image and on the GOPHER of the Arizona State University Department of Mathematics. Thanks to B ruce Long for taking the initiative in this matter. The connections to this GOPHER are available along a variety of routes through the Internet.

PUBLICATION INFORMATION

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1. FIFTH ANNIVERSARY OF SOLSTICE The current issue marks the beginning of the second half of the first decade of Solstice. Thanks to all who have participated in this project--editors, authors, and readers, alike! Over the course of the past five years, Solstice has garnered attention from the media. If you know of additional citations, please share them with us for our electronic scrapbook! Thank you. Science (AAAS) "Online Journals," [Joseph Palca] 29 November 1991, Vol. 254. Science News "Math for all seasons" Ivars Peterson, Jan. 25, 1992, Vol. 141, No. 4. Newsletter of the Association of American Geographers, June, 1992. American Mathematical Monthly, September, 1992. American Mathematical Monthly, September, 1992. Harvard Technology Window, 1993. Graduating Engineering Magazine, 1993. Earth Surface Processes and Landforms, 18 (9), 1993, p. 874. On Internet, 1994. Papers in Regional Science: The Journal of the Regional Science Association. "Wide Area Computer Networks and Scholarly Communication in Regional Science." Gunther Maier and Andreas Wildberger.

2. NEW FORMAT FOR SOLSTICE AND NEW TECHNICAL EDITOR With this issue, we work to make Solstice available to a wider readership. For the first five years, all articles were typeset using TeX, the typesetting program of Donald Knuth and the American Mathematical Society. Our goal is to continue to provide text that is available to a wide variety of readers; thus, we do transmit directly so that those without Gopher access can read Solstice. Surely one great advantage of e-mail is the ease with which it can deliver information to points remote from its source. We also wish to push the text delivery in the directions of current technology, as well. Richard Wallace has kindly agreed to serve as Technical Editor of Solstice, working in conjunction with the Editor-in-Chief, to continue to develop innovative presentations that take advantage of current technology. With this issue, we transmit a separate packet of figures to accompany the single text file. In the future, we hope to have World Wide Web access to Solstice, in addtion to the direct delivery via e-mail and continuing archiving on a Gopher. When the mathematics used requires it, we intend to offer that notation within the direct e-mail transmission (as we have in the past).

