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## Development, Growth, and the Future of the Border Environment

Paul Ganster, Alan Sweedler, and Norris Clement

### SUMMARY OF ISSUES, PROBLEMS, AND RECOMMENDATIONS

#### Issues and Problems

The U.S.-Mexican border currently has a population of 12 million and will likely double by the year 2020, with most of this growth taking place in the urban regions on both sides of the border. Accompanying this large growth in population will be a sizable increase in cross-border trade and other regional economic activity. The population and trade growth will place significant stress on water and energy resources, transportation infrastructure, and essential social services. It could also have serious environmental consequences for the health and quality of life of border residents. For example, at the present time, all surface waters in the border region are fully allocated by international treaties and domestic agreements. In addition, groundwater deposits are very limited and overused in many regions. Air quality is also a serious problem for many border residents, particularly the high levels of ozone and particulate matter found in the urban regions along the border. Another serious problem is the lack of adequate transportation infrastructure needed to assure the steady flow of goods within the border region. Inadequate roads and highways and poor border crossing facilities result in long delays at the border and heavy congestion in the border region, all contributing to degrading air quality. Finally, much of the historic economic expansion in the border region has not brought economic development, with increasing real wages, standard of living, or prosperity. This has been a lim-

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iting factor on the fiscal base of many border communities, compromising their ability to address environmental and infrastructure problems.

## Recommendations

Although most of the environmental issues in the border region arise from rapid population growth and the lack of financial resources to meet the needs of the population, this growth can also be viewed as a resource to meet projected needs. For this to happen, it will be necessary to distinguish economic growth from economic development. In the effort to create jobs, many communities have not taken into account social and environmental impacts, nor the medium- and long-term implications of their economic development policies. By and large, the following considerations should be systematically incorporated into the efforts to stimulate regional economic development:

- 1 Do the new economic activities bring higher paying jobs to the communities and will the quality of the jobs have a positive impact on the fiscal base of the region?
- 1 What are the medium- and long-term implications of providing subsidies, tax holidays, and other inducements to companies to locate in the region? For example, do these subsidies reduce the ability of the community to build and maintain infrastructure?
- 1 What are the environmental consequences of the economic development activities? For example, will the resulting growth have negative impacts on air quality, water availability, traffic congestion, open spaces, and important habitats? Will the activities simply expand the size of the communities without bringing an improved quality of life and living standard?

Specific recommendations related to improving air and water quality in the border region include:

- 1 Maintaining and expanding the system of air monitoring stations in the border region.
- 1 Developing an inspection and maintenance program for vehicles (private and commercial) in the border region.
- 1 Developing clean energy projects that take into account impacts of energy use on the air and water resources in the region.
- 1 Investing in technologies and processes that put a premium on water conservation in all sectors (residential, commercial, and industrial).

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1. Providing technical assistance to border communities to enable them to compete for NADBank financing by working closely with the BECC.

## INTRODUCTION

This paper discusses the relationship between economic and demographic growth and the environment in the U.S.-Mexican border region. In the first two sections, the historical factors that have shaped current economic and demographic patterns in the border region and what is now being done to change those patterns, are reviewed. The third section focuses on those aspects of the environment that have suffered the most as a result of economic and demographic patterns. In the final section, some of the indicators that have proved valuable in monitoring a region's environmental health are examined.

## ECONOMIC GROWTH AND DEVELOPMENT IN MEXICO

### AND THE BORDER REGION

#### Historical Trends

For over a century, the U.S. economy has been the main driver of urban expansion on the Mexican side of the border. From the Mexican-American War of 1848 until just a few decades ago, Mexico considered the large desert area of its northern states as a barrier to further U.S. expansionism and focused on the economic development of the central part of the country. As the U.S. economy grew and prospered during the late nineteenth and early twentieth centuries, the vast differences in total and per capita income between the two countries grew. As a result, Mexico's northern regions, originally sparsely settled, became more populated in response to the opportunities related mainly to U.S. economic growth.

This symbiotic growth on the Mexican side of the boundary accelerated after World War II with the growth of the U.S. Southwest. There, migration of both capital and population intensified the growth of border twin cities, the urban areas characterized by high population growth rates, rapid expansion of the service sector, and increasing cross-border integration. Some twin cities (e.g., El Paso and Ciudad Juárez), because of their immediate proximity to each other, developed strong and visible commercial, cultural, and social linkages, while in others (e.g., San Diego and Tijuana) these linkages were not so strong nor visible, but present nevertheless. Conse-

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quently, the economic health of most Mexican border cities has become intimately intertwined with the performance of the U.S. economy generally and the neighboring U.S. state economy specifically. In fact, it is common to hear the saying in Mexico, and especially in the northern border region, that when the U.S. economy sneezes, the Mexican economy catches pneumonia. The relationship between business cycles in the United States and Mexico has long been recognized by economists and policymakers in both countries.

The development of the economy of Mexico's northern border region has been conditioned by many factors, not just the U.S. economy. It is important to note that the Mexican national economy has evolved a great deal over the last half century. While Mexico did experience a long period of economic growth in the late nineteenth and early twentieth centuries, the Mexican Revolution (1910-1917) wiped out most of the gains of the earlier period. It was not until the 1930s that Mexico was able to focus on economic development once again. World War II provided Mexican industry an opportunity to develop while U.S. corporations, which supplied a good part of Mexico's manufactured products, were busy supplying the needs of U.S. troops in Europe and Asia. After World War II, Mexico adopted a strategy of Import Substitution Industrialization (ISI) that focused on high tariffs and government incentives to industrialize a country which, at that time, was a full century behind the United States in terms of economic development. As a result of that strategy, Mexico enjoyed relatively high rates of economic growth (6 percent per year) and low rates of inflation (3 percent) during the 1950-1970 period. Mexico did attain a modest level of industrialization during that period, but beginning in the early 1970s, the ISI strategy began to falter. Inflation started rising and commercial bank loans from developed countries were incurred in order to sustain growth.

During the 1977-1981 period, Mexico's economy boomed as its oil exports grew and world prices soared. However, in 1982, when interest rates skyrocketed and a global recession and plummeting oil prices converged, Mexico was forced to declare a moratorium on its debt service payments. The value of the peso fell dramatically and inflation rose to record levels. The U.S. government and the International Monetary Fund came to Mexico's rescue with emergency loans, but in return demanded that Mexico stabilize its economy through tight monetary and fiscal policies and reform its economy along market-oriented lines. Stabilization was necessary in order to reduce inflation and, consequently, the need for further reductions. It also meant that employment and living standards were reduced and

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the economy oscillated between low and negative growth for more than a decade.

Since 1982, Mexico has undergone a profound revolution in its economic development strategy. In less than two decades, protection and regulation of the domestic economy were reduced, state-owned firms were privatized, and the economy was opened to foreign investment and free trade with its North American partners. This new development strategy, frequently referred to as neo-liberalism, seeks development through expanded exports, an expanded role for market mechanisms, and a new, more selective role for government. While these revolutionary changes have important implications for the border region, there are other border-related factors that must also be discussed.