3. MOTOR VEHICLE TRANSPORT AND GLOBAL CLIMATE CHANGE: POLICY SCENARIOS Richard Wallace The University of Michigan Urban, Technological, and Environmental Planning Driven largely by rapidly increasing atmospheric levels of greenhouse gases, such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (CFCs), the global climate appears to many observers (e.g., Meadows, Meadows, and Randers 1992) to be in a period of change. Computer models suggest that throughout most of the temperate zones of the world this change will take the form of rising temperatures. Motor vehicles, which are powered by fossil-fuel burning engines that emit carbon dioxide and nitrous oxide, contribute significantly to the production of potentially climate altering greenhouse gases. Simply put, carbon dioxide "is an inevitable byproduct of fossil fuel consumption and it streams out of tail pipes in direct proportion to the quantity of fuel burned" (Wilkinson 1993). On average, for every kilogram of standard motor vehicle fuel (gasoline) consumed, three kilograms of carbon dioxide are released into the atmosphere (Faiz 1993). Furthermore, motor vehicles emit other greenhouse gases, too, such as CFCs that leak from air conditioners. Thus, while improved fuel economy can have a mitigating effect on total greenhouse emissions, in general the greater the number of motor vehicles, and the more miles that they are driven, the larger their contribution to global climate change. Therefore, understanding trends in the number of vehicles registered and examining policy options to curb growth in this number can play a significant role in combating global climate change. Worldwide, transport energy accounts for about 20 percent of total emissions of greenhouse gases (Lashof and Tirpak 1990), but this figure varies from nation to nation. In the OECD nations as a whole, transport contributes between 26 and 31 percent of all greenhouse emissions produced there, while in the U.S. transport accounts for 38 percent of domestic greenhouse emissions (International Energy Agency 1993). In the Less Developed Countries (LDCs) and in Eastern Europe, largely due to lower rates of car ownership and use, the transport sector currently accounts for a smaller contribution to greenhouse emissions (Faiz 1993), but these nations represent a burgeoning new market for vehicles. As a result, greenhouse emissions from the LDCs are expected to rise in the near future. By contributing significantly to greenhouse gas emissions and, therefore, to global climate change, the motor vehicle sector plays a role in the general class of phenomena known as population-environment dynamics. This dynamic, as described by Drake (1993), is characterized by transitions from one stable state to another. While the second stable state may be a more or less desirable state than the original condition, and it is often worse (e.g., the transition from forest to desert that is taking place in some regions), Drake argues, and offers supporting data, that the transition phase itself is a period of vulnerability, characterized by the potential for extremely negative outcomes. Transitions, however, also offer opportunities, and positive outcomes can occur, too, especially if appropriate policies are pursued to manage the transition. Thus, while human society and environmental systems both may survive under a new climatic regime, the transition period may prove to be the most dangerous period of all. The field of population-environment dynamics thus leads us to see not only that transport affects the global environment, but also that transport emissions of greenhouse gases are not purely a function of the number of vehicles, miles driven, fuel use, and emissions technology. Worldwide, the ratio of people to motor vehicles varies considerably from nation to nation. While we might expect this ratio to be highly correlated with GNP per capita, a simple linear regression fails to detect a significant relationship between these two variables. Approaching this relationship geographically (see Figure 1), however, reveals a clear relationship--wealthier nations in general have a lower ratio of vehicles per person. Figure 1. Map. Persons Per Auto with GNP. Bivariate thematic map. Population growth, too, can have an effect on the number of vehicles. By examining trends and relationships in and between these technological and social factors, this paper seeks to investigate the efficacy of different policy options on reducing the quantity of greenhouse emissions from the transport sector. This analysis will be performed for six nations that typify the range of transport, economic, and population dynamics across the globe. By examining nations that differ in these key respects, the analysis will illustrate different dimensions of the dynamic and provide policy guidance tailored to the specific circumstances of each nation and beyond to the world community. The six nations examined here, and the patterns that they represent, are listed in Table 1. Table 1. Nation Pattern United States Wealthy, high use of autos and energy Japan Wealthy, more emphasis on public transit and more energy efficient Hungary Former Eastern Block, dirty cars India Less developed, low car ownership, booming population Mexico Latin American, Industrializing South Korea Asian Newly Industrialized Country (NIC) While no rigorous attempt will be made to justify this categorization, a few observations backed by data collected by the World Resources Institute (WRD) and the American Automobile Manufacturers Association (AAMA) provides it some legitimacy. First, vehicle technology varies substantially between the most highly industrialized nations and the rest of the world. The typical vehicle manufactured in Eastern Europe and the LDCs is only about half as fuel efficient as typical OECD-manufactured vehicles (Faiz 1993). Second, an examination of trends in the number of registered vehicles in Hungary, India, Mexico, and South Korea (see Figure 2) reveals a clear distinction between them, with the two industrializing nations (South Korea and Mexico) showing an especially steep growth curve, India showing a slower rate of growth, and Hungary showing little growth at all. Based on this evidence, these six nations do appear to represent distinct patterns. Figure 2. Motor Vehicle Registrations. **Patterns of Vehicle Use** Across the six nations listed in Table 1, reliance on motor vehicles for transportation varies greatly. In 1992, for example, India and South Korea each had roughly the same number of motor vehicles registered, but India's population was nearly twenty times that of South Korea. On the other hand, of these six nations, India, which had by far the highest ratio of people to vehicles in 1992, experienced the largest absolute drop in this figure over the last twenty years (see Figure 3, which is drawn to log scale so that all six nations may be viewed on one graph). Thus, while the U.S. and Japan currently are the largest contributors to greenhouse emissions from the transportation sector, population and consumption trends suggest that other nations will account for an ever-increasing percentage of transportation's contribution to greenhouse gas emissions in the future. Figure 3. Persons Per Auto, 1970-1992. Figure 3 shows that all six nations, with the exception of the U.S., still are experiencing a decline in the ratio of people to vehicles. What is driving this trend, however, varies from nation to nation. In some cases, rising consumption, as measured by GNP growth, appears to be the driving factor, while in others increasing urbanization as measured by urban population, appears to be the culprit. Epitomizing these two dynamics are Japan, South Korea, and Hungary. In Japan (see Figure 4), the increase in vehicle registrations appears to have been driven largely by increases in population and urbanization in the early post-war years, with more recent gains appearing to be more associated with increased GNP. By comparison, South Korea (see Figure 5), displays a relationship between increased vehicle registrations and a rising GNP, with population appearing to have little effect. Finally, Hungary (see Figure 6) displays a combination of the two effects, with both urban population growth (despite a steady total population) and GNP growth associated with increased vehicle registrations during the study period. Figure 4. Japan. Figure 5. South Korea. Figure 6. Hungary. **Policy Options** As described by Meadows, Meadows, and Randers (1992), environmental impacts can be viewed as a function of population, consumption patterns, and the state of technology. These variables also appear within the policy options available to reduce the contribution of the transportation sector to greenhouse gas emissions. Among these are: (1) increased fuel efficiency, (2) reliance on alternative fuels, (3) reliance on public transportation and other travel behavior approaches, (4) consumption limits, and (5) population-control policies. While these approaches range from technological fixes to changes in societal norms, even the technology-based approaches demand a corresponding societal component. Increasing fuel efficiency, for example, requires the political will to raise minimum standards, and increasing use of public transportation requires alteration of travel behavior. If we are to explore the likely effectiveness of each of these policies, we must first understand how and what each contributes to the reduction in emissions of greenhouse gases and, where possible, gauge how this dynamic might play out in the near future--not an easy undertaking. Given a rather large body of research and literature in the field, gauging future technical abilities is perhaps the simplest forecasting task. DeLuchi (1993) has estimated the reduction in greenhouse gas emissions from a variety of alternative fuel sources. His findings indicate a broad range of outcomes depending on the source of the alternative power. Electric vehicles powered by coal-burning plants, for example, can be expected to lead to an increase in the amount of greenhouse emissions compared to a standard gasoline- or diesel-burning vehicle. Emissions reductions, however, would be realized from a variety of alternative fuels, including solar-powered electric, compressed natural gas, methanol (from wood), and ethanol (from several sources). The International Energy Agency (IEA; 1993) produced similar findings, also adding liquid hydrogen to the list of alternative fuels that would reduce greenhouse emissions. Using middle estimates from the latter source, anywhere from a 25 to 50 percent reduction in emissions appears feasible. Recent technological breakthroughs in the manufacture of photovoltaic panels, which suggest the possibility of producing solar energy at very competitive market rates by next year, promise to make this figure even higher (Myerson 1994). The IEA also studied potential improvements to fuel economy and found that by 2006 a 10 to 20 percent improvement is feasible for OECD nations. This estimate is conservative and is based only on marginal improvements to currently employed vehicle technologies and materials. Other researchers, however, have cast aside such industry-bound restraints and discussed what could be done even today using technical inputs from beyond the traditional steel-centered perspective of the global auto industry. Typifying this approach, Lovins and Lovins (1994) tout the revolutionary potential of a new car design known as an ultralight hybrid. These light-weight vehicles, manufactured from high-tech composite materials such as carbon fiber, and powered by a combination of liquid fuel and a battery-powered flywheel that captures and stores energy now lost during braking, offer a tenfold improvement in fuel economy over today's typical car. These vehicles also offer equal or better safety, mostly because, pound for pound, these ultralight materials possess far superior crash resistance than does steel. As the Lovins's recognize, bringing such vehicles to market will require a major restructuring of the auto industry, but large auto companies that resist making these changes may soon be leapfrogged by other manufacturers, such as former defense contractors, more experienced with these new materials. Public transportation provides another alternative to reliance on motor vehicles. Although increased urbanization seems to be a factor associated with increased vehicle registrations, public transportation works best in urbanized areas. Which effect seems to dominate may be a consequence of urban density. As Newman and Kenworthy (1991) showed in their study of 32 of the world's major cities, per capita consumption of gasoline can vary considerably, even across affluent nations. They found that, generally, in high-density cities such as Tokyo, per capita gasoline consumption is far less (about 1/6) than in relatively low-density U.S. cities. Much of this difference can be explained by examining the rate of transit use between these cities. The average resident of Tokyo takes 472 transit trips per year, while the typical New Yorker takes 58 and a Detroiter only 17; vehicle ownership rates may be similar in Japan and the U.S., but vehicle use is lower in high density areas. Given the relationship between fuel consumption and greenhouse emissions, less vehicle use results in less greenhouse emissions. Consumption limits represent perhaps the most difficult policy option to address. While draconian laws certainly hold out the promise of being effective in reducing reliance on motor vehicles, such approaches carry high social costs and appear incompatible with dominant social and political standards in much of the world. Fortunately, policies exist that achieve the goal of reduced consumption without serious intrusions on individual liberties. On the regulatory side, for example, implementation and enforcement of vehicle occupancy regulations can reduce the preponderance of singly-occupied vehicles. On the market-based side, high fuel taxes provide economic incentives for people to choose non-vehicular travel modes, as does the elimination of free parking in employment centers (Wachs 1981). Finally, in those nations experiencing rapid population growth, policies aimed at slowing or reducing population growth may have some promise in reducing their transportation sector's contribution to greenhouse emissions. On the other hand, it may be that controlling population will increase wealth in these nations, thereby increasing demand for motor vehicles. Either way, India, with its large population of would-be motorists, has an enormous potential to contribute to greenhouse emissions, and the ratio of people to motor vehicles in India has been falling. **Tailoring Policy to Population-Environment Conditions** Given differences in the forces influencing increased motor vehicle registrations, and therefore increased greenhouse emissions, the range of potentially effective policy options available to each nation also is likely to be different. Each of these policy options thus is best suited to a particular set of political, technological, economic, and societal conditions. A policy that promises to be effective in one country, therefore, may be inappropriate for another. Population-control measures, for example, appear to be an unlikely candidate to reduce greenhouse emissions from the transportation sector in nations such as Hungary that are experiencing little or no population growth. The task at hand, therefore, is to match policies to nations in the most effective manner. Doing so requires forecasting growth in the motor vehicle population, particularly the fossil-fuel powered motor-vehicle population, within the societal context of each nation. To start this analysis, let us begin with the number one emitter of greenhouse gases via motor vehicles--the United States. Because the U.S. has so many more motor vehicles than any other nation, reducing emissions in the U.S. alone would signal progress toward worldwide reduction. As can be seen in Figure 7, the U.S. is undergoing a steep rise in GNP, alongwith a moderate rise in both total and urban population. The rate of increase in the number of registered automobiles, however, appears to be declining. The already enormous number of vehicles registered in the U.S. points to the need of reducing either the per-capita use of each vehicle or the amount of emissions per vehicle or both. This state of high wealth and an abundance of motor vehicles suggests pursuing one or more of the technological approaches listed above--California's mandate that two percent of vehicles sold be zero-emissions vehicles by 1998 (and 10 percent by 2005) is a good example--along with some modifications to travel behavior, such as increasing the importance of public transportation. Based on these policy pursuits, future vehicle registrations for the U.S. can be projected. Figure 7. United States. To begin forecasting, we first need to find a good fit to the current trend in vehicle registrations. From Figure 7, the growth in the number of motor vehicles in the U.S. appears to be S-shaped, suggesting a logistic (or other similar) function. Assuming a maximum value of 225,000,000 cars by 2025, an S-shaped curve can be fit successfully to the data. Furthermore, following California's lead, we can mandate that one percent of all vehicles registered be zero emissions by 1998. Next, we can go a step further and assume that the zero-emissions portion of the vehicle fleet will increase by one percent each year thereafter. As shown in Figure 8, this scenario implies a gradual decrease in the number of fossil-fuel powered vehicles, with this number falling below current levels by 2005 and continuing down to 160 million (more than 30 million below the current number) by 2025. While this decrease is modest, combining it with increased fuel economy in remaining fossil-fuel-powered vehicles, and at worst, no increase in vehicle miles traveled per vehicle, could multiply the result by a factor of ten or so. In effect, this means the equivalent of about 16 million of today's motor vehicles--a figure not seen in the U.S. since the mid-1920s. Figure 8. Vehicle Registrations--United States. For Japan, the other economic powerhouse in the analysis, technological solutions also are appealing. As can be seen in Figure 4, however, growth in motor vehicle registrations in Japan continues at what appears to be a linear rate (with r^2=0.99 when beginning with the year 1960, this trend is fit better by a straight line than either an exponential or logistic curve), driven by a growing GNP. If this linear trend continues, Japan will have about 125 million registered motor vehicles by 2025 (see Figure 9). Assuming a similar pattern of switching to zero-emissions vehicles as was forecast for the U.S., we find that the number of fossil fuel vehicles does begin to assume an S-shaped curve. Like the U.S., Japan would appear to have the technical and economic means to also pursue fuel-economy improvements, too. Again, another tenfold increase in effectiveness is possible, meaning the equivalent of a little more than 9 million of today's cars by 2025. As discussed earlier, Japan also displays less reliance on the cars that are registered. If this pattern also continues, then the effectiveness of Japanese efforts to reduce greenhouse emissions can be further enhanced. Figure 9. Vehicle Registrations--Japan. In Hungary, as we saw in Figure 3, the population growth rate is close to zero. Nonetheless, the urban population continues to grow, as does the number of registered vehicles. Currently, however, Hungary has the fewest registered vehicles of all six nations included in this study, but many of these cars are relatively high polluting and inefficient vehicles based on the engine technology typical of Eastern European nations (Michelberger 1991). To a large extent, then, Hungary's contribution to greenhouse emissions is related to poor vehicle technology. Thus the ongoing replacement of its fleet of older, outdated vehicles with newer, Western-style vehicles offers a sure path to fewer overall emissions. This dynamic, however, competes with growth in the size of the vehicle fleet. This growth is fit well by both a linear and a logistic curve (with a maximum value of 5 million), with these two not diverging by much until around 2010 (see Figure 10). This result suggests that Hungarian transportation policy stands able to influence future growth in vehicles: Hungary can choose to maintain and improve alternate modes (especially public transit) or accept the consequences of a vehicle-centered society. Either way, however, Hungary will continue to have the smallest vehicle fleet in this study and can be expected to make only a small contribution to greenhouse emissions. Figure 10. Vehicle Registrations--Hungary. India, which has yet to see its population growth rate begin declining, has been projected to soon overtake China as the world's most populous nation (see Figure 11). Relative to this enormous population, however, India has a very low number of registered vehicles. In the near term, the rate of growth in the vehicle population, however, is exponential, regardless of whether an exponential or logistic function (with a maximum value of either 140 or 200 million) is fit to the actual data (see Figure 12). Thus India's growth rate in this area may not be boundless, but current trends suggest that India eventually will meet or surpass the number of motor vehicles currently registered in the U.S. Figure 11. India. Figure 12. Vehicle Registrations--India. Given this growth in vehicle registrations, India can be expected to experience increased negative consequences of fossil-fuel based travel, including worsening congestion and pollution, and to dramatically increase its contribution to greenhouse emissions from the transportation sector. The level at which this growth is bounded, along with which technologies and policies India applies to mitigate these problems (e.g., alternative fuels, emissions controls, demand management), will determine the severity of future outcomes and India's contribution to greenhouse emissions. Unfortunately, however, India does not appear to have the economic strength to address this problem with technological approaches, save what may accrue naturally from advancing vehicle technology. Developing infrastructures for alternative fuels, for example, would appear unlikely in the near future. These leaves India with only one option from the above list of policies for addressing greenhouse gas emissions from transportation--travel behavior measures. In this regard, India already relies predominantly on non-motorized forms of personal transit in rural areas and on high vehicle-occupancy rates in urban areas. Restricting access to vehicle purchases--perhaps unpopular with the growing middle class--and financial disincentives, such as a high fuel tax, for vehicle travel both are options worth considering. Excluding the U.S. and Japan, Mexico has far more registered vehicles than the other nations in this study and, as Figure 1 shows, trails only OECD nations and Australia in having a low people to vehicle ratio. As in India, in Mexico both the population and the motor-vehicle fleet are growing quickly, but Mexico possesses a much stronger economy than does India. As can be seen in Figure 13, Mexico's GNP has shown a strong increase--despite a brief setback in the early 1980s--over the last 25 years; meanwhile, both its total and urban population have grown steadily. During the period of economic decline in the early 1980s, motor vehicle registrations also stagnated, but did not decline. This suggests a strong and tight temporal relationship in Mexico between GNP and vehicle registrations (r^2=0.87 for a simple linear model since 1970 for a relationship that would seem to demand a time lag). Therefore, if Mexico's GNP continues to rise--perhaps as a result of NAFTA--then vehicle registrations also should soar, barring a policy intervention. Figure 13. Mexico. In many ways, the situation in South Korea closely resembles that in Mexico: GNP, vehicle registrations, population, and urban population all are rising--most of these rapidly. In South Korea, however, the economy did not decline in the early 1980s and the rate of population growth began declining shortly after 1950, while Mexico is just now beginning to see its rate of population growth decline. As a result, motor vehicle registrations have grown exponentially in South Korea with no break since 1970. Clearly, however, this growth cannot be unbounded, because it were it would lead to nearly one billion registered vehicles by 2025--about 200 cars per person! Therefore, we must assume a logistic growth rate, bounded at about 50 million, or one per person (see Figure 14). Figure 14. Vehicle Registrations--South Korea. This curve fit indicates a nearly tenfold increase in South Korea's motor vehicle fleet, which can be expected to increase South Korea's contribution to greenhouse gas emissions. Given South Korea's strong economic position and world class domestic vehicle production facilities, however, South Korea, like the U.S. and Japan, stands in a good position to pursue technology as one policy approach for mitigating the effects of a growing vehicle fleet. Furthermore, given that most of South Korea's population is urban, the maintenance of public transportation and the restriction of parking in city areas offer parallel options aimed at the behavioral side of the equation. **Discussion** Overall, all nations in this study displayed a propensity toward more motor vehicle registrations and, hence, increased greenhouse emissions. Furthermore, all save Hungary, either already are or soon will be large contributors on a global scale. Analysis of trend data, however, also shows that all five nations faced with this problem have available policy options that will allow them to mitigate the problem, perhaps even leading to a net decline in greenhouse emissions from the motor vehicle sector. As expected, the likely solutions that emerged from the data vary from nation to nation. In general, the nations with high GNPs, domestic auto industries, and low rates of population growth seem best poised to pursue technologically based remedies, including transitioning to alternative fuels and mandating improved fuel economy. Such nations also appear able to benefit from changes in travel behavior. While numerous approaches to reducing the reliance on vehicular travel have been proposed, including following the European lead of internalizing some of the social costs of driving into car and fuel prices, none have been greeted enthusiastically in the U.S. In Japan and South Korea, where such policies do exist, car ownership is associated with status, prestige, and other difficult-to-overcome attributes. Two related possibilities that have some promise in all three nations are road pricing and congestion pricing. These two policies are both aimed at capturing some of the social costs of driving by introducing per-trip tolls based on mileage, time of travel, or both, thereby increasing the marginal cost of a vehicle trip (Gomez-Ibanez 1992). Congestion pricing already has succeeded in reducing traffic volume in places such as Singapore, and California soon will unveil a congestion pricing scheme in the Anaheim-to-Riverside corridor. In Hungary and the rest of Eastern Europe, typified by little or no population growth and outdated vehicle technology, technological advances again appear to be the best path to reduced greenhouse emissions, but the relevant technologies are different than what was prescribed for the U.S. and Japan. Rather than expecting a transition to ultralights and super-efficient cars of tomorrow, Hungary and other Eastern European nations can be served well simply by allowing market forces to engender a transition from 1970s to 1990s technology, while at the same time taking steps to protect against the development of an autocentric culture. In this regard, following the lead of their Western-European neighbors and internalizing the social costs of driving should provide an ameliorative influence. For third world nations, characterized here by India, technological solutions appear to be out of reach due to economic factors. Although the transportation sector in such nations currently makes a relatively small contribution to global greenhouse emissions, large populations and the hope of future economic development leave these nations poised to dramatically increase their vehicle use and greenhouse emissions. In these nations, a policy emphasis on travel behavior patterns appears to be most appropriate. If pursued, such a policy may allow such nations to avoid developing an emissions problem in the first place. Finally, for nations such as Mexico caught squarely in the middle of larger and more unstable population and economic transitions, the motor-vehicle future is far more difficult to predict. Compared to South Korea--a developing nation nearing the end of its development transition and on a par economically with the developed world--Mexico has yet to enter an exponential growth phase in motor vehicle registrations (a simple linear model better fits vehicle registrations than does an exponential curve). Probably, Mexico and similar nations have the possibility of pursuing all policies available--bringing the latest technology into their vehicle fleet when possible, promoting public transit, while at the some time bringing population growth under control--to avoid entering this vehicle growth spurt. Therefore, these nations have the opportunity to approach or match the OECD nations in economic development without falling prey to at least one of the ills of life in the industrialized world--over reliance on motor vehicles. Thus, the transition period presents nations with two paths, and the selection of one or the other is to a large extent within the control of policy. One path--chosen explicitly or implicitly by South Korea--closely follows the Western world and leads to over-reliance on motor vehicles and increased environmental degradation on a global scale. The other path, less traveled and partially unexplored, appears to lead to economic development that is more friendly to the global environment. As described by chaos theory (see, e.g., Prigogine and Stengers 1984), periods of uncertainty may quickly give rise to irreversible outcomes. Therefore, the selection of a path to follow is crucial, and evidence from the industrialized world suggests that choosing the motor-vehicle dominated path is costly to the global environment and may dictate an undesirable future from which there may be no escape. **Conclusion** The ultimate effects of greenhouse gases on the global climate remain uncertain. Even more uncertain is how these global changes will play out at local and regional scales. Some still argue that global climate change is either not occurring or not dangerous even if it is occurring. Others, of course, predict dire consequences if global climate change is not halted (Brown, et al. 1994). Following Drake, however, we must not neglect the possibility that the period during which the climate is changing, and not the resultant state of the future global climate, is the period most deserving of close scrutiny and remedial action. That period is now. By following some or all of the policy recommendations discussed in this paper, we may yet be able to slow the pace of change, which should serve to mitigate the negative consequences of a transitional period. Furthermore, by not delaying our policy response, we allow scientific research on global climate change to find more answers before we needlessly condemn future generations to a changed global climate of our making. **References** American Automobile Manufacturers Association. World Motor Vehicle Data, 1994 ed. American Solar Energy Society. Alternative Transportation Fuels and Vehicles. Boulder, CO: American Solar Energy Society. DeLuchi, M.A. 1993. 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4. EXPOSITORY ARTICLE DISCRETE MATHEMATICS AND COUNTING DERANGEMENTS IN BLIND WINE TASTINGS JOHN D. NYSTUEN College of Architecture and Urban Planning The University of Michigan SANDRA L. ARLINGHAUS School of Natural Resources and Environment The University of Michigan WILLIAM C. ARLINGHAUS Department of Mathematics and Computer Science Lawrence Technological University The statistician Fisher explained the mathematical basis for the field of "Design of Experiments" in an elegant essay couched in the context of the mathematics of a Lady tasting tea (Fisher, in Newman 1956; Fisher 1971). In Fisher's text, the problem is to analyze completely the likelihood that the Lady can determine whether milk was added to the tea or tea added to milk. Problems associated with the tasting of wines have a number of obvious similarities to Fisher's tea-tasting scenario. We offer an analysis of this related problem, set in the context of Nystuen's wine tasting club. To begin, a brief background of the rules of that club seems in order; indeed, it is often the case that the application is forced to fit the mathematics in order to illustrate the abstract. Here, it is the real-world context that guides the mathematics selected. **Wine Tasting Strategy** The Grand Crew wine club of Ann Arbor has been blind-tasting wines monthly for years. In a blind tasting, several wines are offered with their identity hidden. Not only are labels covered, but the entire bottle is covered as well because the shape and color of the bottle provides some clues as to the identity of the wine. The wines are labeled 1 through n in the order presented. Six to eight wines are tasted at a sitting. Members sip the wines and score each on a scale from 1 to 20, using a scoring method suggested by the American Wine Association. The wines are judged on the basis of quality and individual taster preference. The evening's host is in charge of choosing and presenting the wines. Usually wines of a single variety but from different vineyards, wineries, prices, or distributors are tasted. Two sheets of paper are provided to each taster. One is a blank table with a row for each wine numbered 1 through n in the order presented. The columns on this sheet provide space for comments, the individual's numerical ratings of the wines, average ratings of the group, and the range in scores for each wine. One column is reserved for the member's guess as to the identity of the wine. The second sheet contains information about each wine to be used to match the wines tasted. On this sheet the wines are labeled a, b, c, and so forth, along with information on age, winery, negotiant, and price. The tasters try to match the identity of the wine with their individual rating on sheet 1. The wines are listed in unknown order on the second sheet. The tasters make their decisions by matching the letter identification with the numerical order of presentation. On rare occasions one or more members correctly identifies every wine. More often two or more wines are mislabeled, and quite often the identities seem hopelessly scrambled. Guessing at random would seem just as effective. The question then arises, "what are the chances of getting one, two, more, or all correct by chance alone?" Discrete mathematics and the algebra of derangements provides the answer to this question. Probabilities are a matter of counting. In what proportion does a particular combination of correct and incorrect identifications occur purely at random out of all possible combinations? The denominator in this proportion is a count of all possible arrangements and the numerator is a count of all possible ways a particular event occurs, such as one right, all the rest wrong. The denominator is easily determined. If one has five things any of the five might be chosen first; there remain four things any of which might be chosen next. The process continues until the last stage in which only one can be chosen. Thus, there are 5*4*3*2*1=120 ways to arrange five bottles of wine--the customary notation for this product is 5! (read five factorial). This notation extends to arbitrarily large positive integers in the obvious way; 0! is defined to be 1. The factorial of a number grows rapidly with an increase in the size of the number; thus, 7!=5040 while 8!=40,320. The numerator of the proportion sought is not found as easily. Consider the case of a blind tasting of three bottles of wine. Suppose the first one is correctly identified; the remaining two outcomes must be both right or both wrong. It is not possible to identify two wines correctly and the third one incorrectly. Table 1 illustrates all possible patterns of identification for three bottles of wine, a, b, and c, with bottle "a" presented first, bottle "b" presented second, and bottle "c" presented third. As this table indicates, there is only one arrangement in which all are correct, two arrangements with none correct and three arrangements with two correct. There are, of course, no arrangements with exactly one correct. Table 1. All possible arrangements of three items, a, b, and c. Number of matches and non-matches to the arrangement abc. Matches Non-matches abc 3 0 acb 1 2 bac 1 2 bca 0 3 cab 0 3 cba 1 2 When all possible outcomes, shown in Table 1, are enumerated, it is an easy matter to calculate the probability of each type of event-- to obtain the probability, divide each outcome from Table 1 by 3!, the number of total possible arrangements. Table 2 shows the probability of each outcome: P(0) denotes none right, P(1) denotes exactly one right, and so forth. The sum of all probabilities adds to 1.00, as it should. Table 2. Probability of a correct labeling. P(0) = 2/6 = 0.33 P(1) = 3/6 = 0.50 P(2) = 0/6 = 0.00 P(3) = 1/6 = 0.17 A total enumeration approach to finding the probabilities is satisfactory for introductory purposes and for very small samples. Even for six, seven, or eight wines at a single tasting it is, however, not satisfactory; Table 1 would expand to 720, 5040, or 40,320 columns for each of those cases. Clearly more clever and mathematically elegant ways of counting, rather than brute force listings, are required. In this latter regard, one is reminded of the story of Gauss who, as a young child, astounded his German schoolteacher with an instant result for what the teacher had planned as a tedious exercise. The teacher, in order to keep his students busy, told them to add all the numbers from 1 to 100. Gauss immediately wrote the answer on his slate. He had apparently discovered for himself that the sum, S, of the first n positive integers is given by the recursive relationship S=(n(n+1)/2). Thus, all he had to do was multiply 50 by 101 to obtain the answer: an elegant solution to an otherwise tedious problem. It was the more mature Gauss and later Laplace that would do pioneering work in the Theory of Errors of Observation which in turn would serve as a significant part of the base for applications of mathematics and statistics (in Design of Experiments) in the Scientific Method. **Derangements** For our problem, we need a way to count the number of times a taster can get all the wines right, one wine right and all the others wrong, two wines right and all the others wrong, and so forth. To convert the tedious, brute force task of listing permutations and combinations for this problem, to a more tractable situation, we employ the concept of "derangement," that will eliminate, notationally, combinations that we do not wish to consider. A "derangement" is a permutation of objects that leaves no object in its original position (Rosen 1986; Michaels and Rosen 1991). The permutation badec is a derangement of abcde because no letter is left in its original position. However, baedc is not a derangement of abcde because this permutation leaves d fixed. Thus, the number of times a wine taster gets all the wrong answers in tasting n bottles is the number of derangements of n numbers, D(n), divided by n!: D(n)/n!. The value of D(n) is calculated as a product of n! and a series of terms of alternating plus and minus signs: D(n)=n!(1-1/1!+1/2!-1/3!+1/4!-1/5!+...+((-1)^n)/n!). Readers wishing more detail concerning this formula might refer to Rosen (1988); for the present, we continue to consider the use of derangements. In order to see how derangements can be enumerated visually, we construct the following tree of possibilities for arrangements of 5 letters which do not match the natural order of abcde. On the first level, the natural choice is a--so choose some other letter instead. The second level would be b in the natural order so choose all others, instead, and continue the process until all possibilities have been exhausted. Following each path through the tree will give all possible derangements beginning with the letter b--there are 11 such routes. Thus, there are 11*4 derangements. Tree of derangements for 5 bottles. Indeed, when there are five wines, D(n)=5!(1/2!-1/3!+1/4!-1/5!)=5!/2!-5!/3!+5!/4!-5!/5!=60-20+5-1=44. What is of particular significance is that derangements focus only on wrong guesses: because a non-wrong guess is a correct guess, it is possible to focus only on one world. The Law of the Excluded Middle, in which any statement is "true" or "false"--with no middle partial truth admitted, is the basis for this and for most mathematical assessments of real-world situations. It is therefore important to use the tools appropriately, on segments of the real-world situation in which one can discern "black" from "white." **Derangements and Probability in Random Guesses** In the case of the five wine example, the number of ways of choosing (for example) three correctly out of five is the combination of five things taken three at a time: C(5,3)=5!/2!3!=10. Exhausting all possible combinations reflects an expected connection with the binomial theorem--these values are the coefficients of (x+y)^5. C(5,0)=1 C(5,1)=5 C(5,2)=10 C(5,3)=10 C(5,4)=5 C(5,5)=1. The total number of right/wrong combinations is therefore 2^5 or 32. Notice, though, that the pattern within each grouping is disregarded; to discover the finer pattern, of how right/wrong guesses are arranged we need permutations. To limit the number of permutations necessary to consider, we investigate the derangements. If we can count derangements, we can now address the question of how many times a taster, guessing randomly, gets exactly one wine correct. The answer is simply the number of ways one bottle can be chosen from n bottles times the number of derangements of the other (n-1) bottles of wine. When this value is divided by n!, the probability P(1) of guessing exactly one wine correctly is the result. That probability is: P(1)=(n!/1!(n-1)!)*D(n-1)/n! This idea generalizes in a natural manner so that the probability of choosing exactly k wines correctly is given as: P(k)=(n!/k!(n-k)!)*D(n-k)/n! Table 3 displays all the probabilities for outcomes in blind tastings in which random choices are made in situations for which from 2 to 8 wines are offered by the evening's host. Notice that there is less than a one percent chance of guessing all wines correctly by chance alone whenever the host offers five or more wines in the evening's selection. Evidently, some knowledge of wines is displayed by a taster who accomplishes this feat with any regularity. On the other hand, one could expect, by chance alone, to guess none of the wines correctly about 37 percent of the time, independent of the number of wines offered for tasting. The same situation holds for guessing exactly one wine correctly. The reason that this is so, as readers familiar with infinite series will note, is that the alternating series contained in the parenthetical expression in the formula for counting derangements is precisely 1/e, where e is the base of natural logarithms (a transcendental number of value approximately 2.71828). That is, $e^x = 1+x/1!+(x^2)/2!+(x^3)/3!+\ldots$ so that when $x=-1$, then $e^{(-1)}$, or 1/e, is precisely the parenthetical expression in the formula for D(n). The larger the value of n, the closer the approximation to 1/e=0.3678797. In a blind tasting with an infinite number of bottles of wine, random choices will result in approximately a 0.368 probability that all will be in error! Table 3. Probability of correctly matching K wines from tasting a total of n wines Table 3 suggests some rules of thumb about how well a taster has done. In a normal-sized tasting of six, seven, or eight wines, identifying at least five of them correctly occurs less than 1% by chance alone. Identifying four correctly happens by chance about 2 percent (or less) of the time. However, identifying three correctly occurs by chance from near five to six percent of the time: in every 16 to 18 tastings. Usually there are ten to twelve tasters at a sitting in this one club. None to one member at a sitting rates to guess three wines correctly by chance alone; the group usually does substantially better than this, suggesting some expertise in identifying the wines. **The Principle of Inclusion and Exclusion: The Basis for Counting.** The expression for counting derangements, as a product of n! and and a truncated series for 1/e, has some interesting properties, most notably perhaps the alternating plus and minus signs preceding terms of the series. This alternation occurs because the principle of inclusion and exclusion has been used as the basis for the counting. Readers versed in elementary set theory, Boolean algebra, or symbolic logic, are familiar with the idea of including the intersection, and then subtracting it out, in order to count the number of elements in intersecting sets. This idea, in this context, was clearly familiar to Augustus DeMorgan in the late nineteenth century. Indeed, in a wider context, it dates back to the time of Eratosthenes of Alexandria and his sieve for determining which numbers are prime: those that are multiples of numbers early in the ordering of positive integers are excluded. Only those numbers not excluded have divisors of only themselves and 1, and so are exactly the set included as prime numbers. The following example illustrates how inclusion and exclusion is used in counting derangements; the reader interested in the general proof is referred to Rosen (1988). It is easy to visualize cases when n is small using Venn diagrams--thus, the linkage between inclusion/exclusion, set theory, and derangements becomes clear. Consider for example, a tasting of two wines. Let a be the event that the first wine is correctly identified; let b be the event that the second wine is correctly identified. Draw a rectangle on a sheet of paper and within the rectangle draw two intersecting circles, a and b--a familiar Venn diagram. The content of the rectangle is the universe of discourse. The content of circle a is the set of all events that the first wine is correctly identified (either alone or with another), denoted N(a). The content of circle b is the set of all events that the second wine is correctly identified, denoted N(b). The intersection of the two circles has content ab, the set of all events in which both the first wine and the second wine are correctly identified, denoted N(ab). The set of all derangements is the content of that area of the rectangle outside the two circles. The content of the two circles is the sum of the content of the first circle plus the sum of the content of the second circle: N(a)+N(b). This sum however includes N(ab) in the first term and also N(ab) in the second term; thus, N(ab) must be excluded from the sum to get an accurate count of the content of the union of the two circles--hence inclusion and exclusion. The accurate count of one or more wines correct is thus given as N(a)+N(b)-N(ab). The case for three circles is more complicated to visualize but can be enumerated carefully as a set of three two-circle problems. With values greater than 3, visualization in this manner becomes impossible and one must rely on extension of the notation and visualization in the world of language rather than in the world of pictures--both subsets of "the world of mathematics." Indeed, geographers interested in spatial statistics should be familiar with this issue in using the statistical forms to capture what becomes increasingly toocomplex to map. **Retrospect** These classical ideas, whether cast in the number theoretic context of prime numbers, in the discrete mathematics context of inclusion and exclusion, or in the set theoretic context of intersections, served once again, when cast in the context of derangements and the counting of incorrectness, to permit a clever solution to a complicated, uncontrived, real-world problem. What this sort of analysis offers is a challenge to look at the world in different ways: from the use of classical theoretical material in new real world situations, to the development of new theoretical material which can foster further theoretical exploration and application. **References** Fisher, R. A. The Design of Experiments. Eighth edition, reprinted, New York, Hafner and Co., 1971. First edition, Edinburgh, London, Oliver and Boyd, 1935. Fisher, R. A. "The Mathematics of a Lady Tasting Tea" in Newman, J.R., ed. The World of Mathematics, Simon and Shuster, New York, 1956 (pp. 1512-1521). Michaels, John G. and Rosen, Kenneth H. (eds.) Applications of Discrete Mathematics, New York, McGraw-Hill, 1991. Polya, G.; Tarjan, R. E.; and, Woods, D.R. Notes on Introductory Combinatorics, Boston, Birkhauser, 1983. Rosen, Kenneth R. Discrete Mathematics and Its Applications. First edition, New York, Random House, 1988.

5.INDEX

4. ELEMENTS OF SPATIAL PLANNING: THEORY. PART I. SANDRA L. ARLINGHAUS** One reason that planning of any sort is a difficult process is that it involves altering natural boundaries to fit human needs and desires. While it may not be "nice to fool Mother Nature" the act of planning may be predicated on such an attempt, especially when the balance between human and environmental needs is tipped strongly toward the human side. At a very general level, planning how to use the Earth's surface involves what space to use and when to use it. The "what" issues are those that involve spatial planning; they typically involve the concept of scale. The "when" issues involve temporal planning; they typically involve the concept of sequence. Particular spatial issues might address whether or not boundaries of a parcel of land are clearly designated with respect to one's neighbors; whether or not a proposed land use is consistent with the general character of a larger region; or whether or not a developer's site plans give sufficient attention to natural features. Temporal issues might address the long range and the short range view of a traffic circulation pattern; the sequence, in years, in which lands are to be annexed to a city; or the length of time trees need to have lived in order to be designated landmark trees. When one considers that budget concerns often function as an underlying factor that can help to sway this balance, the fragility of the art of planning becomes apparent. One way to view complicated issues is to consider them at an abstract level in order to understand the logic that links them. The two-valued system of logic on which much of mathematics is based offers one structure that exposes logical connections. When using this structure in conjunction with real-world settings, which often defy the Law of the Excluded Middle, one generally has a number of difficult decisions to make; it is in the act of making these decisions that thoughts can become clearer. **WATERSHED PRINCIPLE** The preservation of natural features is an issue that can be a developer's nightmare, just as development can be the bete noir of the environmentalist. When man-made boundaries are superimposed on the natural environment, there is often little correspondence between the two partitions of space. Abstractly it is not surprising, therefore, that individuals using one way to partition space will be at loggerheads with those using a different partition of space. When the topography of a region is altered, it is necessarily the case that the natural features on that surface are also altered. Considering the contrapositive of this statement, a logical equivalent, leads to the idea that the preservation of natural features is dependent on the preservation of topography. When this idea is coupled with the notion that the fundamental topographic unit is the drainage basin or watershed (Leopold, Wolman, and Miller, Fluvial Processes in Geomorphology), the following principle emerges. **Watershed Principle.** If the preservation of natural features depends upon the preservation of topography and if the fundamental topographic unit is the watershed, then the preservation of natural features depends upon the watershed. If one accepts this Principle, then it may well be a small step to the following Corollaries. **Corollary 1.** When environmental concerns are involved, the drainage basin should be the fundamental planning unit. **Corollary 2.** When the drainage basin is the fundamental planning unit, the partition of wetlands and other elements of the drainage network, by man-made planning unit boundaries, is not possible. Decisions as to the impact a proposed development project will have on a wetland are facilitated by having the entire wetland contained within the legal boundaries of the parcel; using the drainage basin as the fundamental planning unit ensures that such set-theoretic containment will be the case. Issues involving the welfare of the entire watershed also become tractable under such an alignment: neighbors become neighbors with respect to the drainage pattern rather than with respect to superimposed human boundaries. Indeed, what my neighbor does three miles upstream from me may have far more impact on my land that does the action of a neighbor 100 feet away who is in a different drainage basin. Current technology (Geographic Information Systems, for example) might make it possible to alter the inventory of lands to create suitable, substantial changes, along these or along other lines, in legal definitions. The use of technological capability to make legal definitions correspond more closely to natural definitions can lead to the resolution of conflicts: the closer the fit between natural and man-made boundaries the fewer the disagreements. **MINIMAX PRINCIPLE** The basic idea behind the Watershed Principle might be captured as one that minimizes damage to the environment and maximizes satisfaction of human needs and desires. Viewed more broadly, the Watershed Principle might be recast as a MiniMax Principle which can then be recast downstream abstractly, in a number of other more specific forms (such as the Watershed Principle). **MiniMax Principle** An optimal plan is one which minimizes alteration of existing entities and maximizes the common good. Highly general principles, such as this one, demand attention to definitional matters: what is meant by "common good" or how might one measure "alteration." These are difficult problems: one advantage to an abstract view is to bring important and difficult issues into focus. **EARTH-SUN RELATIONS: GEOGRAPHIC COORDINATES AND TIME ZONES.** One case in which the fit between natural and man-made boundaries is done in a style consistent with the Minimax Principle is the spatial layout of reckoning time (thus, time becomes transformed in a "meta" fashion into space). Much of the developed world measures the passage of time by the position of Earth relative to our Sun. One unit of time, the year, corresponds roughly to one revolution of the Earth around the Sun. Another, smaller, unit of time, the day, corresponds roughly to the rotation of the Earth on its axis--the man-made boundaries in both cases are set by the natural planetary motions in space. When planetary motions do not permit any further refinement of the day into even smaller units, we subdivide the day into hours. When the partition of the day into 24 hours is put into correspondence with the grid system based on latitude and longitude, one hour corresponds to fifteen degrees of longitude. Fifteen degrees of longitude corresponds to a central angle of fifteen degrees intercepted along the Equatorial great circle. Thus, 24 man-made time zones of 15 degrees of longitude each envelop the Earth--man-made boundaries again follow (although a bit indirectly) from natural boundaries. The Earth becomes a "clockwork orange" of 24 sections, each 1 hour wide, with boundaries along meridians spaced 15 degrees apart. Across oceans, this alignment of time-zone and longitude may reasonably have boundaries along meridians; interior to a continent, however, human needs and desires may reasonably prevail, making it prudent to bend the natural alignment for the common good. ** The author wishes to thank her colleagues on the City of Ann Arbor Planning Commission and in the Planning Department of the City of Ann Arbor. The challenge and stimulation fostered by this lively Commission helped to generate this viewpoint.

5. MAPBANK: AN ATLAS OF ON-LINE BASE MAPS SANDRA L. ARLINGHAUS The enclosed images contain a number of projections of the world made from Geographic Information System (GIS) technology. Right-click on the image (on a PC) to save it to your local hard drive. Then open the .jpg file using Adobe PhotoShop or other software and, if you wish, save it in a different format (such as bitmap). When these downloaded maps are put into Windows Paintbrush (or other software) as bitmaps and are projected from the computer screen onto the wall (using a data-show and overhead projector, or some such) their resolution is of about the same quality as that of the original on-screen display in the GIS. Thus, wall-maps can be carried around on diskette. This strategy offers an easy way for university professors and pre-collegiate teachers alike to give lectures with maps tailored to their needs--from base maps for simple place-name recognition, to maps showing voting patterns by party in presidential elections, to maps showing global vehicle registration patterns, to detailed topographic maps. Naturally, the first in the MapBank series of maps offered for this style of communication are base maps. Behrmann Equal Area Cylindrical Projection

Mercator (conformal) Projection

Robinson (compromise) Projection

Miller Cylindrical Projection

Latitude/longitude display

Mercator, with cylindrical nature evident.

Eckert IV, Equal Area

Eckert VI, Equal Area

Mollweide, Equal Area

Sinusoidal, Equal Area

Tobler's Hyper-Elliptical

6. INTERNATIONAL SOCIETY OF SPATIAL SCIENCES July 18, 1995, the International Society of Spatial Sciences (ISSS--I-triple-S) was founded as a division of the non-profit Community Systems Foundation of Ann Arbor, MI. This primarily electronic society has as board members: Sandra L. Arlinghaus (founder), W. C. Arlinghaus, M. L. Bird, B. R. Burkhalter, W. D. Drake, F. L. Goodman, F. Harary, J. A. Licate, A. L. Loeb, K. E. Longstreth, J. D. Nystuen, W. R. Tobler. To follow its activities, browse the under-construction WebSite http://www-personal.umich.edu/~sarhaus/isss with direct links to material of the American Geographical Society and the Thunen Society. internet: sarhaus@umich.edu The focus of this new society is to place in a core position those sciences, of spatial character, that are often relegated to the periphery within academic institutional structure. Such sciences are, to name only a few, geology, geography, and astronomy. In moving along this continuum from the center of the Earth to the outer reaches of the universe, one might imagine a whole host of sciences that could also be included (from oceanography to atmospheric science to regional science). Thus, ISSS offers a platform from which individuals, institutions, and professional societies devoted to some aspect of spatial science might further their interests. The previous article announces one of the projects of ISSS. For the past two years, during the developmental stages of ISSS, a continuing project has been the development of a MapBank. This is a bank composed of maps made by students; most of the maps are thematic maps made to supplement student term papers or as maps to be used in the classroom by students of Education. For teachers to use the MapBank, free of charge, they must make a deposit of an electronic map. Currently the MapBank numbers more than 100 electronic maps. Look for thematic maps to appear in future issues of Solstice and on the WebSite of ISSS. There are currently ten base maps of the world on the ISSS MapBank WebSite: http//www-personal.umich.edu/~sarhaus/isss.

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Robert F. Austin: *Digital Maps and Data Bases: Aesthetics versus accuracy.* Introduction; Basic issues; Map production; Digital maps; Computerized data bases; User community.

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Sandra L. Arlinghaus, David Barr, John D. Nystuen: *The Spatial Shadow: Light and Dark* -- *Whole and Part.*

This account of some of the projects of sculptor David Barr attempts to place them in a formal systematic, spatial setting based on the postulates of the science of space of William Kingdon Clifford (reprinted in Solstice, Vol. I, No. 1.).

Sandra L. Arlinghaus: *Construction Zone--The Logistic Curve.*

Educational feature--Lectures on Spatial Theory.

Volume I, No. 2, Winter, 1990.

John D. Nystuen: *A City of Strangers: Spatial Aspects of Alienation in the Detroit Metropolitan Region.* This paper examines the urban shift from "people space" to "machine space" (see R. Horvath, Geographical Review, April, 1974) in the Detroit metropolitan regions of 1974. As with Clifford's Postulates, reprinted in the last issue of Solstice, note the timely quality of many of the observations.

Sandra Lach Arlinghaus: *Scale and Dimension: Their Logical Harmony.* Linkage between scale and dimension is made using the Fallacy of Division and the Fallacy of Composition in a fractal setting.

Sandra Lach Arlinghaus: *Parallels Between Parallels.* The earth's sun introduces a symmetry in the perception of its trajectory in the sky that naturally partitions the earth's surface into zones of affine and hyperbolic geometry. The affine zones, with single geometric parallels, are located north and south of the geographic parallels. The hyperbolic zone, with multiple geometric parallels, is located between the geographic tropical parallels. Evidence of this geometric partition is suggested in the geographic environment--in the d esign of houses and of gameboards.

Sandra L. Arlinghaus, William C. Arlinghaus, and John D. Nystuen: *The Hedetniemi Matrix Sum: A Real-world Application.* In a recent paper, we presented an algorithm for finding the shortest distance between any two nodes in a network of n nodes when given only distances between adjacent nodes (Arlinghaus, Arlinghaus, Nystuen, Geographical Analysis, 1990). In that previous research, we applied the algorithm to the generalized road network graph surrounding San Francisco Bay. Here, we examine consequent changes in matrix entries when the underlying adjacency pattern of the road network was altered b y the 1989 earthquake that closed the San Francisco--Oakland Bay Bridge.

Sandra Lach Arlinghaus: *Fractal Geometry of Infinite Pixel Sequences: "Super-definition" Resolution?* Comparison of space-filling qualities of square and hexagonal pixels.

Sandra Lach Arlinghaus: *Construction Zone*--Feigenbaum's number; a triangular coordinatiztion of the Euclidean plane; A three-axis coordinatization of the plane.

Volume I, No. 1, Summer, 1990.

Reprint of William Kingdon Clifford: *Postulates of the Science of Space.* This reprint of a portion of Clifford's lectures to the Royal Institution in the 1870s suggests many geographic topics of concern in the last half of the twentieth century. Look for connections to boundary issues, to scale problems, to self-similarity an d fractals, and to non-Euclidean geometries (from those based on denial of Euclid's parallel postulate to those based on a sort of mechanical `polishing'). What else did, or might, this classic essay foreshadow?

Sandra Lach Arlinghaus: *Beyond the Fractal.* The fractal notion of self-similarity is useful for characterizing change in scale; the reason fractals are effective in the geometry of central place theory is because that geometry is hierarchical in nature. Thus, a natural place to look for other conn ections of this sort is to other geographical concepts that are also hierarchical. Within this fractal context, this article examines the case of spatial diffusion. When the idea of diffusion is extended to see "adopters" of an innovation as "attractors" of new adopters, a Julia set is introduced as a possible axis against which to measure one class of geographic phenomena. Beyond the fractal context, fractal concepts, such as "compression" and "space-filling" are considered in a broader graph-theoretic setting.

William C. Arlinghaus: *Groups, Graphs, and God.*

Sandra L. Arlinghaus: *Theorem Museum*--*Desargues's Two Triangle Theorem from projective geometry.*

Construction Zone--centrally symmetric hexagons.

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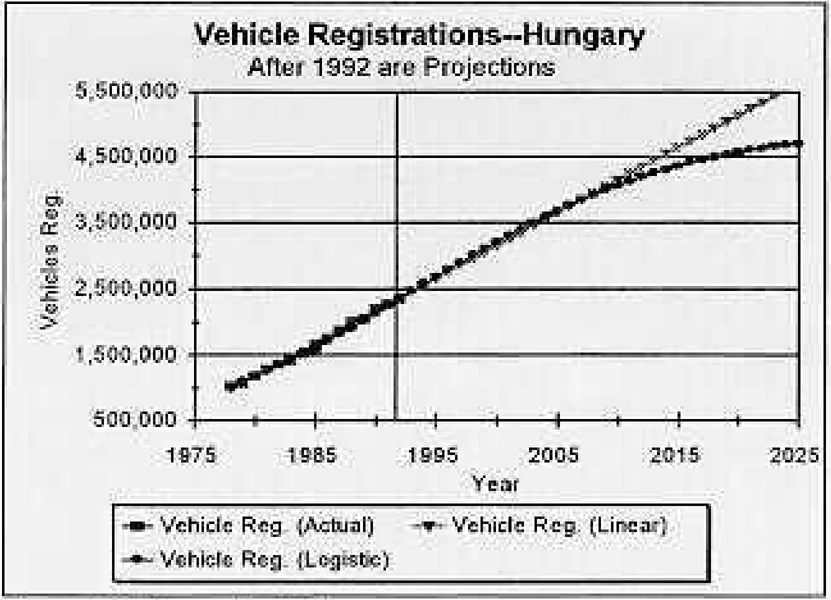
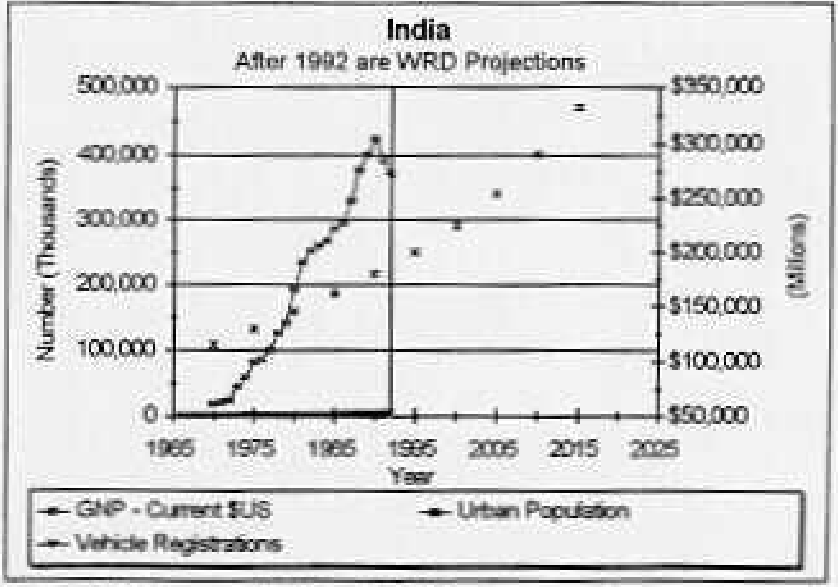


Figure 10. Source: AAMA.