### The Maquiladora: From the Bracero Program to Industrialization

A key factor in the economic development of the U.S. Southwest and the border region was the integration of Mexican labor. One of the great deficiencies of Mexico's development strategies in the post-World War II period has been the inability of the economy to employ the rapidly expanding labor force. Population growth rates prior to the introduction of family planning measures in the mid-1970s hovered above three percent per year and subsequently have fallen to around two percent. Nevertheless, it is estimated that currently Mexico's economy must grow at a rate of six percent per year simply to absorb the new entrants into the labor market. Thus, while open (urban) unemployment is usually estimated at less than 10 percent, the rate of underemployment (i.e., people involuntarily working part-time) is estimated to be more than 40 percent. Thus, at any point in time, approximately half of the labor force is either un- or underemployed. This situation has, over the last several decades, led to the integration of a growing proportion of the Mexican labor force into the U.S. economy; first through the Bracero Program and then through the Border Industrialization Program.

The Bracero Program was first implemented in 1942 in response to the wartime labor shortage in the United States. The Mexican and the U.S. governments agreed to a guest worker program to allow temporary contract of Mexican laborers to work in the United States, initially in agriculture, but later in other sectors. The program was extended beyond the wartime emergency and was finally terminated in 1964. Nonetheless, driven by poverty and lack of jobs in Mexico and attracted by employment opportunities and higher wages in the Unit-

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ed States, the flow of Mexican labor northward has continued to the present time in the form of illegal migration. The movement of Mexican migrants into the United States has profoundly affected border communities and today constitutes a key issue for the border region.<sup>1</sup>

Simultaneously, as many Mexicans acquired visas for work in the United States, and as many border Mexicans acquired U.S. citizenship, a significant group of commuter workers developed along the entire border region. Living in the Mexican twin city and commuting to work in the United States, these workers are an important regional economic force. They constitute approximately eight percent of the economically active population in Mexico's border cities and account for a disproportionate share of personal income in Mexican border cities because of the higher wages earned in the United States. For example, in the San Diego-Tijuana region in the late 1980s, there were probably more than forty thousand men and women who crossed daily to work in the United States, and presently this figure may be as high as sixty thousand.<sup>2</sup> The total income of this group of commuters is at least several times larger than the income of the 135,000 or so workers in Tijuana's maquiladora industry.<sup>3</sup> Paid in dollars, these individuals benefit from devaluations of the peso and account for important retail purchases in the United States. Often, earners of low wages in the United States, these commuters are middle class by Mexican standards. They often live in Mexico not only for cultural preferences, but also for lower housing and living costs. In addition to providing high quality and low cost labor, these workers benefit the U.S. border cities in another way. San Diego has a serious shortage of affordable housing and in the case of the commuter workers and a growing number of U.S.-born citizens, Mexico meets that basic infrastructure need.<sup>4</sup>

### Border Industrialization Program The Maquiladora Industry

Mexico, fearing significant unemployment as the Bracero Program ended and guest workers returned from the United States, established the Border Industrialization Program in 1965. Designed to generate jobs in Mexican border cities through establishment of assembly plants, or maquiladoras, the program initially enjoyed only modest success.<sup>5</sup> However, beginning in 1984, stimulated by simplified regulations and lower wages brought by the devalued peso, the industry has achieved double-digit increases in employment each year.

The importance of the maquiladora industry to the border region should not be underestimated. On the Mexican side of the interna-

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tional boundary, the industry stimulated significant job creation and produced a group of managers and technical personnel in an industry that has become competitive on a world level at prevailing wages. Since other areas of Mexican industry were not globally competitive, the maquiladora industry, through job creation and investment, has helped the northern border become one of the most economically dynamic regions of Mexico, even during the severe economic downturns of the mid-1980s and mid-1990s. Ironically, however, the maquiladora industry owes much of its success and rapid growth to the weakness of Mexico's national economy since the early 1990s. Labor costs in dollar terms have been kept low by successive peso devaluations, thereby attracting investment that would otherwise have gone to low wage areas in Asia and the Caribbean. Nevertheless, the weakness of the Mexican economy can be blamed for the huge infrastructure deficit that characterizes those border cities where maquiladora growth has been the fastest. Tijuana, for example, throughout the 1980s and 1990s, has experienced population growth rates of well over six percent per year due to its ability to provide jobs for migrants who come from the interior of the country. However, most resources for infrastructure expenditure must come from the federal government, which for the last 15 years has been intent on reducing expenditures and raising taxes. Consequently, as needs in the border regions have grown with the increasing population, the ability of the federal government to provide social and physical infrastructure has diminished.

### Informal Border Transactions

For decades, the most visible element of border economic integration from the perspective of the U.S. border communities was through retail and some wholesale purchases made by Mexican shoppers on the U.S. side of the border. The unrecorded purchases are usually referred to as informal border transactions. Much of Mexico's northern border has been a free zone since the 1930s. This status recognized the northern economy's isolation from the Mexican national economy and its close linkages to the U.S. economy. This policy, which continues currently, acknowledges that enforcement of customs regulations by Mexico at the international boundary was futile. Thus, many Mexican shoppers crossed to the United States where price, variety, and quality of goods were perceived to be better than in Mexico. Many U.S. border communities reported significant negative impacts with the peso devaluations of 1976, 1982, and 1994-1995 that decreased the value of the peso versus the dollar.

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and created recessions, making it difficult for many Mexicans to continue to cross into the United States to shop.<sup>6</sup>

Unfortunately, the regional economies of border twin cities are not well understood due to inadequate data and the complexity of the cross-border economic linkages. There are also significant differences along the border. For example, the regional economy of San Diego is at least ten times larger than that of Tijuana. The Mexico connection accounts for no more than five percent of San Diego's employment, whereas Tijuana's U.S. economic linkages account for more than half of its employment.<sup>7</sup> In the El Paso-Ciudad Juárez region, the relationship is less asymmetrical and in some areas, the larger Mexican city dominates the U.S. twin city, as in the case of Mexicali and Calexico or Nogales, Sonora, and Nogales, Arizona. Consequently, one must be cautious when generalizing for the entire border region.

The expansion of the maquiladora industry in the early 1980s coincided with a decline in Mexican retail purchases, which, in turn, triggered new cross-border collaboration. Many local officials in U.S. border communities, noting the positive economic impact on their own economies from the establishment of maquiladoras in adjacent Mexican cities, began to actively recruit U.S. and other companies to relocate to the Mexican side of the border. For the first time, many business and political leaders, as well as members of the general public in U.S. border communities, became aware of the symbiotic relationship with their Mexican neighbors. Beginning in the mid-1980s, U.S. border communities began to see significant opportunities in expanded economic relations with Mexico. This was especially true in the smaller U.S. border communities, particularly along the lower Rio Grande in Texas where regional economies were narrowly based on agriculture and Mexican retail purchases.<sup>8</sup> These communities viewed maquiladoras as an opportunity to broaden the regional economic base. This change in mentality led to strong support in border communities for the North American Free Trade Agreement that took effect January 1, 1994. It also culminated in enhanced border interactions in areas of life other than those strictly related to trade and commerce, pushing U.S. and Mexican border communities toward cooperation on many fronts.