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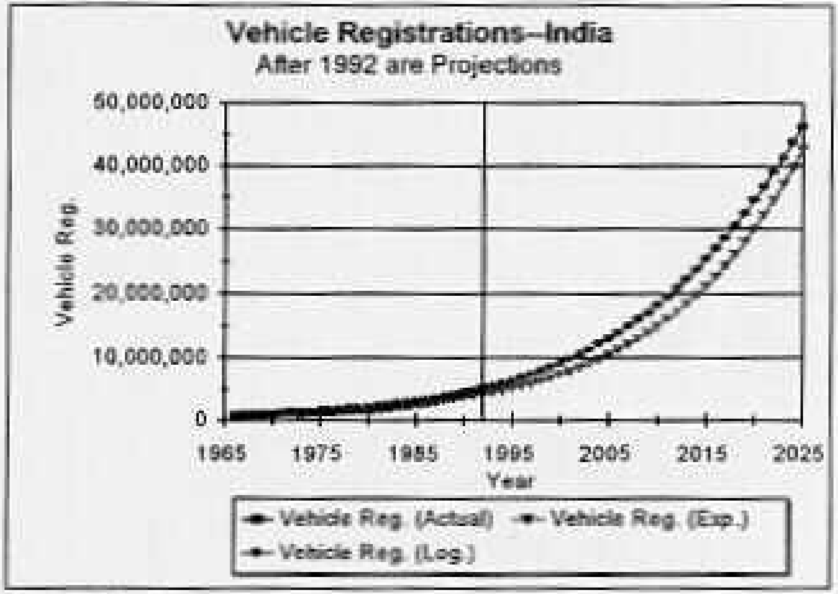

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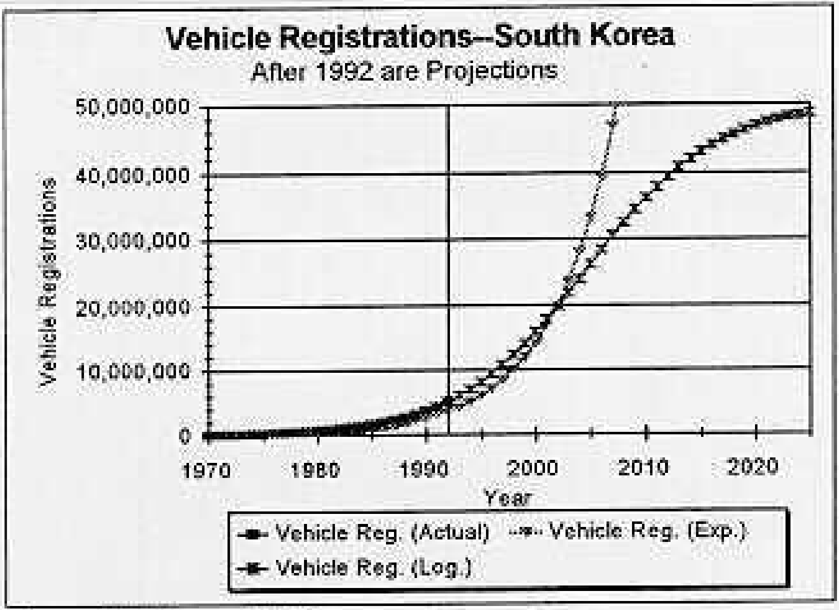

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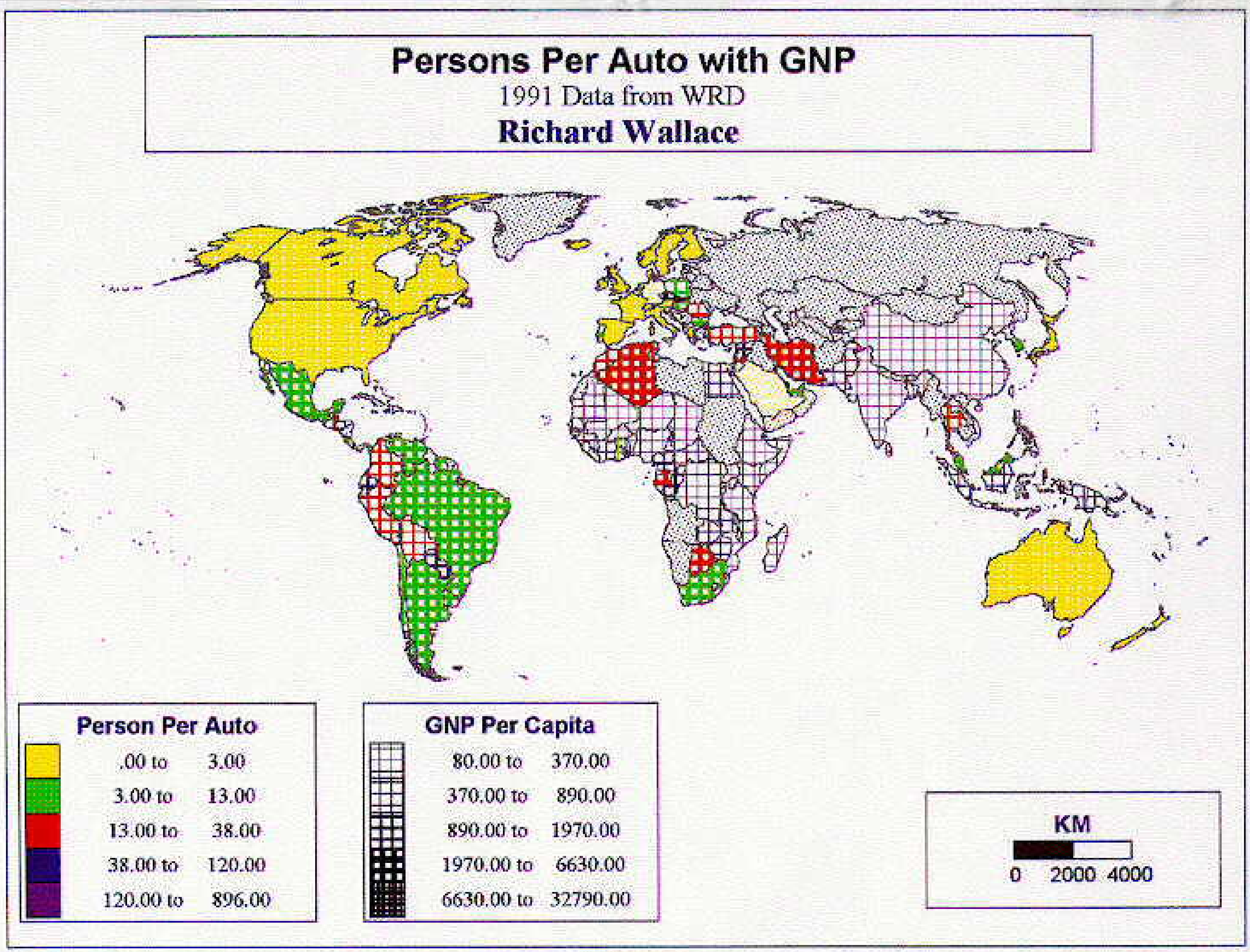
Persons Per Auto with GNP
1991 Data from WRD
Richard Wallace
Person Per Auto
.00 to 3.00
3.00 to 13.00
13.00 to 38.00
38.00 to 120.00
120.00 to 896.00
GNP Per Capita
80.00 to 370.00
370.00 to 890.00
890.00 to 1970.00
1970.00 to 6630.00
6630.00 to 32790.00
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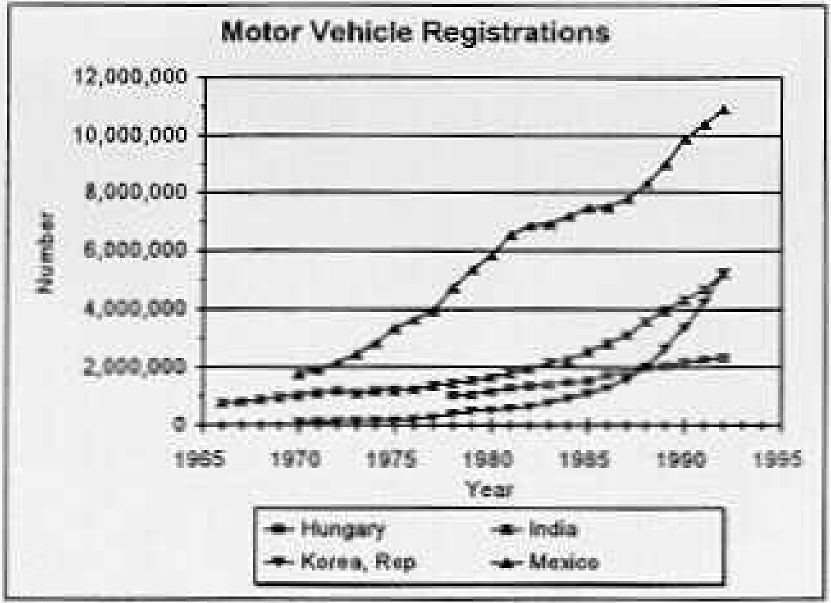

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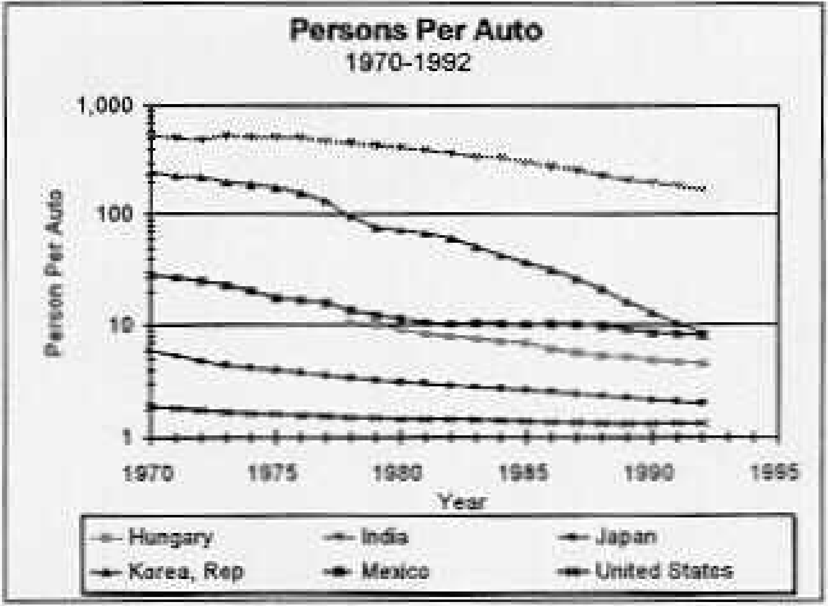


Figure 3. Sources: WRD and AAMA.

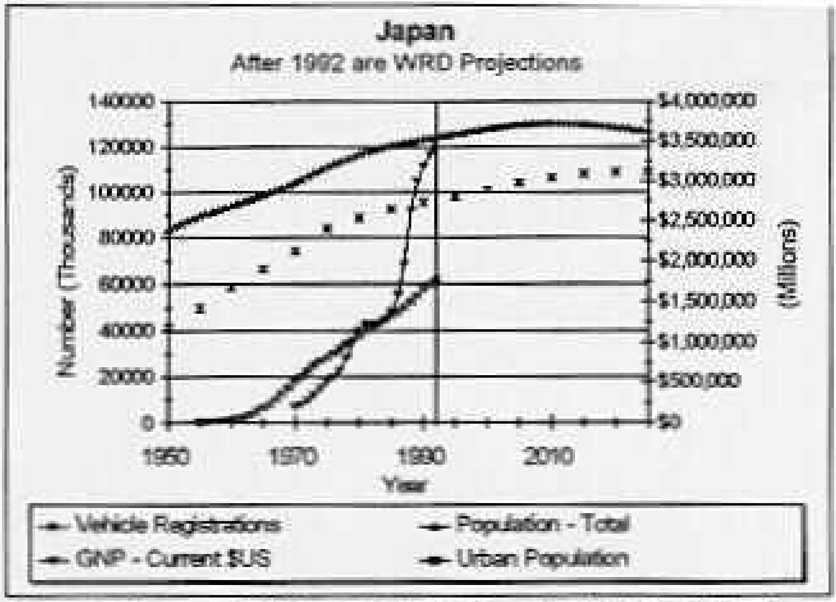


Figure 4. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

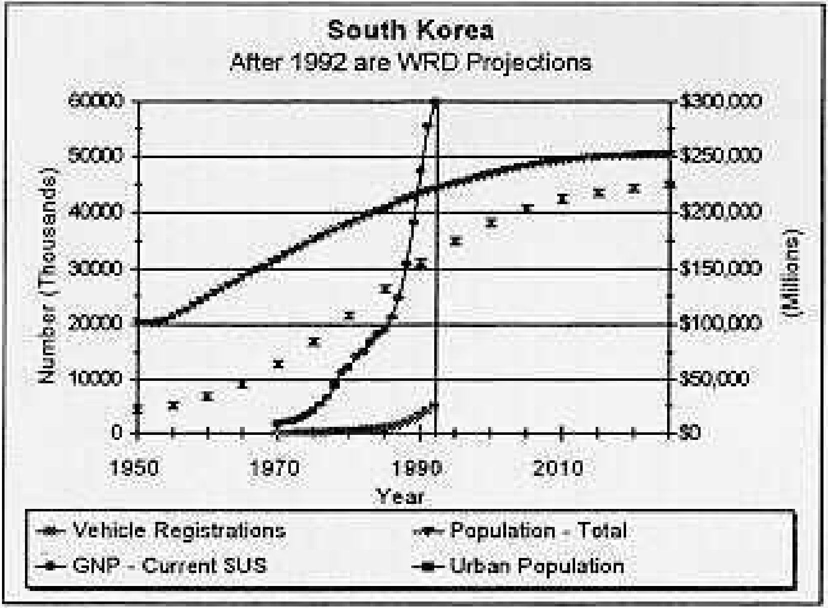


Figure 5. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

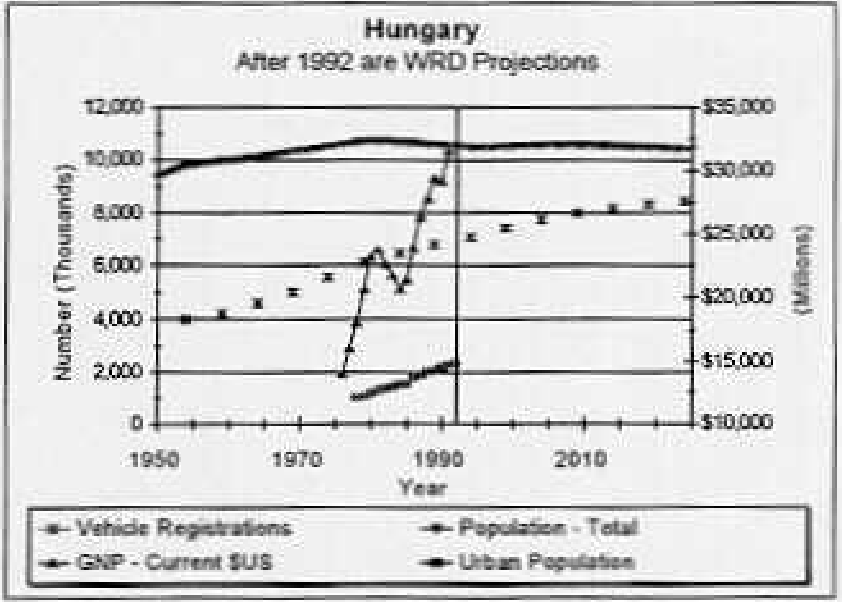


Figure 6. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

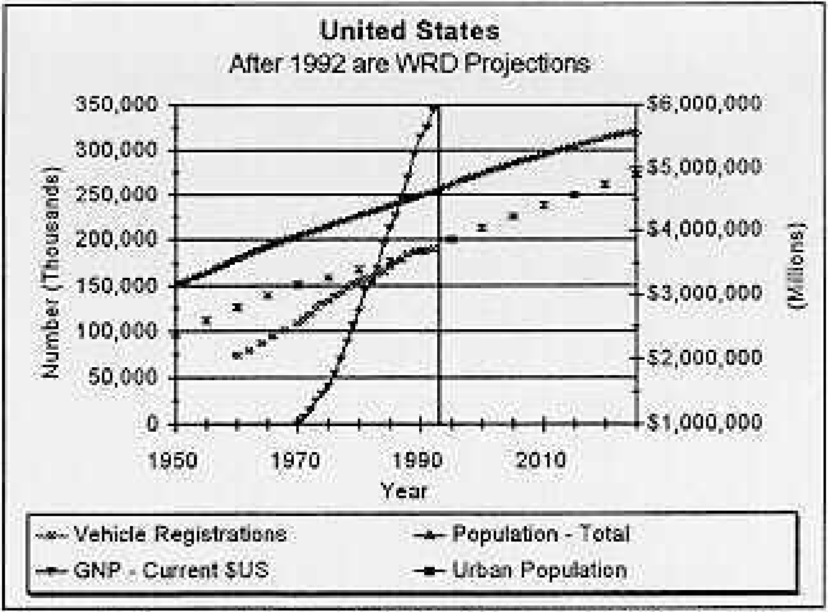
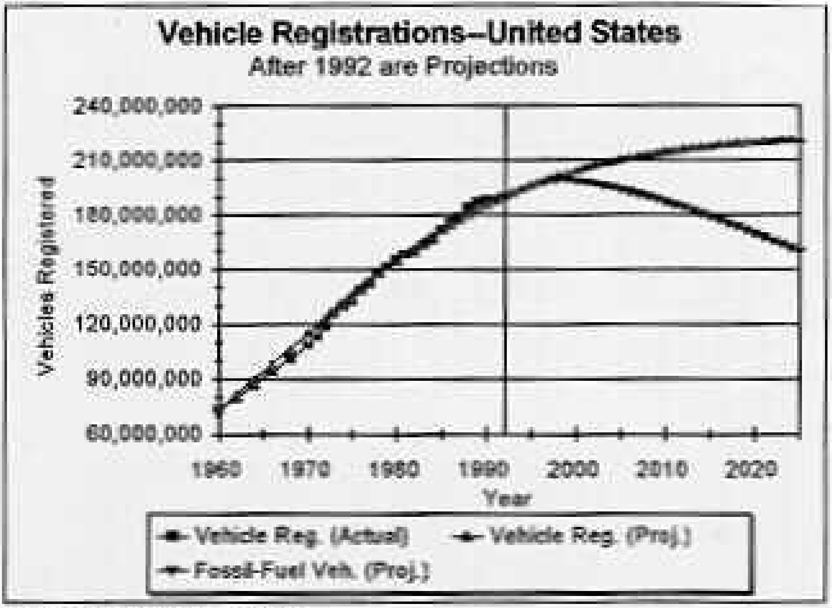


Figure 7. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.



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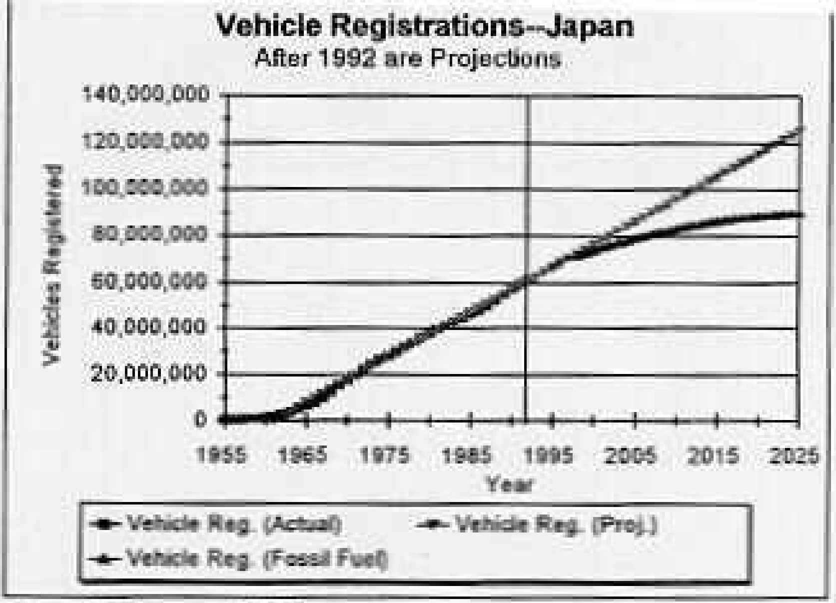


Figure 9. Source: AAMA.

AN INQUIRY INTO DETERMINATES OF FERTILITY

TRACY YODER

Introduction

Unlike the human mind, our environment earth has boundaries and limitations. Consider two possibilities for the future. One, humans continue to reproduce at exponential growth rates until natural resources become depleted and scarce. Ecology will force a "natural" selection and reduction in world population. The other possibility includes the implementation of population planning programs and policies to reduce fertility and eventual stabilization in population growth rates, as an impetus for sustaining the environment.

Figure 1.

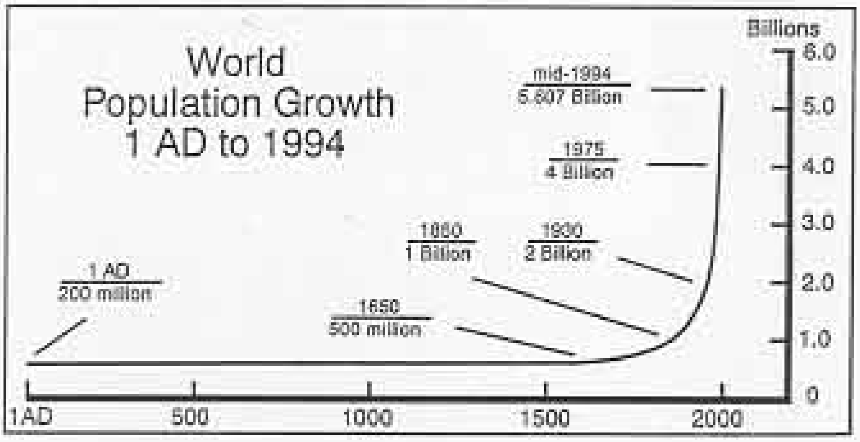


Table 1: World Population and Yearly Growth

Major area	Population (1994 estimates)	Yearly growth (1990-1995)
World	5,664,000,000	1.70%
Africa	705,000,000	3
Asia	3,451,000,000	1.8
Australia	18,000,000	1.1
Europe	710,000,000	0.2
North America	449,000,000	1.2
Pacific Islands (including New Zealand)	13,000,000	1.8
South America	318,000,000	1.9

Source: World Book estimates from UN data

Table 1.

Figure 1 highlights the population transition since 1 AD. Table 1 supplements the transition with manipulative statistics. Imagine a 500 or 1000 year projection for total world population. Logical thinking would predict some stable population plateau. What the ideal or environmentally limiting zero population rate (ZPG) final world population total will be and when it needs to happen is highly speculative.

I postulate that as of the late both century, we are in the steep, rapidly changing part of the population transition. Population policy development and implementation might determine which direction we must choose in this transitional environment or which of the possibilities described above might become reality. It is imperative that more research be conducted regarding gender and reproduction issues for empirical data collection in an anthropological approach, for the accurate assessment of population policy decision-making and implementation.

In transition towards ZPG, I postulate the full utilization and recognition of the collective mind. By collective mind, I mean decision-making and innovation fairly shared, recognized and addressed equally among females, males and other unique social/cultural viewpoints. The collect mind is essential in the development and implementation of innovative ideas and successful population policy making. Movement towards ZPG requires greater effort and communication, but is necessary in the continuing pursuit of a higher quality of life for ourselves and future generations.

Not all scholars agree that an increase in population is detrimental. Pro-natalist Julian Simon argued that a growing population was desirable, because more people meant an increase in human gene pool variations. Simon thought having a large pool of genes provided a greater probability for producing a genus capable of creating innovate solutions to the current problems. (Barlow and McIntosh, 1994).

Brainstorming from all contingencies, anti-natalists and pro-natalist alike, paves creative pathways for prevention strategies and solutions to problems. In practice, population advocates need to work on curbing the total population increase while fully utilizing a male and female collective mind focused on striving to uncover and pursue any and all innovative ideas towards the continuing reduction of fertility and the protection of our environment.

The population/environment dynamic seems to develop in a circular feedback pattern. Ecology determines how populations are changed and shaped by the environment. Populations adapt to their environments and grow, causing alterations in the environment, which in turn effects the social population organizational structure. Let's begin to intervene into the loop which provides the biggest punch for the buck: let's determine ways to reduce world population.

The continuing increase of additional people effects the entire globe. Most people struggle for basic human needs, while others are limited by human ingenuity and imagination. Population specialist and academicians debate about the resource consumption and depletion patterns of industrialized countries versus developing countries (north/south). Indeed, a small increase of people in the north where the standard of living and resource consumption is high, may be more environmentally harmful than high rates of fertility in the lower consuming south.

Despite the magnitude of environmental affects of the north vs. south consumption patterns, an increase in the total population in either venues will continue to deplete the supplies of nonrenewable and renewable sources while contributing to pollution sinks.

Environmental problems are caused by individuals as well as coalitions. Laws govern societal behaviors and norms determine most individual behavior. This paper explores social and individual underlining determinates that effect total fertility rates in discussing policy to curb fertility .

Recent Trends from International Conferences on Population and the Environment

The last two major international conferences on population and environment did not complement one another. The Environmental Conference in Rio De Janeiro preceded the United Nations International Conference on Population and Development (UNICPD) in Cairo. The Rio conference concluded with a commitment towards reducing population growth rates as the most effective approach towards environmental sustainability. (Finkle and McIntosh, 1994). The environmental delegates emerging from the Rio Conference had high hopes for environment to be a central theme at Cairo population conference.

However, instead of environment, the central theme of the Cairo Conference focused on improving women's status. In Cairo, population specialists agree population planning policies and programs implementation are only successful when there is a simultaneous advancement in the status of women.

The reason environmental enthusiasm and population from Rio didn't carry over to Cairo are three fold. One, environmentalist have extremely different opinions of environmental priorities and problems. Two, there is some uncertainty with the exact variables which effect both population and environment (Jason and McIntosh, 1994). Therefore, the problems of how to incorporate the environment and population issues were temporarily arrested in Cairo until a more unified argument could be sought.

Most importantly, politics played a main force behind the lack of environmental concerns in Cairo. Women's advocate groups were simply better organized than the environmentalist and hence women's issues took center stage. The committed and complete presents of feminists were felt in the preparatory meetings. The "Preparation Conferences" (PrepCom) took place in the decade preceding the UNICPD in Cairo. During PrepCom, the draft of the "Program of Action" was written. Before the ICPD took place in Cairo September 1994, 80% of the Program of Action was developed. The Program of Action is a document and the primary product of the decennial UNICPD; a written world consensus of population goals for the next 20 years. PrepComs limited the work at the conference to the discussion and world agreement on the most controversial 20% of the document. The power and influence felt from women's advocate groups, was incorporated in the theme of the draft. Women's groups followed though at Cairo with continuing force and won unprecedented gains for the advancement of women in the international area.

One significant development for international conferences, which began in Rio and escalated in Cairo, was the influence and participation of non-governmental organizations (NGO's) in United Nations policy development. Instead of only governmental delegates making the decisions on major global issues, more of the decision-making responsibilities are being shared with the grassroots, NGO's.

NGO participation is a reinforcing bonus towards success of global problems. This democratic mode of policy making has been established, and will no doubt edify the success of future world conference objectives.

The Analysis

To follow through with current international thought, one way is to ensure the success of population planning and policies, and hence positively effect environmental sustainability, is by the universal enhancement of women's status. One way the status of women could be viewed is by how much control a woman has over her own fertility. Maps and regression data will be presented, to show the significance of the underlining determinates which effect the total fertility rate (TFR), in attempt to highlight venues for the enhancement of women.

Assumption

Fertility rates directly effect environmental sustainability.

Hypothesis

Certain underlining factors influence the proximate determinates of fertility, at varying correlation with TFR.

Bongaart's Proximate Determinates of Fertility

Bongaart proposed seven proximate determinates or biological behaviors that directly effect fertility rates. The first four are considered major determinates which vary significantly in populations and biologically affect fertility rates.

Major

1. the number of people married (affected by the age of marriage)
2. postpartum infecundability (caused by breast feeding practices)
3. the prevalence rates of contraception use
4. the prevalence rates of induced abortion

Minor

5. spontaneous abortion
6. frequency of intercourse
7. natural sterility

Bongaat proposed that minor determinates change the rate of fertility less than major determinates because they remain constant throughout most societies. It might be reasonable however to speculate that the traditionally minor determinants are somewhat more significant today with epidemic rates of new viral and viral like STD's.

Chlamydia trachomatis is the most common bacterial STD, with an estimated 4 million cases annually in the United States, and is the leading cause of preventable infertility and ectopic pregnancy.

Like viruses, chlamydiae are obligate intracellular parasites and can be isolated only by tissue culture (Hatcher, 1994). Unlike viruses, *C. trachomatis* is susceptible to inexpensive, readily available antibiotics. Because many chlamydial infections are asymptotic and probably chronic, widespread screening is necessary to control this infection (Hatcher, pg. 90).

Research efforts of STD effects on fecundability are pending on accurate data collection. Hence, researchers must assume that sexual viral contagion's spread uniformly among populations. Most underlining factors discussed will affect the major proximate determinants of fertility due to the lack this empirical data.

Total Fertility Rate

The total fertility rate (TFR) is a reasonable dependent variable for analysis. TFR has simple, intuitive meaning, which describes the hypothetical average number of children a typical woman in a society would bear over her lifetime. TFR is based on a hypothetical cohort where women at every age from 15 to 49 experiences the same average age-specific fertility rates found in one year (King, 1993). TFR implies that fertility rates remain constant for 35 years while a true cohort of women would pass through an infinite number of varying age-specific fertility rates, if she survives to age 50. (King, 1993). Despite being based on a hypothetical cohort, TFR is the most popular summary measure of fertility among demographers.

Women with Increasing Status Have Lower Total Fertility

TFR is the independent variable of analysis for determination of female status. Looking at a world map of fertility (Map 1), we see trends of low fertility in North America, Europe, Australia, New Zealand, and in China, Indonesia, and Russia due to influential governmental populace programs. Graphs and maps in Appendix's A and B implies an increase in the overall status of women induces a reduction in TFR. The reason this implication may temporarily go against evolutionary selection for the survival of the fittest, is because we are experiencing the exponential stage of the world population transition (Figure 1). I must make an assumption that as women's status increases, her fertility drops. I say this only because we are entering the exponential rate of world population transition. This limits my discussion of the factors which influence the status of women. it does give us insight into some of the social issues which correlate with population relations.

When a woman has fewer children, the assumption is she chose to reduce her fertility. Hence, a woman with low fertility has control over her own fertility. When a woman has control over her own fertility, she probably also has some decision-making power and independence in determining her future. Hence, there seems to be a connection between the low fertility the high female status.

This implies that given the choice, women would find it more desirable (higher utility) to have fewer children, a reasonable argument for discussion. The presence of natural selection inherent in Darwin's evolution would seem to be defied.

One would think, that to ensure the survival of the fittest, the better off parents would have more children. This thought might be thwart by the argument that the people producing fewer children, invest in a higher quality offspring, better educated and developed for adaptability and survivability. Whether the people having more children vs. people having less, but a higher quality children are more fit in the evolutionary scheme is yet to be decided. However, in this paper, I will ague that fertility reduction correlates with an increase in female self-actualization.

Data

The dependent variables of analysis include life expectancy, infant mortality rates, proportion of adult illiteracy, secondary school enrollment rates, percent of GDP spent on health care, proportion of poorest 40% of house holds, proportion of Moslem and proportion of Catholic. Table 2 summarizes the correlation between the variables and TFR. Appendix A contains graphs of actual data of world TFR (from about 78 countries) in relationship with the dependent variables . Appendix B contains maps for visual conceptualization of world trends of fertility and female self-determination.

Results

The data reveals three classifications of the correlation between the underlining factors and TFR: high, medium, and none.

High significance included a multiple R ranging from 0.89-0.73 (0.34 including the outliner female life expectancy)

Medium significance multiple R ranged from 0.44-0.54 and 0.29-0.19, the R square range was 0.19-0.29.

Life expectancy, IMR, proportion of adult illiteracy and secondary school enrollment rates all ranked high. Percent of GDP spent of health care and proportion of poorest 40% of house holds held a medium significance. Proportion of Catholic and proportion of Moslem appeared to have no correlation.

Discussion

Let's look at the analysis of the variables and see if they might influence Bongaart's proximate determinates of fertility.

Life expectancy correlates highest for both females males, yet lowest for females. It's questionable whether the data is accurate, however speculation into the possible causes are relevant for discussion. One possible explanation is much of the maternal mortality, occurring at high rates in developing countries, goes unrecorded. Women from developing countries usually deliver babies at home under the assistance of a traditional birth attendant. Due to the lack of uniform and adequate resources and week communication between villages and national census collection, much of the maternal mortality goes unrecorded.

Life expectancy suggests a certain quality of life. Males correlate high with fertility because they have none of the consequences of pregnancy. Maternal mortality may increase with early age of marriage.

Table 2: Summary of Variable's Correlation with TFR

HIGH SIGNIFICANCE ON TFR

Regression Statistics	Life Expectancy: F/M	Life Expectancy: F
Multiple R	0.887259509	0.343602397
R Square	0.787229436	0.118062607
Adjusted R Square	0.784429824	0.106303442
Standard Error	4.961254993	24.71265158
Observations	78	77

Regression Statistics	Infant Mortality Rates (IMR): F/M
Multiple R	0.85891339
R Square	0.737732212
Adjusted R Square	0.734235308
Standard Error	22.08937375
Observations	77

Regression Statistics	Prop. of Adult. Illiteracy: F/M	Prop. of Adult. Illiteracy: F
Multiple R	0.853088874	0.8109556
R Square	0.727760627	0.657648984
Adjusted R Square	0.724130768	0.653084304
Standard Error	0.153278998	0.120066282
Observations	77	77

Regression Statistics	Second. Sc. Enroll. Rates: F/M	Second. Sc. Enroll. Rates: F
Multiple R	0.811415277	0.733479282
R Square	0.658394751	0.537991856
Adjusted R Square	0.653899945	0.531831748
Standard Error	0.119273758	26.21849951
Observations	78	77

MEDIUM SIGNIFICANCE ON TFR

Regression Statistics	Percent of GDP Spent on Health Care
Multiple R	0.544909074
R Square	0.296925899
Adjusted R Square	0.287551578
Standard Error	1.781485986
Observations	77

Regression Statistics	Proportion of Poor 40% of House Holds
Multiple R	0.44068615
R Square	0.19420428
Adjusted R Square	0.18346034
Standard Error	8.08034437
Observations	77

When a 15 year old gets pregnant in a developing country, her nutritional requirements have been insufficient since birth or during pregnancy and nursing. If she is stunted, there is a high probability of an obstructed birth and consequential maternal mortality.

Cultural norms may effect postpartum infecundability. In Africa for example, sometimes women feel pressure from their husbands to discontinue breastfeeding early. Some Africans believe semen will contaminate the breast milk and harm the baby. To resume sexual relations with her husband, a mother must publicly feed her baby with a bottle, to affirm her resumed sexual status with her husband. Not only does the infant receive less nutrients, resulting in possible stunting, but discontinuing breast feeding shortens the postpartum infecundability period, results in increased fertility due to the shortage of contraction.

Illegal abortion results in many maternal fatalities, and also go unrecorded in the developing world.

IMR correlates strongly with TFR. This might be due to an inability of very young mothers to care for their infants. A high TFR also implies close spacing between siblings, possibly increasing IMR.

Proportion of adult illiteracy and secondary school enrollment rates strongly correlate with TFR, implying education plays a role in fertility reduction. Education delays the age of marriage, because women are physically in the classroom for more days of their adult life. Education also increases the knowledge and user effectiveness of contraception. Educated women tend to want their children to also be educated. Economically speaking, educated women find a higher utility in the quality vs. quality of children. And societies which encourage female education may also tolerate induced abortion.

Looking at the GDP spent on health care and proportion of poorest 40% of house holds, we see a less enthusiastic correlation with TFR. These economic indicators have less relevance to the proximate determinates of fertility.

The age of marriage may be determined by the presents or absents of a dowry or in an arranged marriage. The lack of adequate pubic health facilities may result in a higher maternal mortality due to septic induced abortions. Financial constraints may contribute to limited contraception usage.

Interestingly, Catholicism and Islamic forces had little correlation with TFR. Although a lage percent of the world's population claim Catholic and Moslem affiliation, they tend not to uniformly heed religious dogma restricting contraception and abortion. This is evident in the very Catholic Italy and Spain, were fertility rates are the lowest in the world.

Policy Implications

The population transition will not finish successfully in place with a healthy environment without population policies and programs to reduce fertility. Intervention must continue through a unified, global effort. International conferences on population and environment help unify the collective voice of not only of concerned governments, but including concerned citizens. NGO's must continue contributing to the population policy decision-making processes.

A substantial increase in finical support might encourage continuing research into the underlining determinates of fertility. Research is limited due lack of empirical data..

The United States, and other powerfully economic countries should denote more money towards fertility and reproduction research. With the change in the executive branch in the US, from 12 years of radical right influences on the appropriation of public funds to the Clinton administration, we have seen a increase in the funds allocated for population research.

Population issues and research are impeded in the US by a minority of anti-feminists who collect under the abortion controversy umbrella. I consider the pro-choice contingency a front claiming hypocrisies. There can not be support for family values with out contingent support of female controlled fertility. Valuing the life of an embryo over the life of a woman does little to enhance relationships between men and women.

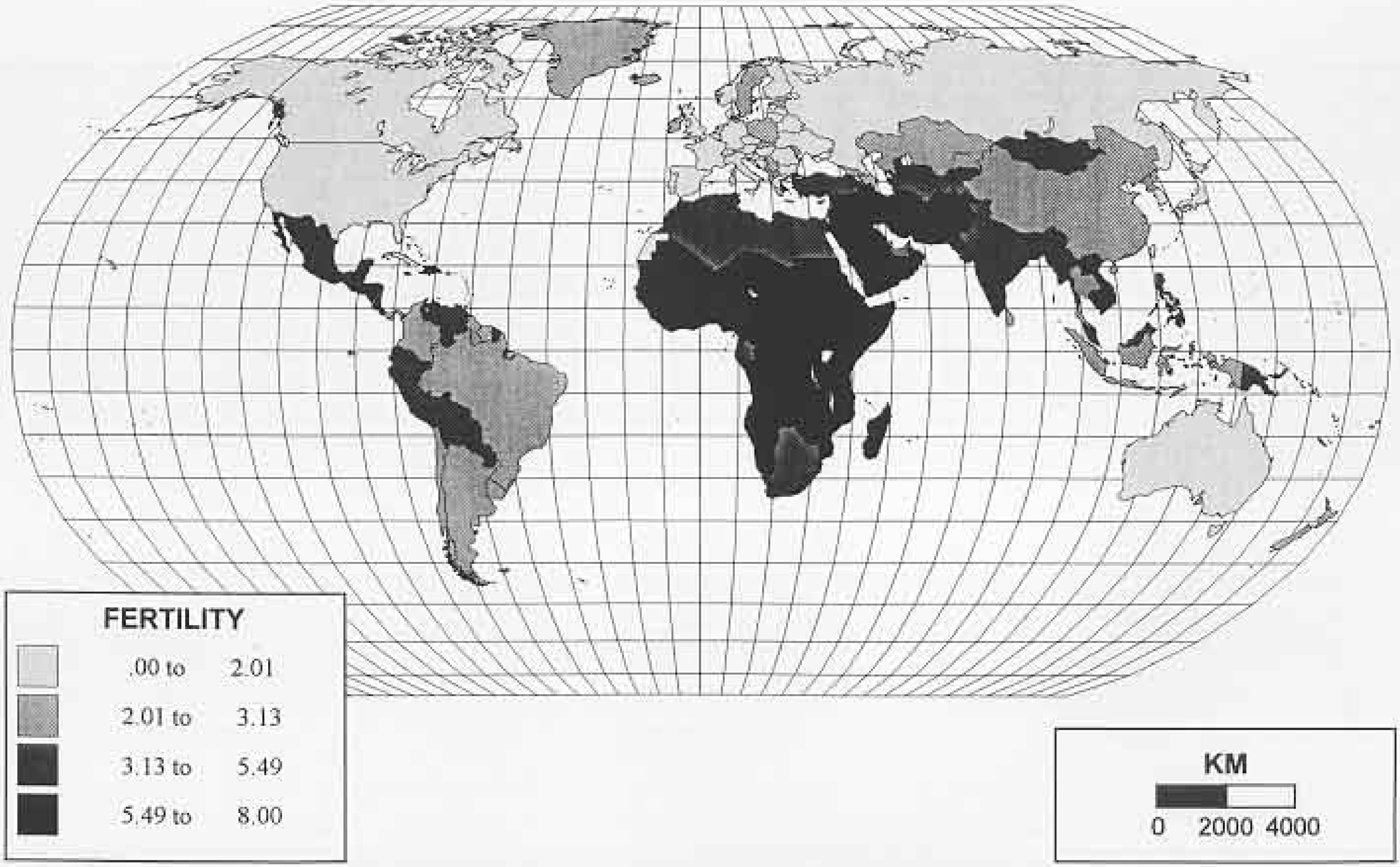
Safe abortion, as controversial as it may be, must be legally available for all women. Nations who promote family planning should legalize abortion as a safe back-up for contraception failure. This logic is not always follow reality. In Indonesia for example, the government won support of the religious leaders in the national effort to promote birth control under the mutual agreement that abortion remain illegal.