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## Border Economic Growth and NAFTA

The changes in Mexico's economic policy initiated under the presidency of Miguel de la Madrid (1982-1988) and continued under Carlos Salinas de Gortari (1988-1994) have significantly altered the economic relations between the United States and Mexico. Mexico's decision to enter the GATT (General Agreement on Tariffs and Trade) in 1986 resulted in the elimination of import licenses and reduction of tariffs, providing much greater access for U.S. exporters to Mexican markets. Additional changes in Mexico's trade, investment, real estate, and maquiladora laws and regulations followed and these liberalizing measures produced a significant increase in U.S.-Mexican trade. Since most bilateral trade moved goods by land, trade-related activities boomed in border cities. At the same time, infrastructure in the border cities, including customs facilities, ports of entry, and roads became saturated.

While it is likely that the overall economic impact of NAFTA has been greater economic growth for Canada, Mexico, and the United States than otherwise might have occurred, the regional impacts have varied considerably. Border communities have experienced a number of effects, including greater integration of the regional trans-border economies, a huge increase in commerce passing through the border cities, and a significant growth of the maquiladora industry.

The expansion of the border economy has created large numbers of new jobs. The maquiladora industry is a case in point. However, there is a downside to the nature of job creation in border communities. Most of the new jobs created over the past decade, and particularly since NAFTA, have been in entry-level service positions or in the maquiladora industry. While employment in the maquiladora industry has risen rapidly, real wages have not increased and have actually declined somewhat. Thus, the industry has failed to improve standards of living for most of its workers. The challenge of improving the real wages of maquila workers is clearly recognized by economic development organizations and by the maquiladora industry itself. The problems of low maquila wages and other wages in Mexican border cities are compounded by the dollarized Mexican border economy and the very high cost of living.

U.S. border communities have also faced a similar problem with improving real incomes. Regions such as San Diego that lost high paying jobs related to the defense industry decline during the early 1990s have added new jobs in the recovery from the recession. How-

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ever, many of the new jobs are in entry-level service positions that pay low wages and often do not include health care and other benefits. Most of these jobs cannot support families without substantial public assistance through social services, indigent health care, subsidized housing, or other governmental assistance. Thus, many of these positions actually require a public subsidy and consume more taxes than they generate. All these problems are exacerbated by the relatively high cost of living in U.S. border towns, particularly on the western end of the border.

### Economic Growth Versus Economic Development

Within the globalized economy, more communities and regions are beginning to take a proactive role in fostering economic development at the local and regional level. Border communities now view their economic regions as the entire transborder region of the twin cities and surrounding areas, and through local economic development organizations and governments they have worked to expand trade and investment opportunities. The ultimate goal of these efforts is to create jobs in their communities. Examples include cities of the lower Rio Grande area working to bring maquilas to cities across the border, joint economic development efforts of the Arizona-Sonora Commission, joint marketing in Asia of the California-Baja California border region as a manufacturing and commerce location,<sup>9</sup> and border-wide efforts to enhance physical infrastructure for trade and commerce led by the Border Trade Alliance. A standard tool employed by communities in economic development efforts has been to recruit companies to locate in the region by offering tax breaks, subsidized buildings and industrial parks, infrastructure subsidies, and so forth.

In the efforts to create jobs, many communities have not taken into account the social and environmental impacts nor the medium- and long-term implications of their economic development policies.<sup>10</sup> By and large, the following considerations and questions have not been systematically incorporated into the efforts to stimulate regional economic growth:

1. Do the new economic activities bring higher paying jobs to the communities? By 1998, many border communities were concerned that they had been left out of the benefits of expanded trade and investment brought by NAFTA. Simply put, regions such as El Paso-Ciudad Juárez had experienced a great increase in trade and manufacturing, but had failed to add higher value to the trade and manufacturing activities. At the

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same time, this region experienced some negative impacts of free trade, including job displacement and increased traffic congestion.<sup>11</sup> Thus, prosperity driven by NAFTA has been elusive.

1. What are the medium- and long-term implications of providing subsidies, tax holidays, and other inducements to companies to locate in the region? For example, do these subsidies reduce the ability of the community to build and maintain infrastructure?
1. What is the quality of the jobs created in terms of salaries, wages, and benefits? Will these jobs have a negative impact (and require social services) or a positive impact on the fiscal base of the region? Entry level positions often require more in government services than they contribute in taxes. Do the new jobs raise the standard of living?
1. What are the environmental consequences of the economic development activities? For example, will the resulting growth have negative impacts on air quality, water availability, traffic congestion, open spaces, and important habitats? Will the activities simply expand the size of the communities without bringing an improved quality of life and living standard?

## Future Scenarios

The aforementioned considerations suggest that communities that continue efforts to create jobs indiscriminately without regard to improving the level of real wages face negative impacts in the medium and long term. These negative impacts will be seen in saturated infrastructure, negative environmental impacts, accelerated growth, increasing poverty, and declining quality of life. Business as usual will most likely bring growth and economic expansion without qualitative improvement in quality of life and prosperity.

These considerations suggest that additional elements should be incorporated into the thinking of communities engaged in economic development activities. The challenge for border communities, then, is to implement policies that will bring economic development, protect and improve the environment, and improve the quality of life in border communities.

## POPULATION GROWTH

The reasons for the flow of people from central and southern Mexico to the northern border and across into the United States are related

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to push factors in Mexico and pull factors in the United States. Mexican development and social policy in modern times, and especially since the 1940s, focused little attention on a more equitable distribution of income and wealth and largely ignored services in the rural areas and small towns of Mexico.<sup>12</sup> The population explosion that hit Mexico beginning in the 1940s first produced internal migration to the cities in search of employment and access to services. Then, the flows turned northward in search of work, following paths established by generations of Mexican migrant workers, including legal guest workers who had worked in the United States as *braceros* from World War II until 1964, when the program ended. The boom of the war years and subsequent postwar economic growth and urban development of the Southwest (the Sunbelt) acted as a strong magnet for Mexicans for whom adequate employment in their native regions was not possible.

There is a clear link between economic conditions and population growth in border communities. Economic growth in U.S. border cities encourages in-migration, both domestic and foreign. Recession in U.S. border communities reduces domestic in-migration and has a dampening effect on international in-migration. Recession in central and southern Mexico encourages out-migration to Mexico's northern border cities and into the United States.

The populations of both the Mexican and the U.S. border zones have, over the long run, exceeded natural growth rates. Migration is the most important factor shaping the demographic picture of the binational border region. For example, Tijuana's population grew 6.9 percent between 1987 and 1988; 1.9 percent of the growth was natural increase and 5 percent was the result of immigration. During the same period, Ciudad Juárez saw a 1.8 percent natural increase and a 7.5 percent increase from migration.<sup>13</sup> In 1980, 48.9 percent of the population of the border counties and municipalities consisted of migrants. Of the 48.9 percent, 8.4 percent were from a foreign country. The 1980 population of the Mexican border municipalities was 31.8 percent migrants, while the figure for the U.S. border counties was 58.2 percent. Eleven percent of the migrants in the Mexican border municipalities were foreign-born, while the figure was a much larger 20 percent for the U.S. border counties.<sup>14</sup>

The relationship between economic growth and population increase in border communities can clearly be seen in the recent history of San Diego. It should be noted that approximately 40 percent of the border's population resides in the San Diego-Tijuana border zone. In the early 1990s, San Diego's economy went through a deep recession, provoked largely by the convergence of a national reces-

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sion with downsizing of the defense industry after the end of the Cold War. During this period, migration out of the region increased, migration into the region decreased, and the region's population grew at an average rate of 1.8 percent per year. This contrasts with a yearly average growth of 3.0 percent in the 1980s.<sup>15</sup> In 1996, the economy began to rebound, and in that year 20,500 jobs were created. In that same year, the county's population grew by 42,300, an increase of 1.6 percent, which was a significant change from the previous year's population increase of 0.9 percent.<sup>16</sup> In one year, the time required for the San Diego population to double decreased from nearly 77 years to 43 years. As the San Diego economy continued to improve throughout 1997, the rate of population growth continued to increase. In 1997, San Diego County's population increased by 68,500 people, an annual rate of 2.5 percent, implying a doubling time of 27.6 years.<sup>17</sup> Thus, in a few short years, the improving San Diego economy caused the population growth rate to double. The relationship between economic cycles and rapid, often unpredictable, population growth presents a challenge to many other border communities in their efforts to plan for future infrastructure requirements.