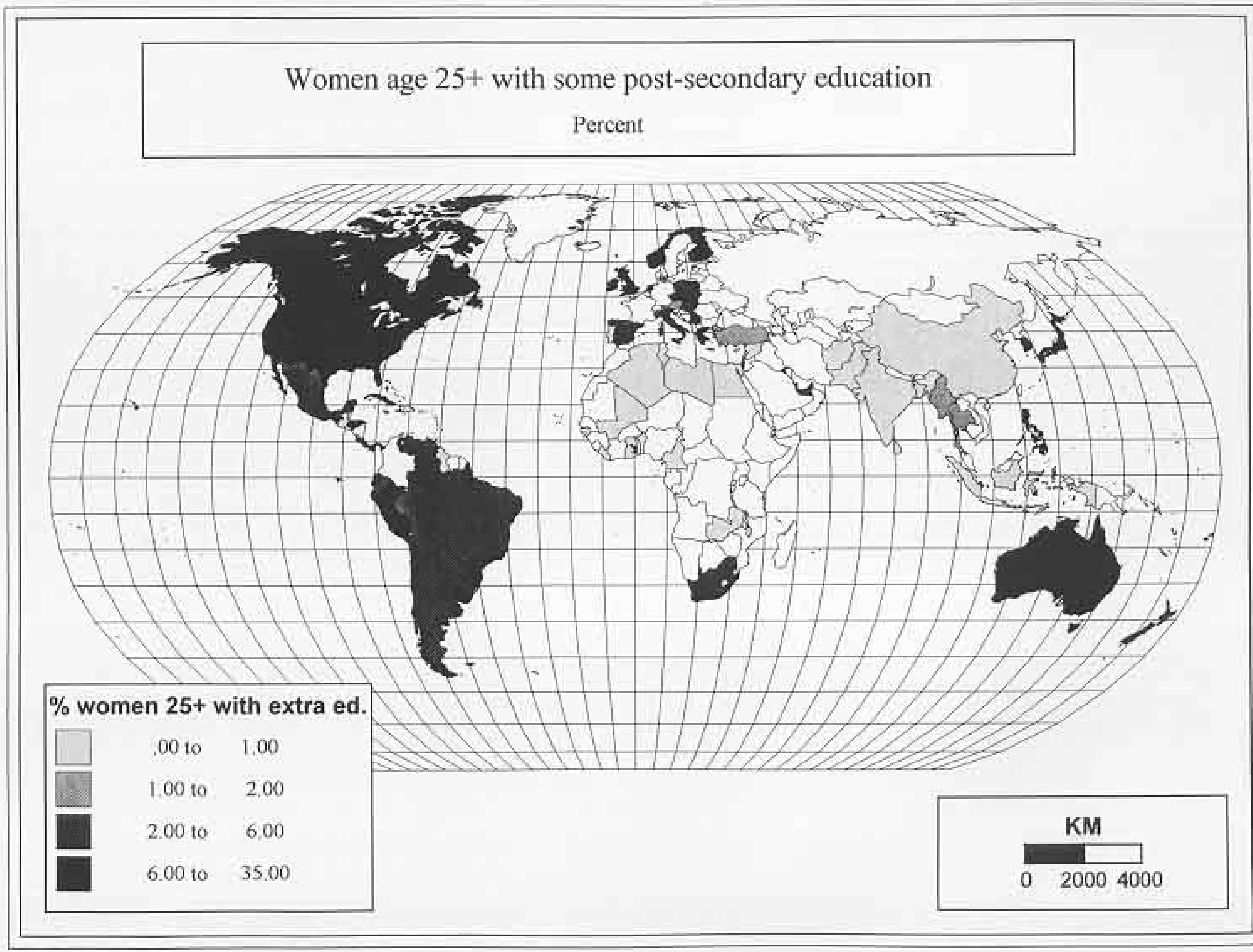
Lastly, I want to reemphasize the importance of utilizing the collective mind. Solutions to the world's fertility problems lie in the minds of women and men. Men have had amply impute into the decision making of reproduction and environmental utilization. Women must contribute a influential female viewpoint, especially the area of reproduction and health. One way might be through a more equal representation of women in policy making positions. Who knows how the environment might be affected if we had a female chief executive, a female majority congress and fortune five hundred chief executive officers representation. But even if politically influential representation never occurs, we must consider and contemplate every and all creative inputs from our diversified culture.

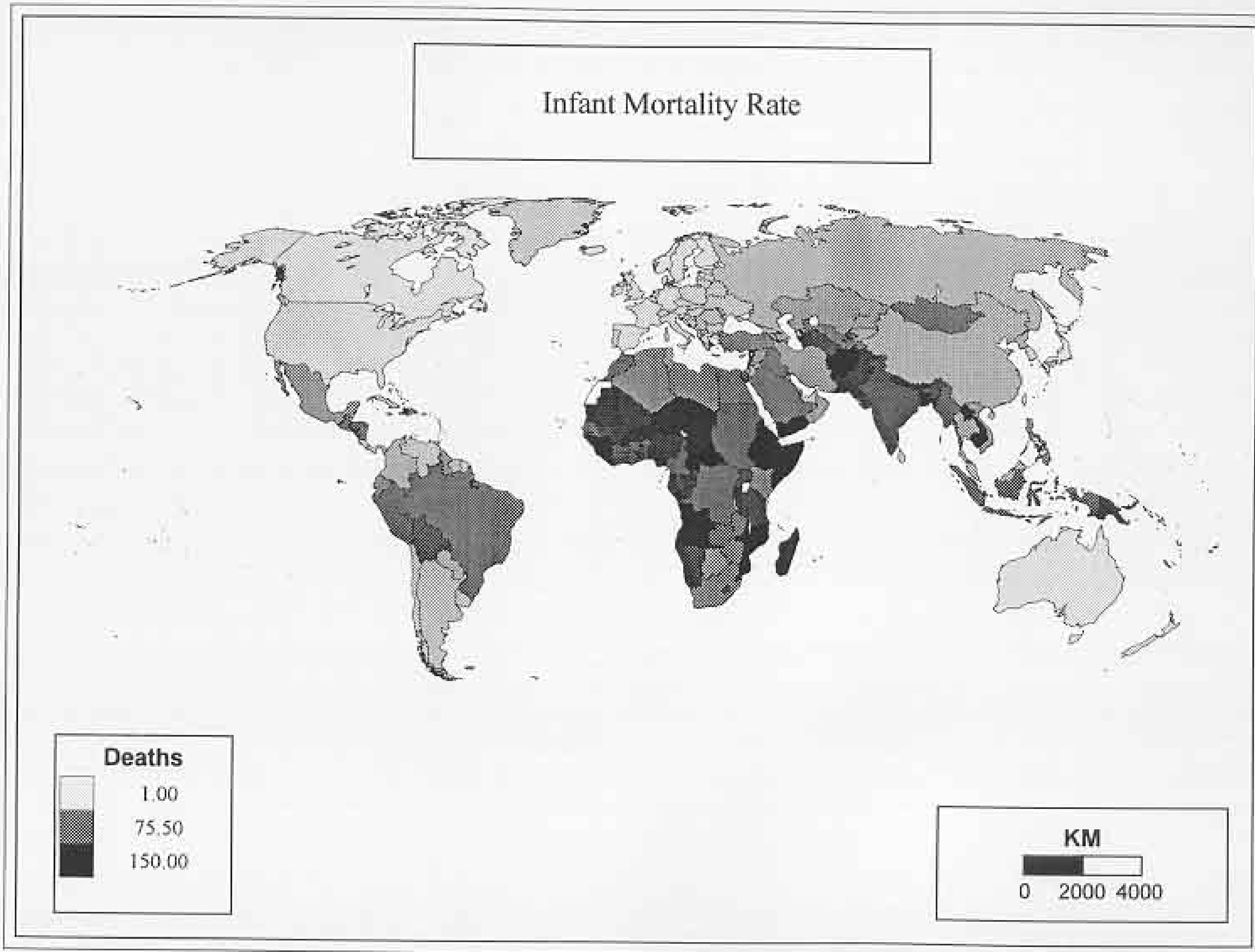
APPENDIX A: MAPS

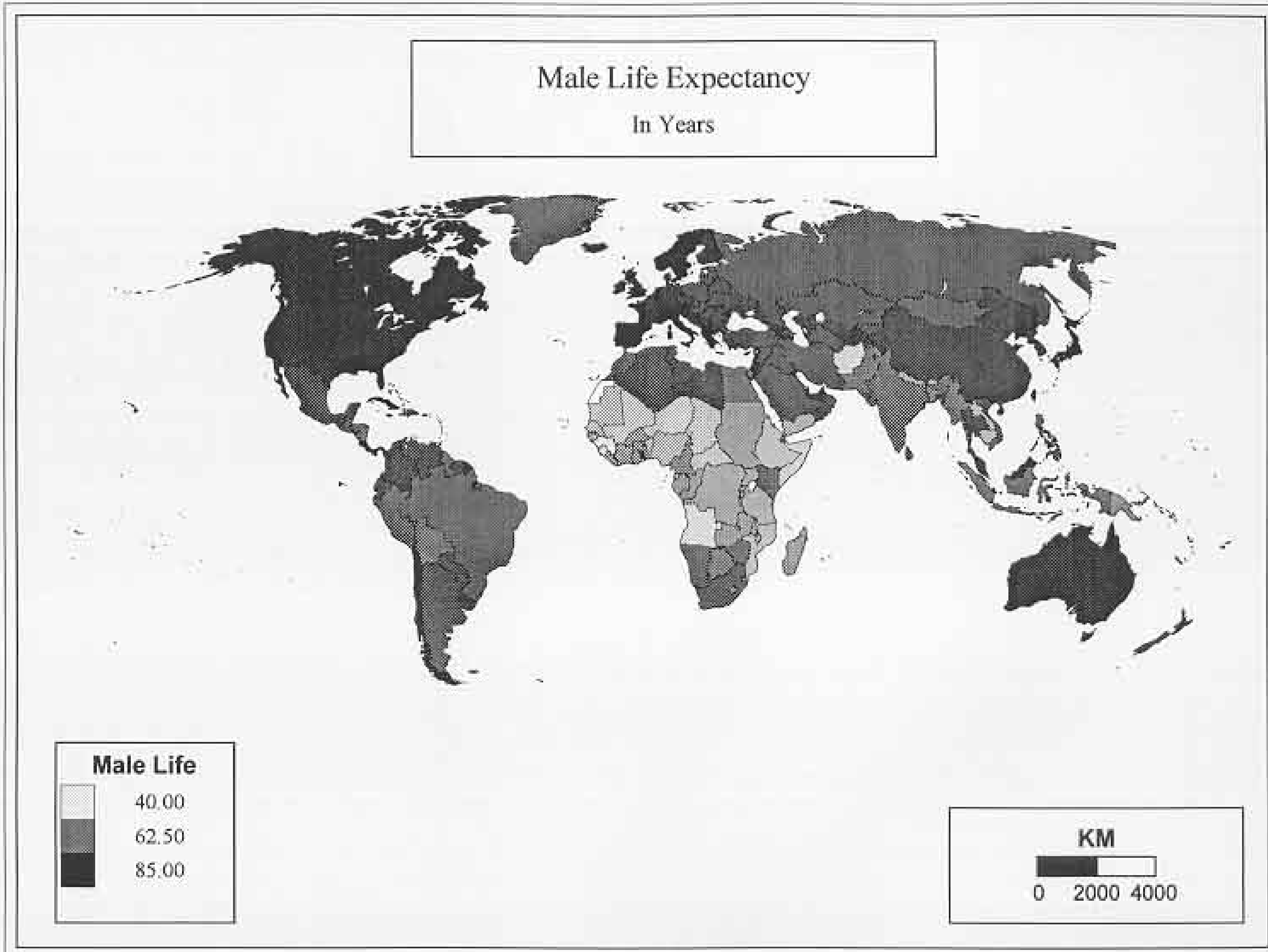
Fertility by country

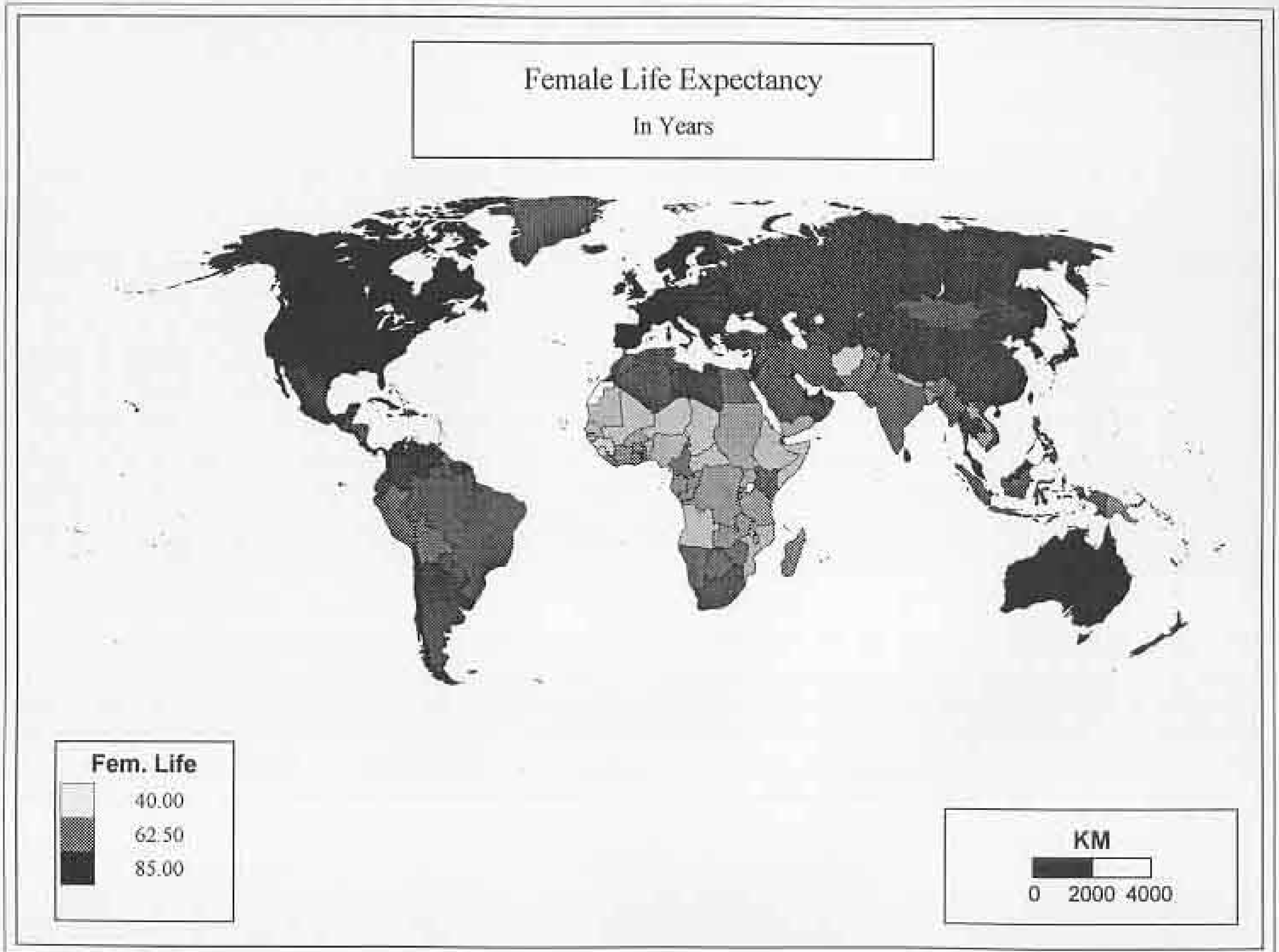
Number of children the average woman will bear in her lifetime