### THE NATURAL RESOURCE BASE, ENVIRONMENTAL CONDITIONS, AND BORDER GROWTH

The U.S.-Mexican border region is largely arid, with limited water supplies for human activities and for maintenance of the viability of important habitats along rivers, streams, and elsewhere. Everywhere along the border, concentrated and rapid urban growth and economic activities including ranching, mining, recreation and tourism, and other pursuits have polluted the environment and have stressed the natural resource base of the region. The section that follows will discuss especially critical aspects of the environment and natural resources of the border and will be illustrated with a few examples.

#### Water Supply and Demand

Economic growth, including industrial activities, irrigated agriculture, urban expansion, and population growth, has created a huge demand for water in the border region. All surface waters in the border region are fully allocated by international treaties and domestic agreements, and groundwater deposits are very limited and overused in many regions. One alternative for the long-term water supply for border communities is water reclamation, combined with conservation. However, this involves significant capital costs for infrastructure

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and major energy costs for reclamation and pumping. Recently, attention has turned to an examination of developing water markets to permit transfer of water from agriculture to urban uses. In the case of California, only five percent of agricultural water would have to be transferred to urban uses to assure an adequate supply for the foreseeable future. Participating in transboundary water markets might be a viable alternative for some Mexican border cities in order to avoid huge infrastructure costs. Not all areas of the border have this option available and continued growth will be possible only through conservation accompanied by radical changes in consumption practices and water reuse. It is clear that most of the population centers of the border do not at present have a secure water supply that will carry them to the year 2020.

## Tijuana-San Diego

San Diego County and Tijuana account for approximately 40 percent of the population of the border region. In a typical year, San Diego County imports over 90 percent of its water and Tijuana imports up to 95 percent of its water, depending upon the amount of rainfall captured at Rodriguez Reservoir.<sup>18</sup> By 2010, the binational region's population will increase from 3.7 to 5.45 million people, with 60 percent living in San Diego and 40 percent in Tijuana. A total of 848,000 acre feet (an acre-foot is 325,851 gallons or 1,233 cubic meters) of water will be required at that time for annual consumption, with San Diego accounting for 87 percent of water use and Tijuana for 13 percent. In 1996, approximately 85 percent of San Diego's water came from its allotment of California's share of Colorado River water. In future years, San Diego will have to rely less on this source as California is forced by other Colorado water users to reduce its draw on the Colorado River.<sup>19</sup> San Diego hopes to meet future needs with transfers of water saved by conservation efforts from the Imperial Valley. Although the source of this water is the Colorado River, it would be from the Imperial Valley's agricultural allotment. Currently, authorities in San Diego and Tijuana are discussing joint construction of an aqueduct from the Imperial Valley-Mexicali Valley region to bring additional water to the area.<sup>20</sup>

In 1996, municipal and industrial per-capita water use in the San Diego region was .197 acre-feet. In the year 2010, it is projected to be approximately .196 acre-feet per person. For Tijuana, 1996 per-capita water use was .063 acre-feet and the projected use for 2010 is approximately .053 acre-feet per person. The significant difference in per capita use between Tijuana and San Diego can be partly explained by the greater density of residential areas in Tijuana (19.3

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persons per acre) than in San Diego (2.9 people per acre). In San Diego, for single-family homes and rural areas, outdoor water use may be as high as 60 percent of total residential uses.<sup>21</sup> Thus, an obvious alternative for San Diego and other U.S. border cities is to become more efficient in use of existing water resources through land-use planning and other mechanisms. Such change will be difficult and will likely be seen by U.S. border residents as a deterioration of the quality of life.

Related water supply problems for the San Diego-Tijuana region include an inadequate storage system and a system of aqueducts from the north and east that is vulnerable to natural hazards such as earthquakes. In order to expand the supply of local water, in recent years there has been a significant effort to enhance water reclamation in the region. At present, there is some capacity for water reuse in the region. There is a small water reuse facility in Tijuana known as Ecoparque that could supply a limited amount of water for irrigation of green areas. There are also reclamation projects in Escondido and Del Mar in San Diego County. The most ambitious reclamation project is the construction of a seven-million-gallon per day reclamation plant adjacent to the International Waste Water Treatment Plant located next to the international border.<sup>22</sup> The reclaimed water will be marketed in the south San Diego area and in Tijuana for landscape irrigation, industrial uses, and groundwater recharge. It should be noted that water reuse schemes for domestic purposes in San Diego have encountered significant local political opposition and the enmity of the largest regional newspaper. Labeled as tap to toilet by its foes, water reuse for domestic purposes faces some difficulties in the political arena. The willingness of border populations to accept innovation regarding water use is problematic and is a challenge that local leaders must face between now and 2020.

While water authorities in the San Diego-Tijuana region are planning for future needs, the task is enormous and greatly exacerbated by rapid population growth. The increase of imports from outside the region will require expensive infrastructure and may not be possible at all. It is likely that conservation and reuse will be employed widely, resulting in higher prices for users. Reduced water consumption per capita by San Diegans implies significant changes in lifestyle. In the not-too-distant future, it may not be possible to supply water to users in new housing developments and businesses, nor to maintain the lush, green urban landscape that San Diegans are accustomed to.

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## Sierra Vista

Sierra Vista is a community of about 35,000 people in southeast Arizona in the Upper San Pedro watershed that includes parts of Sonora and Arizona.<sup>23</sup> Sierra Vista's rapid growth from just over 3,000 people in 1960 is based on the expansion of the military base of Ft. Huachuca, retirement homes, and second homes. Much of the housing development is extensive with the creation of semirural ranchettes.

The region is characterized by a diverse landscape with natural habitats that are home to thousands of migratory birds, and approximately one hundred species of birds use the area as a breeding site. In 1988, Congress created the San Pedro Riparian National Conservation Area, recognizing the importance of this natural area. This area relies on streamflow in the San Pedro River for maintenance of the riparian habitat.

The binational region depends primarily on pumping groundwater for mining, municipal, military, and domestic uses. Extraction exceeds recharge, and around Sierra Vista water has been overpumped to the point of creating a cone of depression. In turn, this has negatively affected the riparian areas.

Sierra Vista and the surrounding area face a very insecure future in terms of water. The present water usage rates are not sustainable and population growth will bring greater demand for water. Competition over water use has created conflicts among local and binational interests, including Mexican ranching and mining interests, conservationists, the Gila Indians, land developers, and others.