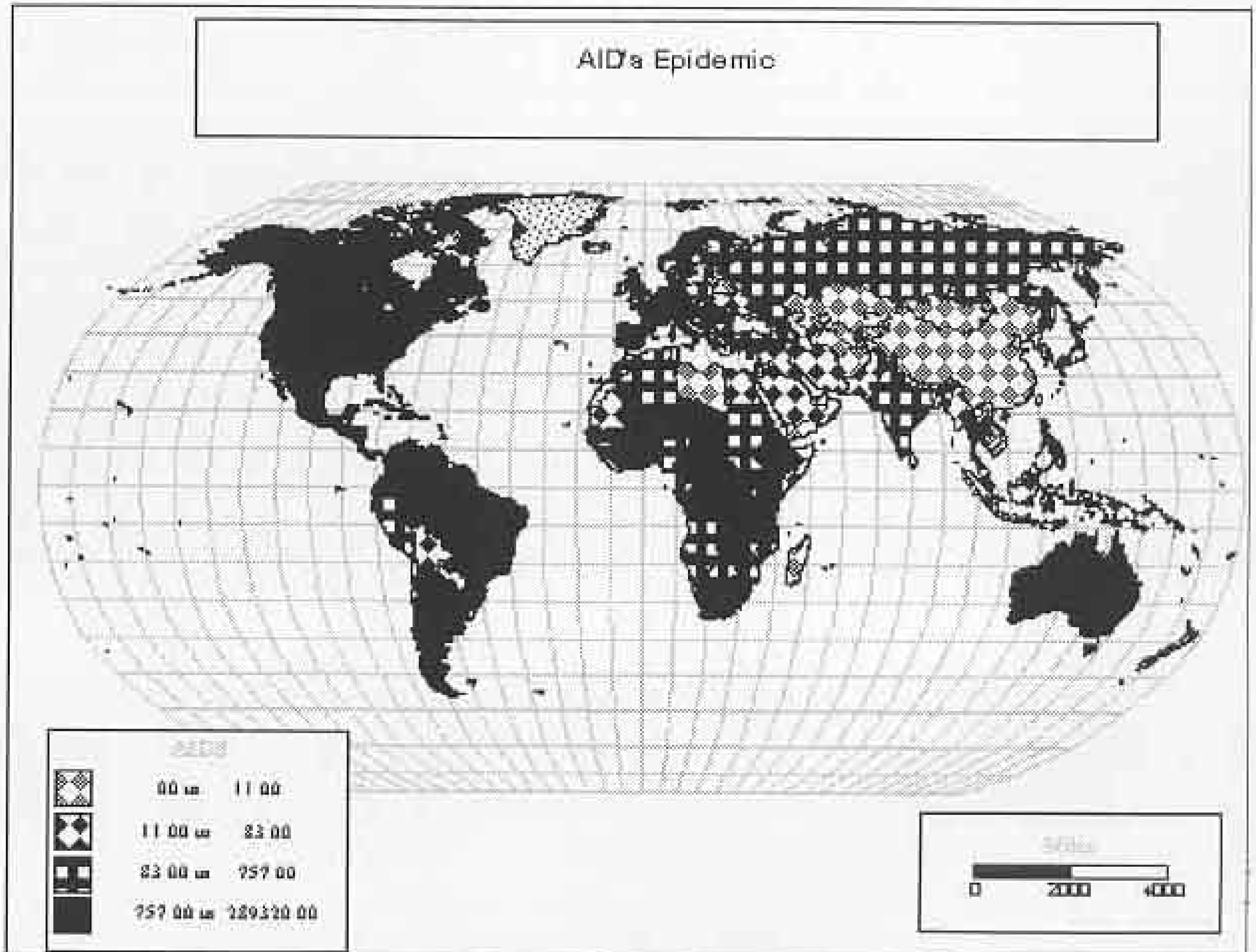


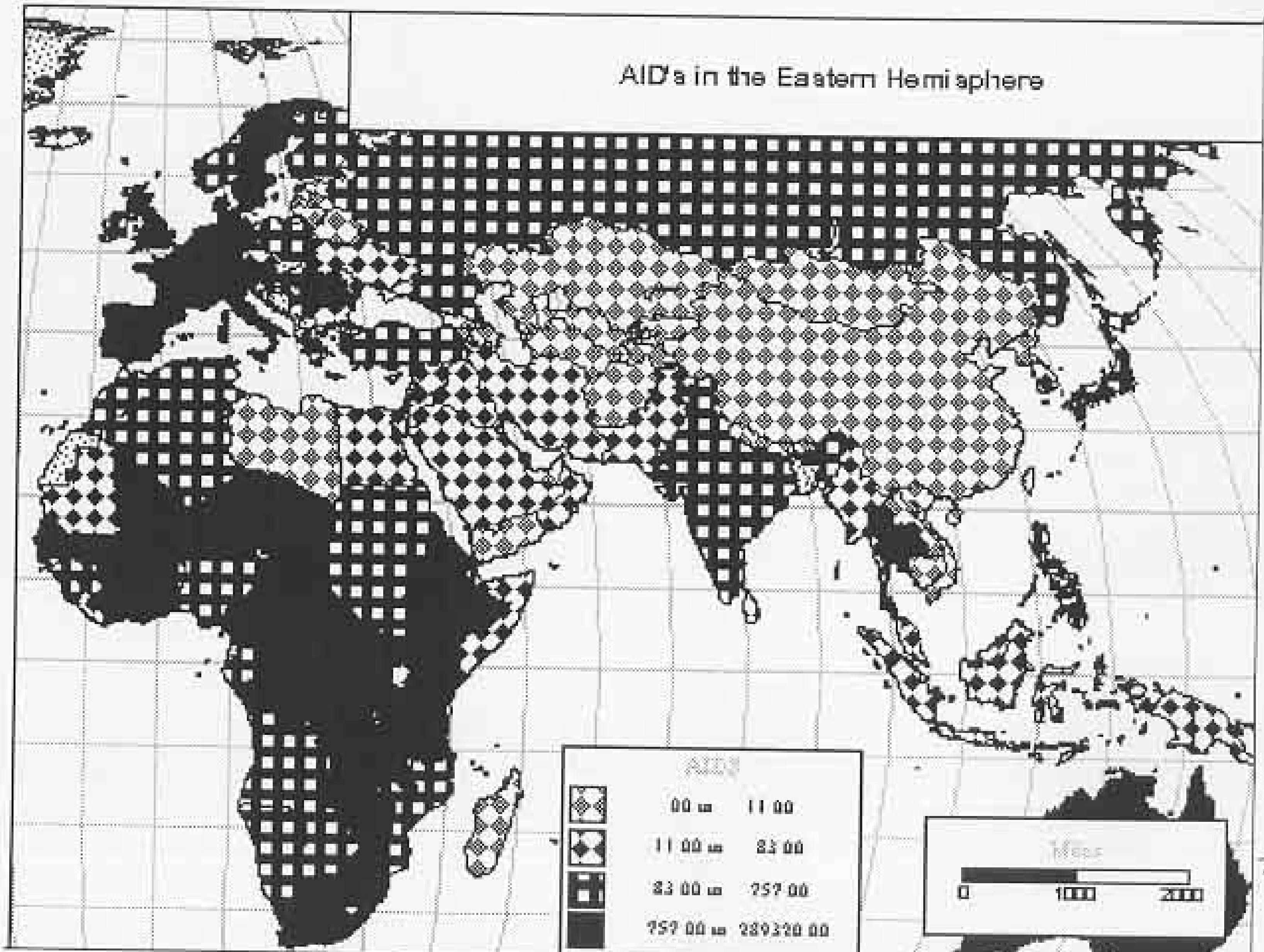

Women age 25+ with some post-secondary education
Percent
% women 25+ with extra ed.
.00 to 1.00
1.00 to 2.00
2.00 to 6.00
6.00 to 35.00
KM
0 2000 4000


Infant Mortality Rate
Deaths
1.00
75.50
150.00
KM
0
2000
4000

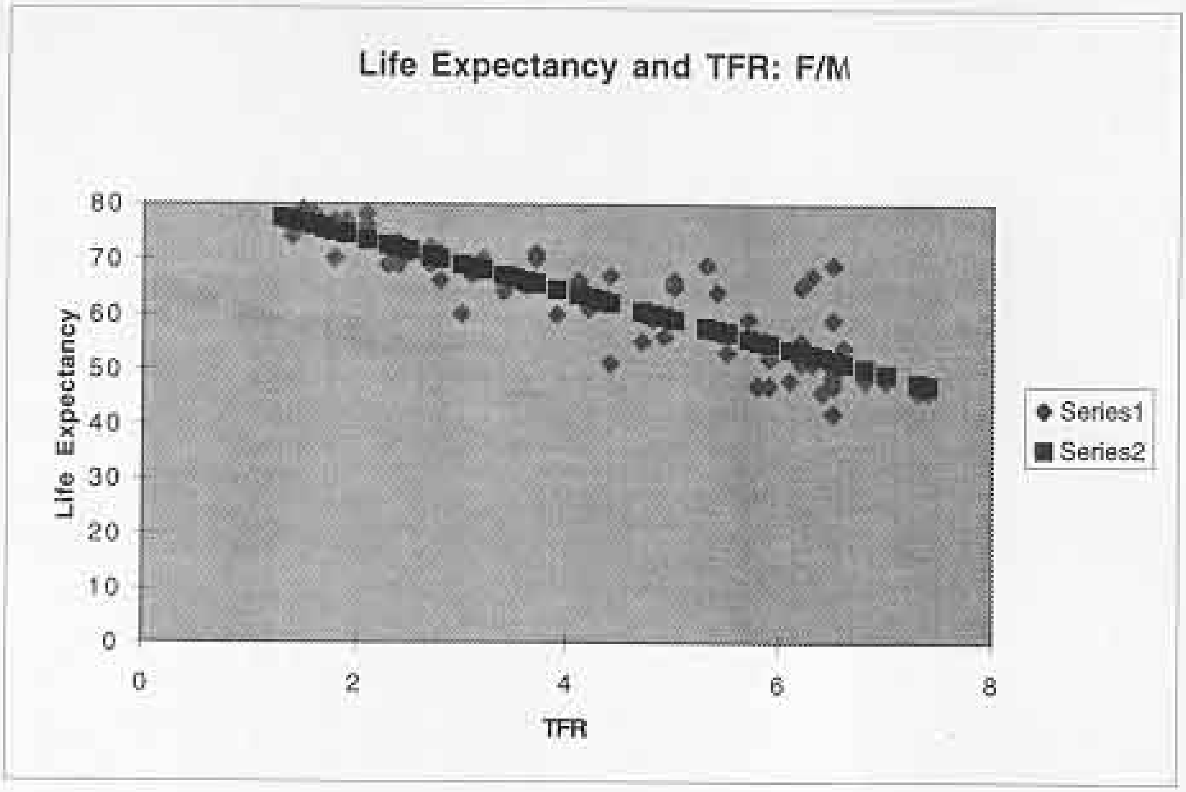

Male Life Expectancy
In Years
Male Life
40.00
62.50
85.00
KM
0
2000
4000

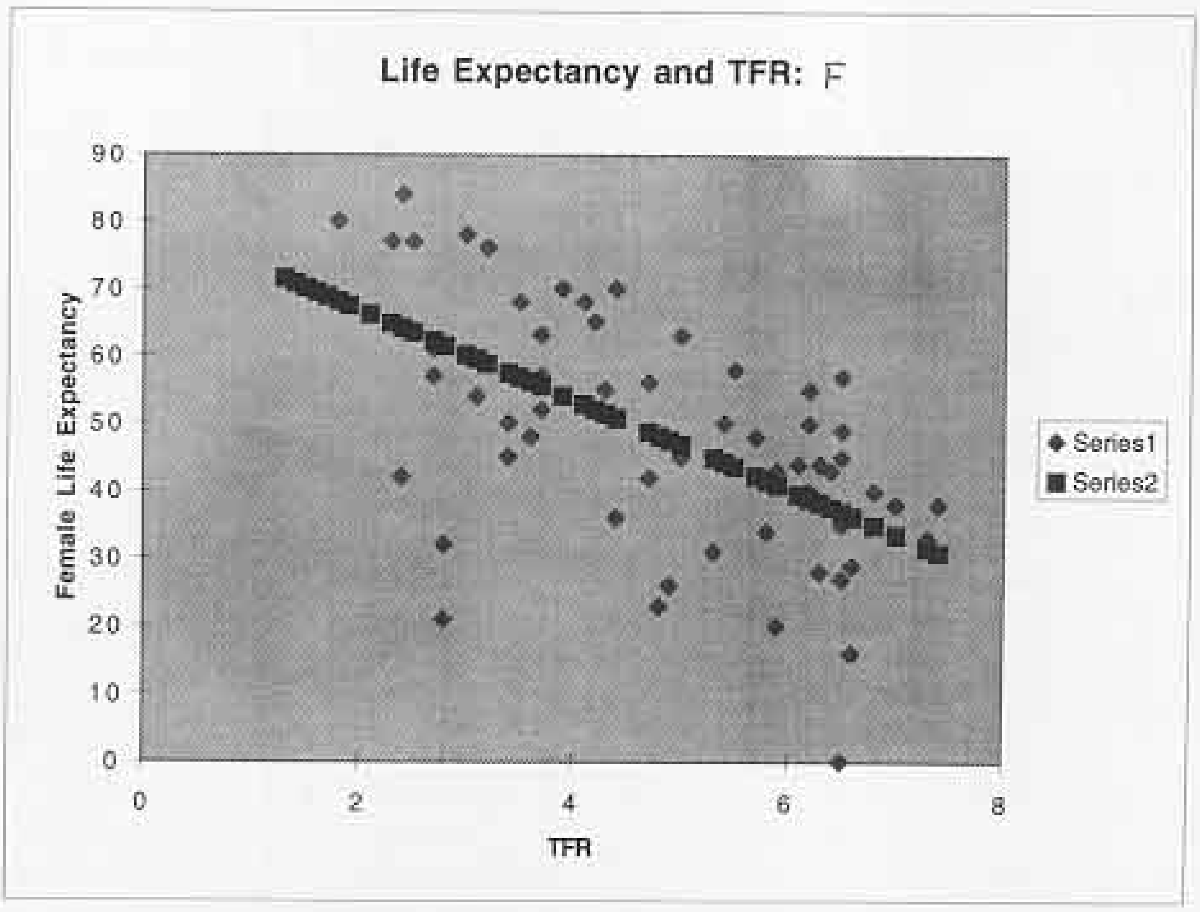

Female Life Expectancy
In Years
Fem. Life
40.00
62.50
85.00
KM
0 2000 4000

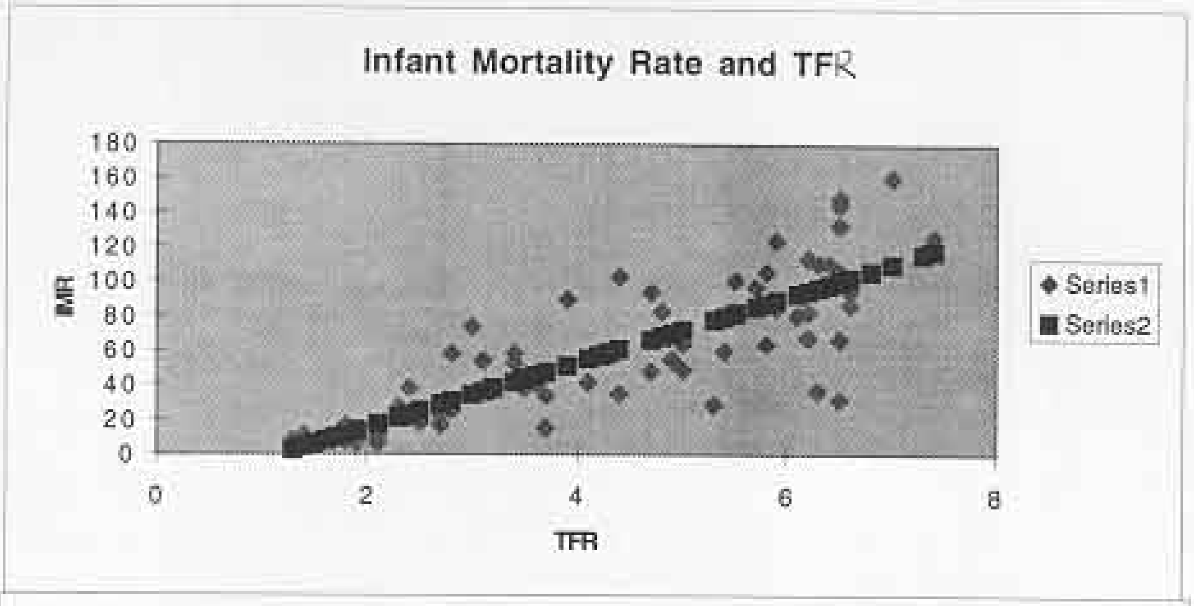

AID's Epidemic
00 11 00
11 00 83 00
83 00 757 00
757 00 229320 00
0 2000 4000

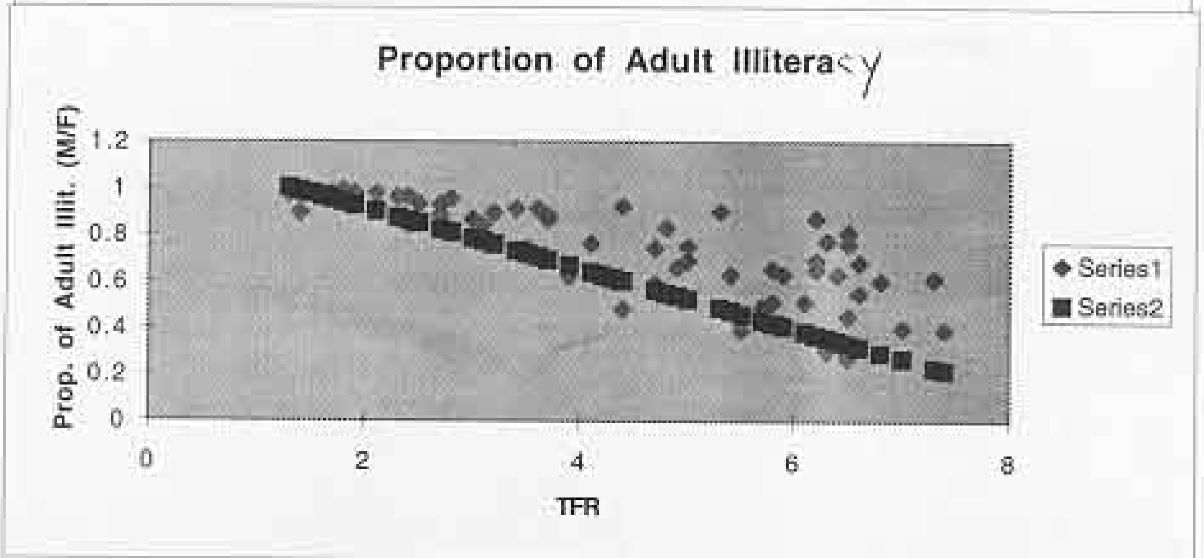

AID's in the Eastern Hemisphere
00 to 11 00
11 00 to 83 00
83 00 to 757 00
757 00 to 289320 00
0
1000
2000

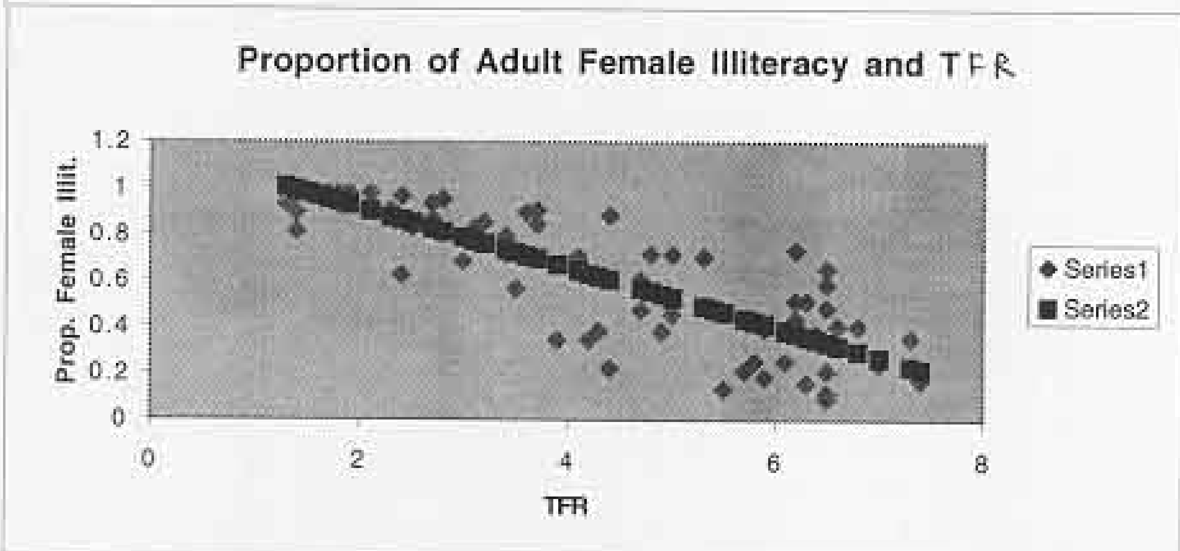
APPENDIX B: GRAPHS

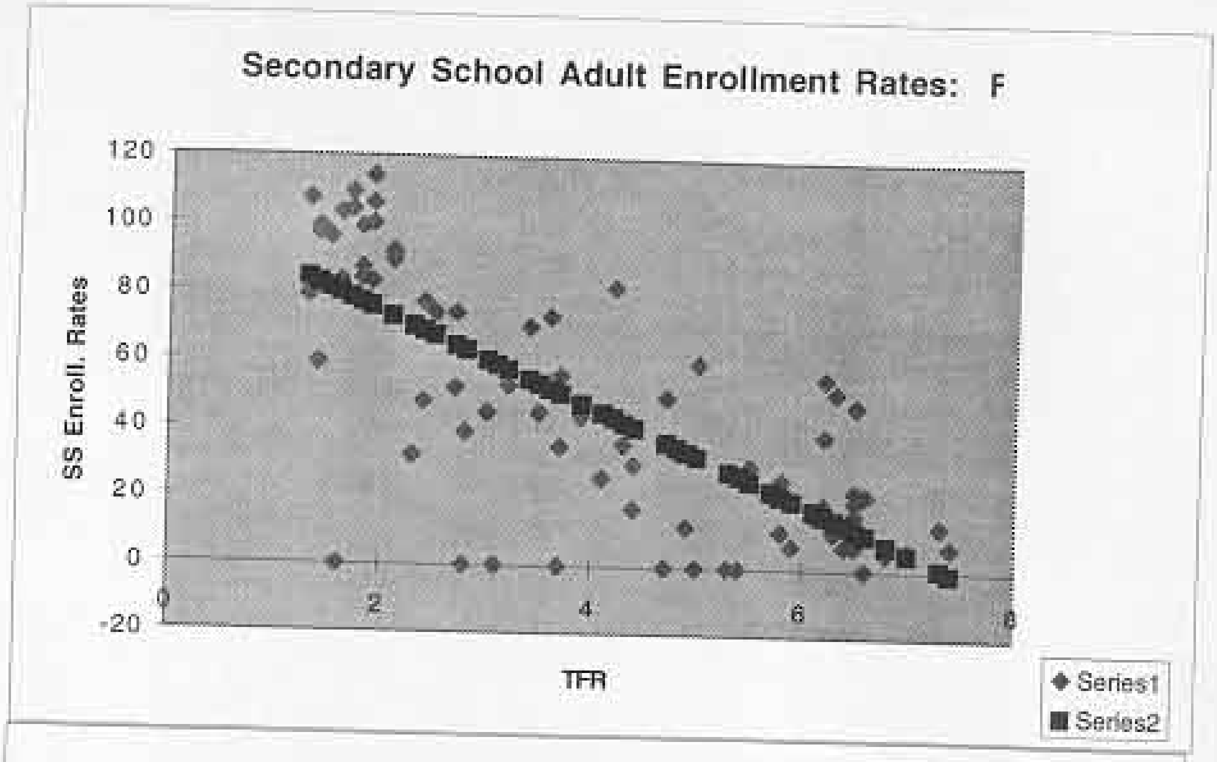

Life Expectancy and TFR: F/M
Life Expectancy
80
70
60
50
40
30
20
10
0
0
2
4
6
8
TFR
Series1
Series2


Life Expectancy and TFR: F
Female Life Expectancy
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
TFR
Series1
Series2

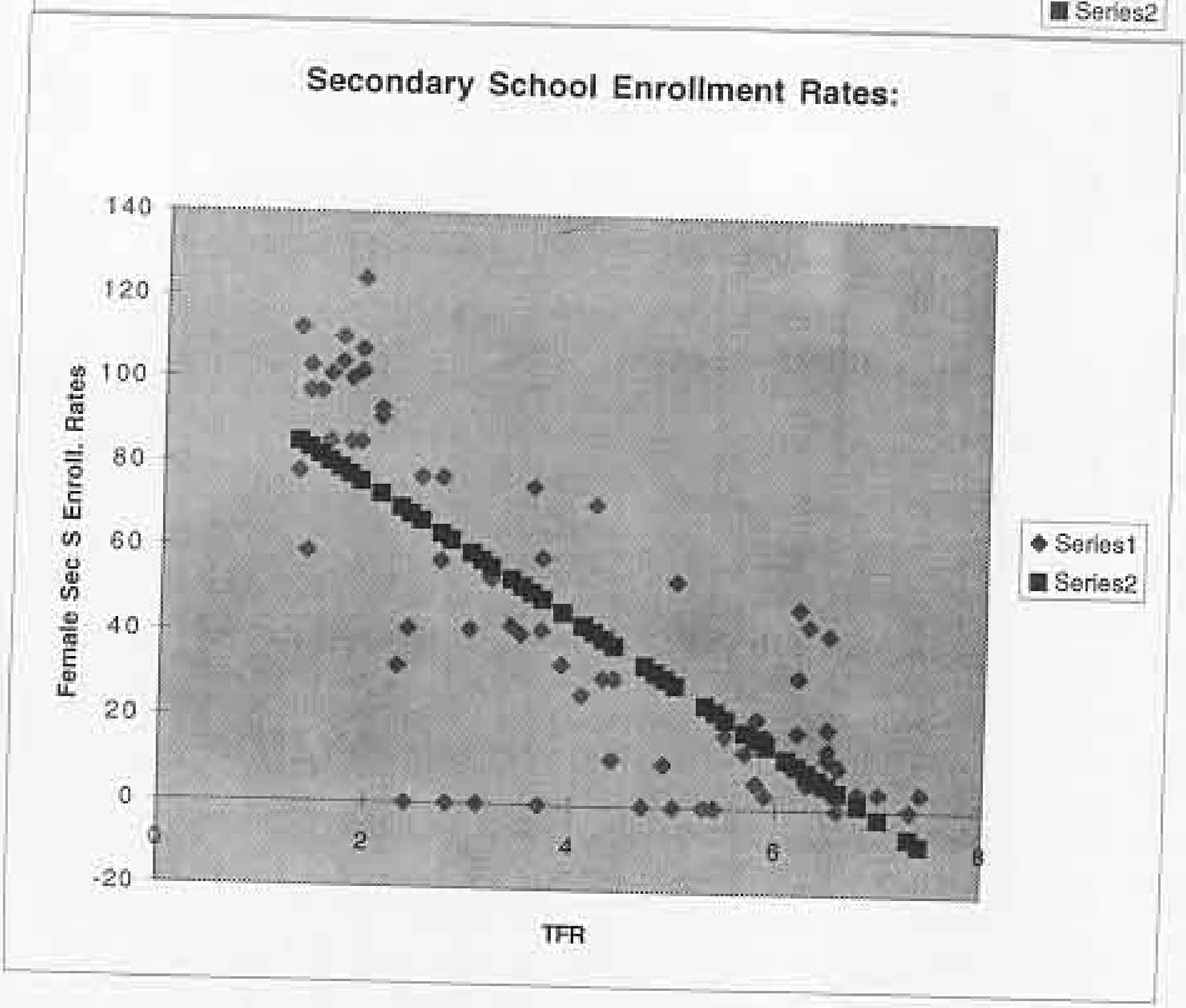

Infant Mortality Rate and TFR
IMR
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
TFR
Series1
Series2


Proportion of Adult Illiteracy
Prop. of Adult Illit. (M/F)
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
TFR
Series1
Series2

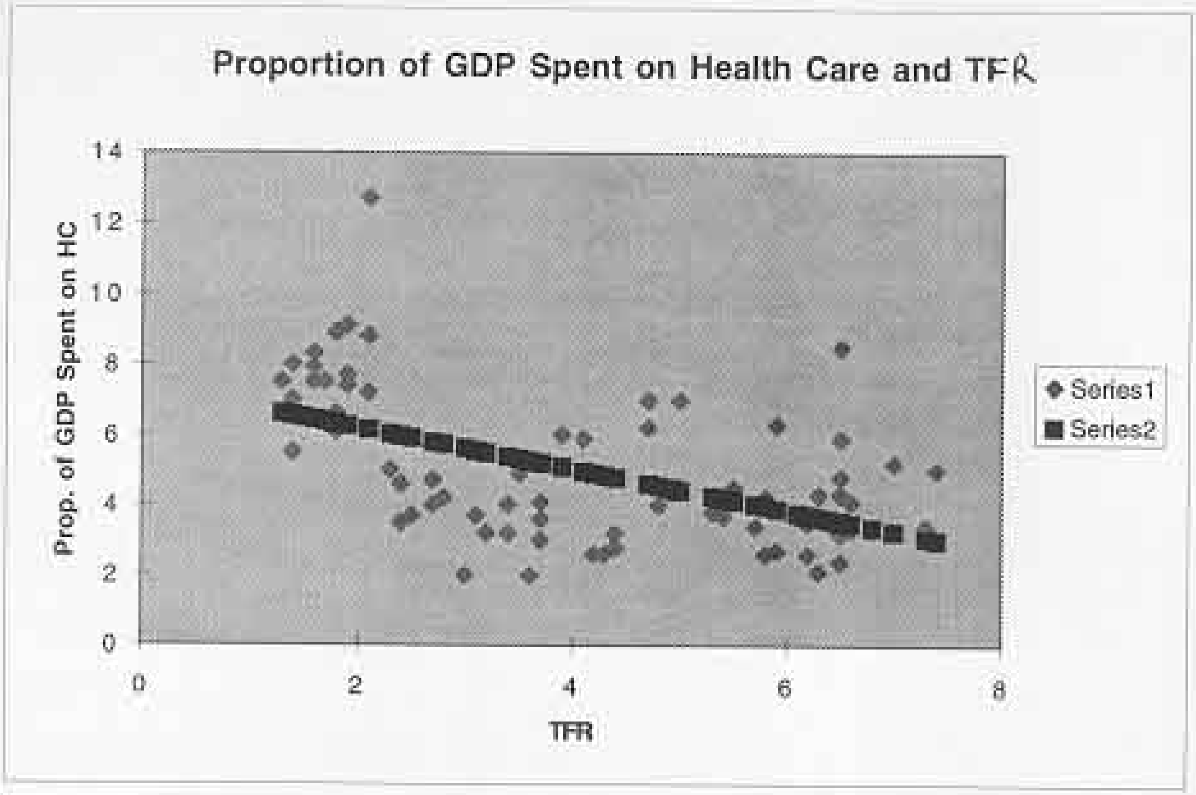

Proportion of Adult Female Illiteracy and TFR
Prop. Female Illit.
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
TFR
Series1
Series2

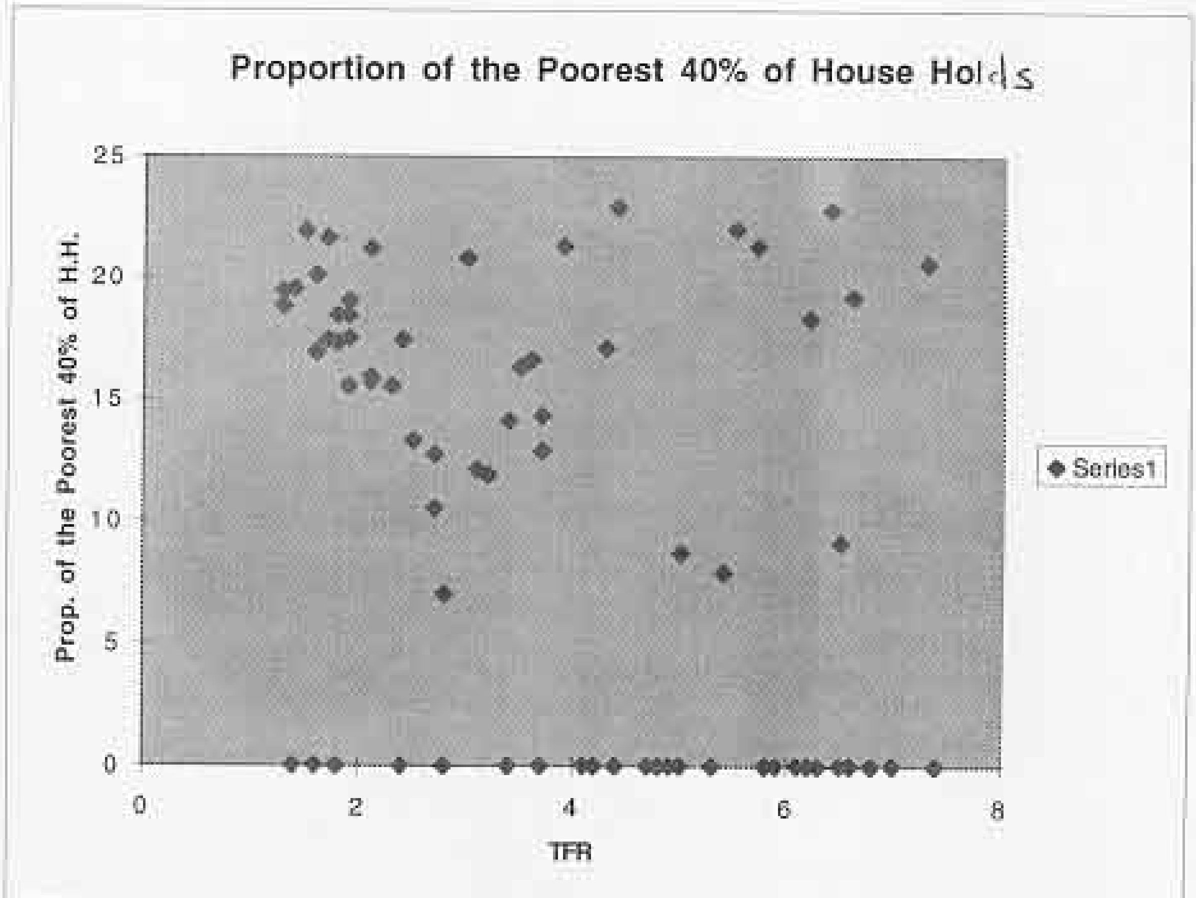


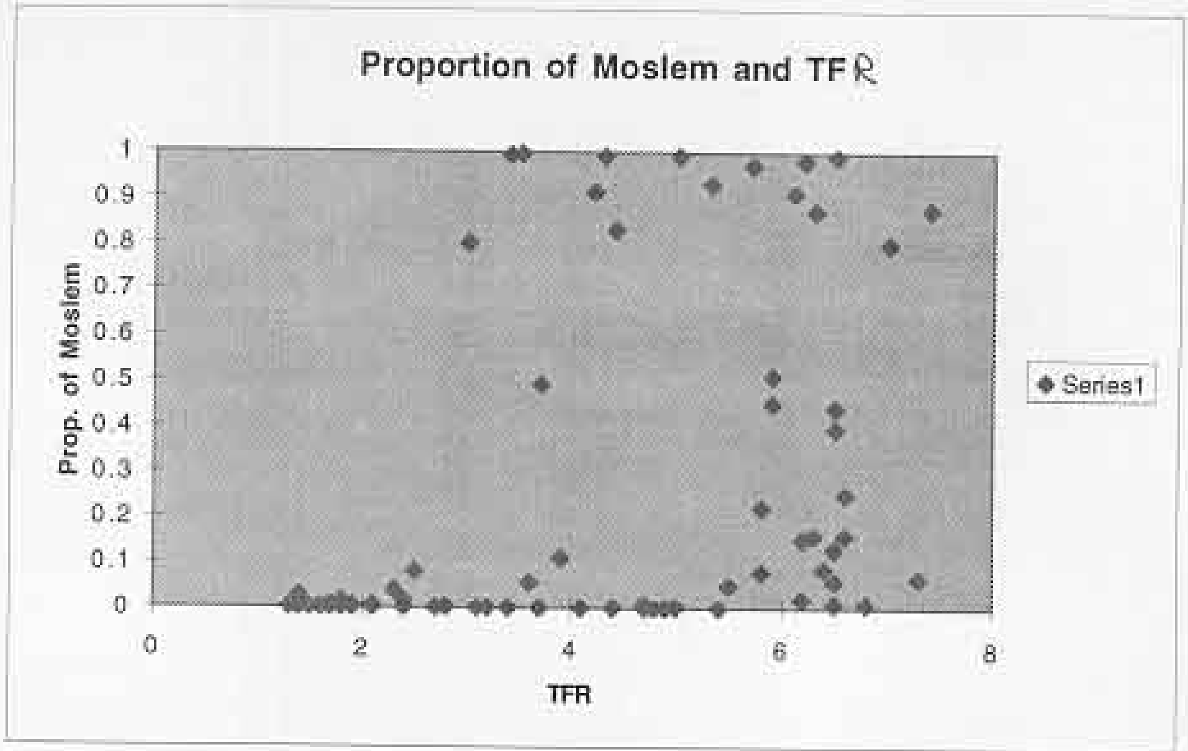
Secondary School Adult Enrollment Rates: F
SS Enroll. Rates
120
100
80
60
40
20
0
-20
0
2
4
6
8
TFR
Series1
Series2

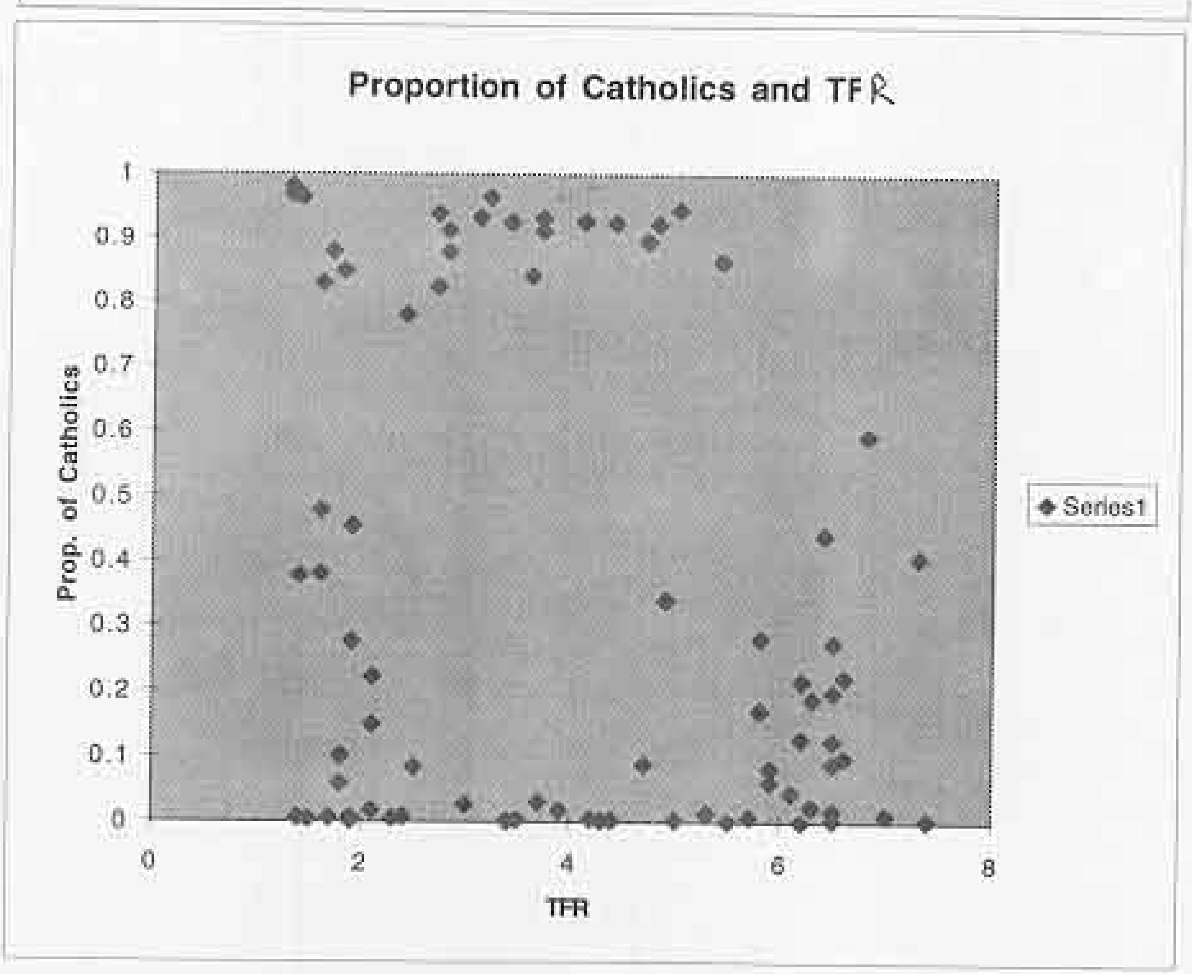


Secondary School Enrollment Rates:
Female Sec S Enroll. Rates
140
120
100
80
60
40
20
0
-20
0
2
4
6
8
TFR
Series1
Series2


Proportion of GDP Spent on Health Care and TFR
Prop. of GDP Spent on HC
0
2
4
6
8
10
12
14
TFR
Series1
Series2


Proportion of the Poorest 40% of House Holds
Prop. of the Poorest 40% of H.H.
0
5
10
15
20
25
2
4
6
8
TFR
Series1


Proportion of Moslem and TFR
Prop. of Moslem
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
TFR
Series1


Proportion of Catholics and TFR
Prop. of Catholics
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
TFR
Series1

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