## El Paso-Ciudad Juárez

The Paso del Norte region consists of the five westernmost counties of Texas, two counties in southern New Mexico that lie along the Rio Grande, and four municipalities in Chihuahua that extend from Ciudad Juárez down the Rio Grande to the confluence with the Rio Conchos. The core of this area, Ciudad Juárez, El Paso, and Dona Ana County (with the city of Las Cruces), currently has a population of about two million persons, which is expected to rise to 2.75 million by 2010 and to about four million by 2020.<sup>24</sup> This projection assumes an annual growth rate of 2.6 percent, which is a doubling time of 27 years. The regional economy has grown rapidly over the past decade and a half. For example the combined El Paso-Ciudad Juárez has averaged 5.3 percent annual employment growth since 1983. Growth of manufacturing has been a key to that growth as the agricultural sector has declined.

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The supply of water is a critical issue in this rapidly growing region. The El Paso-Ciudad Juárez area depends on the Hueco Bolson aquifer, although this source is declining in quantity and quality, and it is estimated that potable water from this source will be exhausted by 2030. The response to the growing water demand and finite underground supply has been to shift to surface supplies from the Rio Grande for urban purposes. This, of course, has been reflected in declining agricultural activities in the region and a dramatic reduction in the amount of land cultivated. Ciudad Juárez does not have access to the Rio Grande surface waters, so its future supply depends totally on underground sources.

### Air Quality

The quality of the air in the U.S.-Mexican border region is a critical factor in the health and well being of border residents. Most of the border's 12 million residents are concentrated in urban zones, which is where most of the air pollution in the border region is generated and where its impacts are most directly felt. This section discusses what is currently known about the ambient air quality in the border region, the sources of emissions to the atmosphere, programs that deal with air quality, future trends, and recommendations to improve air quality in the region.

#### Issues and Problems

Many border residents are currently exposed to health-threatening levels of air pollution. Ozone, particulate matter, carbon monoxide, and sulfur dioxide are among some of the air pollutants of concern in the border region. Air quality problems are due to emissions from mobile, point, and area sources driven by economic growth in the region. The size of the vehicle fleet in northern Mexico is increasing and many older U.S. cars are available in Mexico. This impacts air quality as a large portion of these cars do not comply with either U.S. or Mexican auto emission standards because they have been poorly maintained and contain after-market, used, or inappropriate replacement parts. In addition, authorities have been unable to perform adequate planning and design of roadways to allow the free flow of traffic, which likewise contributes to the deterioration of air quality.

Another important problem is the large amount of pollution produced by mobile sources at the border crossings, since large vehicle lines form during peak crossing hours. The problem is compounded by the poor condition of the vehicles and the extended idling times required to cross into U.S. cities. This produces noticeable air pollu-

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tion at the border crossings. In addition to the tens of millions of passenger vehicles that cross the border each year, there has been a marked increase in the number of heavy-duty trucks now waiting in long queues to enter the United States. The vast majority of these trucks burn diesel fuel, which is a major source of toxic particulate matter.

With respect to point sources of air pollution, industrialization has accelerated the negative impacts with the increased location of industrial operations in the border zone. In combination, the maquiladora sector and national industry emit large quantities of a variety of pollutants from the combustion of fuel and fugitive emissions from industrial processes. The area is experiencing additional air pollution from service and commercial activity that accompanies industrial growth.

Finally, the rapid urbanization and resulting lack of infrastructure to support growth has resulted in the creation of large stretches of unpaved roads that contribute significantly to particulate matter in the air, further reducing air quality.

The important issues related to improving air quality in the border region can be grouped into at least three categories:

1. What are the sources of air pollution?
1. What information exists, and what is needed to determine ambient air quality in the border region?
1. What can realistically be done to reduce pollutant emissions to the atmosphere, given the economic realities of the region?

### Sources of Air Pollution

#### Ambient Air Quality

Ambient air quality is monitored within the border region by a series of monitoring stations on both sides of the border. The monitoring stations on the U.S. side are usually operated and maintained by the state or local air pollution control agency. For example, in San Diego County, the San Diego Air Pollution Control District carries out this work; for Imperial County, monitoring responsibility falls to the Imperial County Air Pollution Control District (APCD); and in Texas, the Texas Natural Resources Conservation Commission (TNRCC) operates the system. Data from these monitoring stations are quality assured and quality controlled (QA/QC) by the responsible agency and the U.S. EPA. The actual data are stored on the USEPA's main-frame computer system located in Research Triangle Park, North Carolina, in the Aerometric Information Retrieval System data base, known as AIRS.

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Until recently, little or no data were available for Mexican cities along the border. Within the last few years, however, a system of monitoring stations has been installed as a result of a cooperative effort by the USEPA and SEMARNAP. Many of these monitors have now been in operation for nearly two years and the data are now becoming widely available. The monitors on the Mexican side of the border are, in most cases, identical to those on the U.S. side, and all data are processed through the AIRS system, ensuring appropriate QA/QC. It is thus possible to compare data from the United States and Mexico with a high degree of confidence. The data presented in this section are all derived from these monitors and have all been verified by AIRS. Only monitors reported in AIRS and located within approximately 100 kilometers (62 miles) of the U.S.-Mexican border are included. State agencies have reviewed the data submitted to AIRS, including the data presented here, to assure data quality.

Most of the monitoring stations are situated in the urban regions of San Diego-Tijuana, Imperial-Mexicali Valley, El Paso-Ciudad Juárez region, and in the Ambos Nogales area of the Arizona-Sonora border. In the near future, monitors will be added for Tecate, Baja California, and a number of other border cities. Monitoring stations are located in the following regions:

- 1 San Diego, California-Tijuana, Baja California Area
- 1 Imperial Valley, California-Mexicali, Baja California-Yuma, Arizona Area
- 1 Ambos Nogales-Tucson-Douglas, Arizona Area
- 1 Ciudad Juárez, Chihuahua-El Paso, Texas-Las Cruces, New Mexico Area
- 1 Portions of the Lower Rio Grande/Rio Bravo Valley

Ambient air quality data from these stations can be obtained directly from AIRS. Summary data are available from a website known as CICA, derived from the Spanish name for the website: Centro de Informaci n Sobre Contaminaci n de Aire.<sup>25</sup>

The pollutants measured by the monitoring stations in the border zone include the criteria pollutants listed below:

- 1 Particulate Matter 10 micrometers or less in diameter (PM10)
- 1 Lead (Pb)
- 1 Sulfur Oxides (SOx) measured as SO2
- 1 Nitrogen Oxides (NOx) measured as NO2
- 1 Ozone (O3)
- 1 Carbon Monoxide (CO)

Data are also provided for a large number of noncriteria pollutants (including air toxics).

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## San Diego-Tijuana Region

The San Diego-Tijuana-Rosarito border region has a population of about four million. The 200-km binational border zone extends north to include all of San Diego County and as far south as the city of Ensenada in Baja California. There are currently 16 ambient air monitoring stations in the binational region, 12 in San Diego County, three in Tijuana, and one in Rosarito. The monitoring stations in Mexico have been in operation for about three years.

Over the past decade, the air quality of San Diego has improved significantly. Since 1991, no Stage 1 smog alerts have been recorded in the County of San Diego.<sup>26</sup> The number of health advisory episodes has been declining. In 1991 and 1992 there were six, in 1993 there were five, in 1994 there was one, and in 1995 there were three. In 1996, no health advisories were recorded.

This improved air quality is the result of reformulated fuels, enhanced air pollution control equipment on mobile sources, and better control of point sources. At the same time, decreased economic activity and population growth rates in San Diego due to the recession of the early 1990s had a beneficial effect on the region's air quality.

Although less is known about the air quality of Tijuana, data are now becoming available as a result of the air monitoring stations. Generally speaking, the gaseous pollutants of ozone, oxides of nitrogen, and, to a lesser extent, carbon monoxide were observed to exceed Mexican legal limits on a number of occasions. The monitoring data for 1996 and 1997 reveal significant exceedences for ozone recorded by the monitors in Tijuana, particularly for sites downtown, and, to a lesser extent, for sites located west and south of the city on the coast. Ozone, and its precursors, oxides of nitrogen and volatile organic compounds, are issues that need to be addressed in this region.

Prevailing winds in the region are generally from north to south, although southerly winds are observed on occasion. Some preliminary data suggest there may be some pollutant transport from north to south, but much more work is needed for this to be confirmed. Despite the poorer air quality in Tijuana, there are little or no data to indicate pollutant transport from south to north, except on an intermittent basis. In fact, the mixing of pollutants in the region from both sides of the border may be considerably more complex than just northerly or southerly transport, and appears to involve westerly winds as well. Clearly, more data are needed regarding ground and upper-level wind patterns in the region.

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An important source of air pollution in Tijuana results from an older vehicle fleet, largely without air pollution control equipment and in a poor state of repair. At the end of 1995, some 212,031 automobiles and 88,403 light and heavy-duty trucks were registered in Tijuana.<sup>27</sup> Many of the older automobiles and light-duty trucks were purchased as used vehicles in Southern California. In other words, California exports its older, more polluting vehicles to Mexico.

Pollution from point sources, particularly from the Rosarito thermo-electric plant, which burns fuel oil with a relatively high sulfur content, as well as many businesses and manufacturing facilities that use volatile solvents, contribute to the pollution load in region. With regard to the Rosarito power plant, recently signed agreements if carried out will provide natural gas to the plant as well as other areas in Tijuana. This should significantly help reduce emissions from the plant and greatly improve air quality in the whole binational region.

One source of ambient air pollution that impacts both Tijuana and San Diego is that of the border crossings, both commercial and non-commercial. Long lines of idling vehicles waiting to cross the border produce significant amounts of pollutants. Although waiting times in the noncommercial lanes have been reduced to approximately 20 minutes, the air pollution generated not only produces unhealthy working conditions for personnel employed at the border, but affects the health of residents of the San Diego communities of San Ysidro and Otay Mesa, as well as Tijuana residents who live close to the border. This problem will increase as transborder vehicular traffic and the regions of San Diego close to the international border are built out and have greater numbers of residents.

In addition to the waiting times at the border crossings, there are a number of vehicles that cross into San Diego each day from Tijuana. It is difficult to estimate the impact of this transborder traffic on the ambient air quality of San Diego. Some 50,000 passenger vehicles cross into San Diego each day from Tijuana. If 65 percent of these vehicles are Mexican (the portion of persons entering San Diego from Mexico who are Mexican), then 32,500 vehicles on San Diego streets each day are Mexican. This is equivalent to 1.5 percent of the total passenger vehicles registered in San Diego County (1,200,000, 1996 estimate). It is likely that the Mexican vehicles produce much higher levels of pollutants than the San Diego vehicles, so it is possible that all Mexican vehicles contribute some 2.3 percent of the vehicular air pollution in San Diego County on any day.

Currently, there is no effective vehicular pollution control program in Tijuana. The responsibility for vehicular pollution control is being transferred to the Municipality of Tijuana from federal and state enti-

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ties as part of an ongoing process of environmental administrative decentralization in Mexico. The laws and regulations for this are now being drafted and approved. Once that process is completed, resources are to be assigned to the municipality for monitoring and compliance purposes. The development of the human and physical infrastructure will be a slow process for the municipality and it is unlikely that effective programs will be in place until two or three years in the future.

Tijuana municipal authorities are very concerned about the effects of air pollution on human health and are beginning to design public outreach programs in preparation for future programs for vehicle inspection and maintenance. In the fall of 1997, the Universidad Autónoma de Baja California, with the support of San Diego State University, initiated a public outreach campaign in Tijuana regarding air pollution and vehicles. Experiences elsewhere along the border and in Mexico suggest that public awareness campaigns are an effective and necessary first step leading to successful vehicular emissions control programs.<sup>28</sup> This and similar outreach programs will also have a beneficial impact on Spanish-speaking residents of San Diego. This suggests that in the future it would be appropriate for San Diego and Tijuana to cooperate on these initiatives.

Preliminary data suggest that air quality is poorer in the Mexican border cities compared to cities located on the U.S. side of the boundary. Particulate matter is of special concern in the Calexico-Mexicali, El Paso-Ciudad Juárez, and Brownsville-Matamoros regions of the border. Gaseous pollutants, especially ozone and ozone precursors (oxides of nitrogen), are of concern in the San Diego-Tijuana region.

It is likely that air quality will continue to deteriorate in the border region over the next 20 years. This is due to the large population increase expected in the region, the long lead times to implement any significant pollution reduction programs, the expected increase in the vehicle fleet, and the continued industrialization and growth in truck traffic due to increased trade. Unless major efforts are initiated in the near future, border communities will have poorer air quality in the year 2020 than at present.

### Energy Use and Resources in the U.S.-Mexican Border Region <sup>29</sup>

The 1983 La Paz Agreement between the United States and Mexico defined the border region as a zone stretching 100 km on both sides of the international boundary. For the purpose of discussing the energy sector and environmentally related issues, such as air pollution,

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this definition is not particularly meaningful. Energy and transportation systems cannot be localized to within a narrow region, and the cities in the border area all have important linkages to other regions throughout the United States, Mexico, and Canada. Air and water flows also do not respect national boundaries or politically created barriers. Therefore, although the term border region is used, energy-related programs and facilities located anywhere in a broad area of the southwestern United States or northern Mexico are included in the discussion.

### California-Baja California Region

The energy resources available in the border region vary considerably throughout the border area. The California-Baja California portion of the border, in which almost 50 percent of the total border population is located, is poor in energy resources. The outstanding characteristic of energy use in this portion of the border region is the almost total dependence on energy resources from outside the region. With the notable exception of the geothermal fields located south of Mexicali, virtually all of the energy consumed in the region originates in distant regions. These imported energy resources are in the form of petroleum products (gasoline, diesel, jet fuel, liquefied petroleum, and fuel oil), natural gas, uranium, and imported electricity. Approximately \$3 billion per year leaves the San Diego economy to pay for this energy. All of Baja California's transportation, industrial, and residential fuels must be transported long distances from refineries located far to the south in Mexico. Moreover, the electric power grid in Baja California is not connected to the main Mexican power system. The state has no natural gas pipeline system, although Mexicali recently has been connected to the U.S. gas distribution network and a similar connection is being developed for Tijuana and Rosarito.

Total installed electrical power generating capacity in Baja California is 1.4 GW, compared to 2.5 GW in San Diego. San Diego does not meet its electric demand by in-region generation and must import nearly 60 percent of its electricity from outside the region. Baja California, by contrast, has until recently not only been able to meet its own needs, but had a surplus available for export to California. This situation has changed and now Baja California must import electricity from California. Per capita electric consumption in San Diego is much greater than in Baja California. Residents on the U.S. side of the border use 3.5 times more electricity per capita than people living in Baja California. Per capita consumption of electricity in Baja Cali-

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fornia will very likely increase as industrialization and urbanization continue to expand.

The fuels used for electric generation in Baja California are oil (44%), geothermal (44%), and diesel (12%). This power is generated mostly in two large plants, one near Rosarito, which uses oil, and the other at Cerro Prieto, near Mexicali, which uses geothermal heat. Several smaller plants in Tijuana, Mexicali, and Ensenada utilize diesel.

The salient features of the energy sector in this section of the binational region are the lack of indigenous or nearby energy resources for San Diego, Imperial County, and Baja California; the relatively high cost of electricity in San Diego; the isolation of the Baja California power grid from the rest of Mexico; the absence of a natural gas pipeline system in Baja California; and the growing demand for energy resulting from the increasing industrialization and population in northern Mexico. These facts also provide a basis for developing increased cooperation in the energy field between California and Baja California as well as other regions in Mexico and the southwestern United States.

## Texas-Mexico Border Region

The energy situation in the Texas-Mexico border region is quite different from the California-Baja California area. Texas is the world's sixth largest energy consumer and produces one-fourth of all natural gas produced in the United States and one-fifth of all U.S. oil. Texas consumes three times as much energy per capita as the U.S. average, compared to California which consumes less than the national average. In Texas, natural gas powers 96 percent of the power plants in the border region, with the remainder being Rio Grande hydroelectric plants.

Almost 15 percent of the total Mexican installed capacity for power generation is located in the four Mexican states bordering Texas. Coal (41.2%) and fuel oil/natural gas (50%) fuel the eight generating plants in these states.

Some of the major energy related issues in the Texas-Mexico border region are centered around the need to provide more and better electric services. Texas relies on natural gas (60.1%) and coal (20.2%) for most of its electricity, while Mexican states bordering Texas rely on coal and fuel oil much of which has a high sulfur content. Electricity consumption is increasing faster than population growth in both Texas and Mexico. Electricity consumption in the Mexican states that border Texas is projected to increase six to eight percent annually over the next few years. If this growth rate is realized,

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electricity consumption would double in these states in just 11.7 to 8.75 years, respectively.

The four Mexican states that border Texas—Nuevo León, Chihuahua, Tamaulipas, and Coahuila—have 4.6 GW of installed capacity at eight generating stations. The Texas counties in the border region have 13 power plants, but with an installed capacity of only 1.6 GW. Natural gas fuels 96 percent of this capacity, with most of the remainder being hydroelectric power from the Rio Grande.

As in the western portion of the border, the demand for electric power has increased faster on the Mexican side of the border than on the U.S. side, as the region has grown economically and in population. This increasing use of electricity is an essential part of modernization. Areas currently underserved or unserved by electric power will seek access to electricity. This demand can be met in a more sustainable fashion through the use of renewable energy resources, increased energy efficiency, and demand-side management programs.

Infrastructure issues play a large role in meeting future electric demand in the region. There are eight electrical interconnections that cross the Texas-Mexico border, compared to only two across the California-Baja California border. Due to limited transmission capabilities, these are normally open connections, some used only for emergencies. Active connections could have a negative impact on the reliability and management of both systems. If substantial exchange of electricity is needed on these transmission systems, some infrastructure improvement would be required. Electric power exchange across the border would require the existence of sufficient demand, price advantages, and regulatory means, as well as appropriate interconnects.

#### SUMMARY OF ENERGY ISSUES IN THE U.S.-MEXICAN BORDER REGION

The rapid population growth, urbanization, and industrialization noted earlier have created an increasing demand for energy services, particularly electricity, in northern Mexico. The Mexican Federal Electric Commission (CFE) estimates that demand for electric services will increase at an annual rate of 5.7 percent between 1996 and 2005 for northern Mexico, compared to 4.7 percent for the country as a whole. An additional 5,608 MW of installed capacity in northern Mexico will be required to meet the demand. This will constitute a significant investment in energy-related infrastructure and human resource development. Unless careful consideration is given to the types of

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energy resources used and the technologies employed to meet future energy needs, air and water quality could be further degraded in the border region with negative consequences for human health. Thus, programs need to be developed that can meet the expected need for energy services in the next 10 years, but at the same time, minimize the environmental impacts of increased energy use. By utilizing a mix of appropriate fuels, modern generating technologies, and energy efficiency programs, it should be possible to achieve this end.

### Natural Resources

The impressive growth and development of the borderlands over the past decades have produced significant negative impacts on the native flora and fauna and ecosystems of the region. Expansion of urban areas, destruction of native habitats through grazing activities or agriculture, lowering the water table through excessive pumping of water deposits, and impacts of recreation on fragile ecosystems have all had important consequences on the border region. While efforts have been made to protect certain endangered species such as the masked bobwhite and the white-winged dove, it has been difficult for U.S. and Mexican authorities to establish transborder biosphere reserves to protect habitats of species that live on both sides of the border.<sup>30</sup> In addition, it has not been easy to address transborder impacts on important ecosystems.

The degradation of these ecosystems have important economic consequences for border communities. For example, the tourism industry of Southern California is linked to ocean recreation activities. Increased pollution of the ocean produces beach closures by the local health authorities with direct economic impacts on the communities affected.

Species and habitats are under stress in many areas along the border as the result of human activities. Some of the hot spots include the following:

#### Bight of the Californias

This nearshore marine zone extends from Point Conception in the north to Cabo Colnett in the south. Much of the population of Southern California is located adjacent to the coastline, and human activities have produced significant impacts in the nearshore marine environment through over exploitation of marine resources, contamination of coastal waters through sewage discharges, treated effluent discharges, and nonpoint source pollution through runoff during storm events. Pollution includes biological elements as well as

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heavy metals, industrial chemicals, petroleum products, and pesticides.

### Tijuana Estuary and Watershed

The Tijuana River National Estuarine Research Reserve is located in the United States at the mouth of the Tijuana watershed that lies one-third in the United States and two-thirds in Mexico. It includes the urban and industrial core of Tijuana, the City of Tecate, Baja California, and extensive development in the watershed on the U.S. and Mexican portions. Important habitats throughout the watershed are threatened by unmanaged development. The estuary is impacted by what occurs in the entire watershed. This includes not only increased fresh water flows, but sewage contamination, chemical contamination, and increased sedimentation.

### The Upper San Pedro Watershed

Located in Arizona and Sonora, this region contains important wetlands and other habitats, such as grasslands. The area is especially significant as a habitat for migrating birds. The area is under stress from cattle grazing, agriculture, urbanization, and mining activities on the Sonoran side of the watershed and from grazing activities, urban development, and extensive semi-rural development in the Arizona portion of the region. Water quality and supply are key issues here.

### Rio Grande

The Rio Grande is a complex ecosystem that has been heavily altered by human activities, particularly the construction of major dams and diversion dams to utilize the water for agriculture and urban uses, for recreation, and for the generation of hydropower.<sup>31</sup> Not only is the Rio Grande water use so heavy that at some points the river is reduced to a trickle, but the quality of the water has been severely degraded. Increased sedimentation from farming and ranching activities, salinization from agricultural return flows, biological contamination through discharge of untreated or poorly treated municipal sewage, chemical and biological contamination through nonpoint source pollution, pesticide contamination from agricultural practices, and heavy metal contamination from mining activities all have contributed to the declining quality of the Rio Grande water. The impact of the development has been devastating on native fish, wildlife, wetlands and riparian habitats, and habitats such as the bosques. Despite the intense agricultural development, particularly on the Texas side, some areas of native vegetation remain. These remaining areas are of great value and are the subject of Mexican and U.S. conservation efforts.

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### Laguna Madre

The Laguna Madre, particularly on the Mexican side of the border at the Gulf of Mexico coast, is an important estuarine resource of significant value with diverse aquatic and terrestrial ecosystems.<sup>32</sup> It is home to endangered bird and mammal populations. The principal threats to this resource include alteration of freshwater sources through dam construction, cattle grazing, uncontrolled harvesting of fish species, irregular human settlements, dredging channels to the sea, the possibility of the construction of the intracoastal canal, and biological and chemical pollution.

### ENVIRONMENTAL INDICATORS AND THE FUTURE OF THE BORDER

One of the difficulties in discussing the environment is the lack of a clear and understandable method for measuring change in the quality of the environment. In order to plan for the future, border communities must have some way of assessing the state of the environment in their regions and determining the effects of urbanization, economic growth, and population growth on the environment. Perhaps the most promising approach is the development of environmental indicators for the border region. Related efforts include development of quality of life measures and sustainability criteria.

### Environmental Indicators

A joint project of the EPA and SEMARNAP has produced the United States-Mexico Border Environmental Indicators 1997, an effort that employed the nine workgroups of Border XXI to create indicators to assess the condition of the border environment and progress in addressing problem areas.<sup>33</sup> This is the most comprehensive work to date for development of indicators for the border region.

Some regions of the borders have begun similar work for their own areas. For example, the San Diego Association of Governments (SANDAG) incorporated quality of life elements in the Regional Growth Management Strategy that it adopted in January 1993.<sup>34</sup> The Regional Growth Management Strategy was developed in response to Proposition C, Regional Planning and Growth Control Measure, passed by San Diego voters in November of 1998. A central part of the strategy is that actions should be aimed at preserving or improving the quality of life in the region. It focused on specific areas such clean air, water quality and supply, hazardous and solid waste reduction, traffic congestion reduction, adequate housing, protection of

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open and sensitive lands, adequate public infrastructure, and maintenance of a prosperous economy. The strategy establishes a framework for all of the region's local governments (18 cities and the county of San Diego) to cooperate to meet the objectives outlined in the plan. Since the adoption of the strategy, SANDAG has moved forward with specific action plans on issues such as water quality<sup>35</sup> and has established a system for local agencies and governments to produce self-certification reports on progress toward meeting the goals of the Regional Growth Management Strategy.<sup>36</sup> It is perhaps too soon to evaluate the effectiveness of this effort. Also, it is not clear how much of this strategy is relevant to Tijuana. Although Tijuana shares the same natural environment with San Diego, its social, political, and economic contexts are quite different.

### An Environmental Checklist

It is possible to identify a number of elements from the environmental indicator, sustainability, and growth management strategies that can serve as a checklist in order to determine the state of the environment in different regions along the border and to measure progress in the future. Such a checklist should also be useful for making estimates regarding environmental quality to the year 2020.

This discussion needs to be prefaced with a cautionary note that there are many significant gaps in information regarding the border environment. This is due to lack of basic monitoring, as can be seen in the incomplete coverage of air monitoring stations along the border. It is also due to difficulties in accessing available information that is understandable and useful. A joint project by San Diego State University in partnership with the EPA and SEMARNAP has produced a website that is designed to facilitate access to border environmental information that is available on the Internet. This website, Border EcoWeb, is a good place to begin the search for required information. The address is <[www.borderecoweb.sdsu.edu](http://www.borderecoweb.sdsu.edu)>.

#### Air Quality

Mexico and the United States have similar ambient air quality standards for pollutants that can be measured by air monitoring stations. These standards indicate acceptable limits of specific pollutants and when those limits are exceeded (exceedances), there are clear negative impacts on human health. For some border communities, this information can be obtained to provide an accurate picture of the local air quality and potential health effects. In other areas, where no continuous monitoring stations are functioning, sporadic sampling

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may be used for rough estimates of air quality. The following measures or air pollutants can be used to assess air quality for border communities: ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, particulate matter (PM10), and lead.

### Transportation Infrastructure

Since the roads, highways, and ports of entry of a community are directly related to issues such as traffic congestion and air pollution, the relevant infrastructure should be considered.

### Water Quality

Is potable water of acceptable quality? Usual measures for potable water quality include the presence of disease-causing organisms, chemical contaminants, and total suspended solids (including salts).

### Water Quantity

Is there sufficient water of an acceptable quality available to serve human needs and to sustain a sound economy? Are water conservation and reuse efforts adequate?

### Water Infrastructure

What percentage of the community is served by treated potable water, sewage collection, and sewage treatment services? Since transborder sewage flows impact the entire binational region, the twin cities should be considered as one community.

### Solid Waste

Is there adequate collection, disposal, and recycling? Recycling should be a coordinated binational activity.

### Hazardous Waste

Is proper disposal and recycling taking place? Is infrastructure adequate? Are pollution prevention efforts sufficient?

### Emergency Response

Are plans, equipment, and trained personnel available? Binational capability should be developed.

### Environmental Health

Are there health problems related to environmental conditions? This includes diseases related to air pollution, pesticide exposure, gastrointestinal diseases related to contaminated water, exposure to

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chemicals and heavy metals in industry or other sources, and so forth. Many of these risk factors are transboundary in nature.

### Natural Resources

Is there adequate protection of threatened and endangered species and habitats in the region? This is an important area of transboundary cooperation.

### Natural Disasters

Is the community vulnerable to natural disasters including earthquakes, floods, droughts, and wildfires? The risks associated with these are directly associated with human activity. For example, increased urbanization, agricultural and grazing activities, mining, and alteration of native vegetation significantly increases storm water runoff and risk of flooding. Human activities often change regional climate conditions and induce desertification. Long-term changes in climate and weather patterns are linked to human activities; how will these changes impact local communities?

### Economic Development

The rate and nature of economic expansion have a profound effect on the environment through increased pollution, impacts on natural areas, environmental health considerations, and so forth. The nature of the economic expansion is critical, for economic growth without development might not reduce poverty or bring prosperity. Simple economic expansion might not enhance the tax base sufficiently to provide necessary infrastructure and other measures to mitigate environmental problems.

By considering the topics on this checklist, it is possible to develop a rough assessment of the state of the environment at the community level. By projecting those elements into the future to 2020 in a context of either continued economic expansion or economic growth, it is possible to identify aspects of the environment that will need attention in order to avoid severe environmental effects in the future.

## NOTES

1. For a brief overview of the Bracero Program, see Karl M. Schmitt, *Mexico and the United States, 1821-1973: Conflict and Coexistence* (New York: John Wiley & Sons, Inc., 1974), 214-20; also, Richard B. Craig, *The Bracero Program: Interest Groups and Foreign Policy* (Austin: University of Texas Press, 1971); and Gregory Gross, *Impe-*

